THE ROYAL ENGINEERS JOURNAL.—DECEMBER, 1925. Pages 537—712.

The Royal Engineers Journal.

PUBLISHED QUARTERLY.

VOL. XXXIX. No. 4. DECEMBER, 1925.

CHATHAM:
THE INSTITUTION OF ROYAL ENGINEERS.
TELEPHONE: CHATHAM, 669.
AGENTS: W. & J. MACKAY & Co., LTD.

All Co
MA

EMENT
1.

Much of the time now wasted at International Conferences will be saved when the delegates learn to speak and understand Foreign Languages by the New Pelman method.

THE BEST WAY OF LEARNING LANGUAGES.

Two Distinguished Generals Praise the New Method of Learning French, German, Italian and Spanish.

Amongst those who strongly recommend the new Pelman method of learning Foreign Languages are Lieut.-Gen. Sir Aylmer Haldane, G.C.M.G., K.C.B., and Major-Gen. Sir A. R. F. Dorward, K.C.B., D.S.O.

Lieut.-Gen. Sir Aylmer Haldane, who, it will be remembered, was Commander-in-Chief in Mesopotamia in 1920-1, writes :—

> "*I find that the Pelman method is the best way of learning French without a teacher.*"

Major-Gen. Sir A. R. F. Dorward, who commanded the British, American and Austrian troops at the capture of Tientsin in 1900, says:—

> "*I am well satisfied with my progress. Since I began the Pelman Course I have learnt more French than in eight years spent at school and college, although my memory is not so good as in the past. The Course is, without doubt, the best method of learning a Foreign Language. The study has been a pleasure.*"

"The study has been a pleasure." This is a highly important point in favour of the new Pelman method. Many people start to learn languages. They attend a class or they purchase a grammar and a dictionary. But after a time they get tired. They cease to attend the class. They leave the grammar and dictionary on their bookshelves. Why is this? In nine cases out of ten it is because they have found the study dull. It is the grammar which has bored them—the pages and pages of rules and exceptions which they are told they must master before they can hope to read, speak and understand French, German, Italian or Spanish. And so they give up.

By the new Pelman method this great difficulty is avoided. When you take up a Pelman Course in French, or in any other language, you are introduced to that language straight away. You learn to speak, write, read and understand it. Formal grammar is avoided. You pick up the grammar almost unconsciously as you go along. If, after you have learnt to use the language, you would like to study the grammar, you can do so. But the *grammar* comes *last*, the living *language* comes first. That is why the new method is so interesting—and so successful.

Another important feature of this new method is that it enables you to learn French in French, German in German, Spanish in Spanish, and Italian in Italian; and it enables you to do this even if you do not possess the smallest previous acquaintance with any of these languages.

Many advantages follow. There are no vocabularies to be learnt by heart. You learn the words you need by using them, and in such a way that you never forget them. There is no translation (either mental or on paper) from one language into another. By learning a language as a native learns it you learn to speak it more fluently; there is none of that hesitation (due to translating mentally words of one language into words of another language) which is almost unavoidable when you learn French or Spanish or German or Italian by the obsolete and unscientific old-fashioned method.

Here are two further letters:—

> "*I am more than satisfied. I am astonished. It would have taken me as many years to learn by any ordinary system as much as I have learnt in months by yours.*" (P. 145.)

> "*In sending in the last paper to the Institute I must congratulate it on its splendid method. I have only been learning German for five months, now I can not only read it but also speak it well.*" (G.M. 148.)

The point mentioned in these letters is one which is often being made. People write almost every day to say how *quickly* they have learnt French, Spanish, Italian, or German by this new method. "I learnt for years at school," they write, "but you have taught me more in as many months."

The new Pelman method is taught by correspondence. As there are no classes to attend, you can study in your own home, or when travelling, or in odd moments during the day.

Full particulars of this method are given in four little books entitled respectively, "How to Learn French," "How to Learn German," "How to Learn Italian," and "How to Learn Spanish." You can obtain any one of these books, gratis and post free, by writing to-day (mentioning which book you require) to the Pelman Institute (Languages Dept.), 130, Pelman House, Bloomsbury Street, London, W.C. 1. Call or write to-day.

THE INSTITUTION OF ROYAL ENGINEERS.

All communications for the Institution should be addressed to :—
The Secretary, The Institution of Royal Engineers, Chatham.

CONTENTS.

CONTENTS.

2150—1-12-25

COOPER'S HILL WAR MEMORIAL PRIZE ESSAY.

THE second of the triennial prizes presented to the Corps by the Cooper's Hill Memorial Fund is for competition during the year 1926, and the Council of the Institution of Royal Engineers has chosen the following subject :—

"The effect of mechanicalization of the Army on the organization and employment of Divisional and Corps Engineers in the Field."

Essays must reach the office of the Secretary, Institution of Royal Engineers, not later than the forenoon of the 1st September, 1926. Essays must not be signed, but each must bear a pseudonym and the name of the writer enclosed in a sealed envelope must be attached.

The Cooper's Hill Memorial Prize is a bronze medal, a parchment certificate, and a sum of money, about £20.

(*a*) *Qualifications of the Competitors.*—To be a regular officer of the Royal Engineers under the age of 35 on the 1st January of the year in which the award is made.

MONTGOMERIE PRIZE.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded by the Council of the Institution of Royal Engineers in the manner considered best for the encouragement of contributions on professional subjects, by R.E. officers, to the Corps publications. From the beginning of 1920 it was decided that the Prize should be offered to officers on the Active List not above the rank of Substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions :—

- (*a*) Descriptions of works actually carried out in peace or war.
- (*b*) Inventions.
- (*c*) Design (excluding works of defence).
- (*d*) Labour organization on work.
- (*e*) Scientific investigations generally.
- (*f*) Accounts of exploration work and surveys.

EARL KITCHENER AND HIS CRITICS.

"THE TRUTH ABOUT KITCHENER."

By V. W. GERMAINS ("A Rifleman.")

Published by John Lane, The Bodley Head, Limited.

This book is well worth reading and it may be described as being in the main a reasoned and effective reply to various criticisms of Lord Kitchener's action during the War which have appeared since his death, notably those contained in "1914," by Lord Ypres, "*The Tragedy of Lord Kitchener*," by Lord Esher, "*The World Crisis*," by Winston Churchill, "*The First World War*," by Col. Repington, and in certain writings and speeches by General Sir Ian Hamilton. The author has made a careful study of the facts and is in possession of a good deal of information from other than written sources. In the writer's judgment he has completely answered the criticisms with which he deals, and surely no one can peruse the book without feeling more than ever convinced of the magnitude of Lord Kitchener's services, of how he out-topped his contemporaries—a Triton among the minnows—and of how extraordinarily little substance or foundation there is to the criticisms levelled against him: further how small those criticisms would bulk, even if all of them were true, as compared to the services which he rendered.

It is regrettable, of course, that there has been all this criticism, but in the main it is due to the fact that the doctrines held and taught in pre-war days both by statesmen and responsible soldiers regarding the nature of the impending struggle were discarded directly war was declared and the opposing ones of Lord Kitchener adopted. In such circumstances it is natural that those whose forecasts were so mistaken should have felt mortified, nor can we wonder at some among them endeavouring to find flaws in the actions of him through whom their fallacies were exposed.

In a very interesting opening Chapter, Mr. Germains describes fully and accurately military doctrine in 1914, and shows how restricted was the vision of those who, at the War Office, did so much to prepare the Expeditionary and Territorial Forces. To the end of time, however, it will be a matter of wonder that, as Mr. Churchill writes, "Almost all professional opinion was agreed that the struggle would be short and that the first few weeks would be decisive."

Lord Kitchener, we know, took a precisely opposite view and with a sure instinct, realized that to force a great and proud military power like Germany on its knees must be the work of years. A further fact which the author brings out was that the satellites, military and civilian, who revolved round the War Secretaries and Sir John French from 1906 to 1914, considered Lord Kitchener ignorant of modern war conditions and incompetent to draw conclusions regarding them (Colonel Repington in one of his volumes writes of " Kitchener knowing nothing of modern military organization ") ; to this cause and possibly to the politicians' fear of a strong man, we owe it not only that Lord Kitchener was not brought to the War Office in 1911, but that his advice on matters of military policy was never even sought. Unaided then by the one man who could have helped them, the pundits framed their plans on the basis of a short war carried out so far as we were concerned on a " limited liability " principle, despite the terrible risk involved to the country. Not one single preparatory arrangement was made for the expansion which was ultimately seen to be inevitable directly we actually became involved in a world war.

Perhaps the shallowest and least convincing of the criticisms with which our author deals is that, when expansion was decided on, Lord Kitchener was wrong in not taking the Territorial Force as the basis of expansion and Lord Esher is foolish enough to assert as a reason that Lord Kitchener knew nothing of the Territorial Force, of its organization or origin.

Let us recollect that the Territorial Force was formed and designed for *Home* Defence ; its men were not liable for service overseas ; its regulations were complicated, and would have required many and sweeping changes before the Force could be used as a framework for a General Expansion. New armies were wanted to fight *abroad* and for the war, and it was much simpler and more effective to raise them direct, apart from the Territorial Force, some of which at any rate would be always wanted for Home Defence. Further, as the writer knows from very direct personal experience, the Territorial Force Associations, as they were, had their work cut out and their time fully occupied in raising Second and Third Line Divisions, whilst the personnel of the Associations was not such as to make an appeal through them a very effective one. Lord Kitchener saw in a moment that what was needed was to get as many agencies to work as possible. The Regular Army recruiting agencies did much ; the Territorial Associations captured Territorials, whilst Committees in the Great Towns in raising their own Kitchener battalions did invaluable work which could not have been effectively handled by the Territorial Associations.

Lord Kitchener did many wise things during the War but never a wiser one than when he decided not to carry out all the expansion through the medium of the Territorial Associations.

Space does not permit of following the author through his replies to Lord Esher, Lord Ypres, Colonel Repington and others, but the writer knows sufficient of the subject to assure his readers that Mr. Germains is right in his facts and correct in his conclusions.

An interesting letter from General Ludendorff is included testifying to the magnitude of Lord Kitchener's achievement. We quote one sentence: "His great organizing powers alone would have sufficed to render Lord Kitchener one of the most remarkable and important personalities of the world war, perhaps the most distinguished England has ever had."

Despite the title of his book, the author, more especially in the chapters, "The Armies of the Somme," and "Lord Kitchener and his Successors," discusses a good many war questions unconnected with Lord Kitchener. He deals in some detail with the relations between Mr. Lloyd George and the soldiers, more especially in regard to the Roumanian Campaign. The question whether the Expeditionary Force should not in the first instance have been sent to Belgium instead of to France is also discussed. A few pages are devoted to Admiral Jellicoe and the Battle of Jutland, whilst the Staff arrangements in France are severely criticized. With these matters the writer has neither the space nor the special knowledge to deal, but it is obvious that the very extent of the field covered in a small compass of space gives to this portion of the book some appearance of discursiveness. The politicians come in for some hard knocks. The author speaks of these "earnest men" (Lord Esher's definition of the Cabinet) as resembling "a collection of maiden ladies meeting for tea and tittle-tattle, rather than a body of statesmen entrusted with the guidance of the country's fortunes at a supreme moment of destiny." This may sound severe, but if half the reports are true it is not overdrawn. The most regrettable thing in the book is an attack on a Corps Commander at Gallipoli whom the author saddles with a responsibility which was primarily that of the Commander-in-Chief. The writer hopes that this may be modified in subsequent editions as it is a blot on a stimulating and welcome publication.

H. M. LAWSON,
Lieut.-General.

THE THOMASON COLLEGE, ROORKEE.

By Lieut.-Col. E. W. C. Sandes, D.S.O., M.C., R.E.

The Thomason Civil Engineering College at Roorkee in northern India has been intimately connected with the Corps of Royal Engineers since its foundation in the middle of the last century, and consequently its history, and a description of the methods now adopted there to train civil engineers for India, may be of interest to officers of the Corps. From the remarks of some visitors to the College I have gathered that they were surprised at the completeness of the courses of instruction and the outfit of instruments and apparatus used during those courses. It is to enlighten officers of the Corps on these matters that this article has been written, and though, as the subject is so large, the article has necessarily been prepared in a condensed form, I hope that it may be useful. Many good stories can be told of happenings at the College, but they must wait.

Like most institutions in a country in the process of rapid development the Thomason College grew from the smallest beginnings, step by step with the introduction of western methods of engineering into India. Its foundation may be traced chiefly to the necessity of training civil engineers in India itself for the construction of the great system of irrigation canals undertaken from 1817 onwards in the area around the upper waters of the Ganges river forming part of what was then known as the 'North-Western Provinces.' The construction of the Western Jumna canals began in 1817, and of the Eastern Jumna canal in 1822, and roads were made in many directions to open up the country, so that a demand for skilful engineers, conversant with the methods and needs of the country, grew very rapidly. When, however, the construction of the great Ganges Canal was started, Lord Hardinge, the Viceroy, realized in 1847 that an institution for training engineers must be opened at once to cope with the enormous demand for skilled supervisors and designers, and out of this emergency arose the Thomason College. Roorkee was selected as the site for a college as it is near the first 20 miles of the Ganges Canal in which are several engineering works of the greatest size, and also because it was already a centre of engineering from the presence of many officers of the Bengal Sappers and Miners.

Lieutenant R. Maclagan, R.E., the father of Sir Edward Maclagan, late Governor of the Punjab, was appointed Principal of the College at Roorkee in the 19th October, 1847, assisted by a Headmaster, a

Drawing master, and two Indian teachers. The classes were three in number, one for training candidates for appointment as Sub-Assistant Civil Engineers, another for training European N.C.O.'s and soldiers as Overseers, and a third to train Indians as Surveyors. The College, however, did not become known as the Thomason College till 1854, after the second Punjab War, when it was reorganized and named after Mr. Thomason, the Lieutenant Governor of the North-Western Provinces, the new scheme including the admission of officers of the Royal and East India Company's armies for training as engineers, and a great enlargement of the College buildings. Many young officers of the Royal Artillery and Royal Engineers joined the institution as students, and it began rapidly to rise towards its present position and reputation.

From the foundation of the College in 1847 to the year 1891, all the Principals were Royal Engineers. Lieut. (afterwards Colonel) R. Maclagan (1847-1860) was succeeded by Capt. E. C. S. Williams, (afterwards General Sir E. C. Sparshott Williams, K.C.I.E. Colonel Commandant R.E. (1860-1862),and then by Major (afterwards Colonel) J. G. Medley (1863-1871), Major (afterwards Colonel) A. M. Lang (1871-1877), and Major (afterwards Colonel) A. M. Brandreth (1877-1891). A departure from precedent then occurred in the appointment of Colonel F. D. M. Brown, V.C. (1891-1892), and later Major (afterwards Lt.-Colonel) J. Clibborn, C.I.E. (1892-1902), both of the Indian Staff Corps, as the corps of officers of the Indian Army was then called. However, a Royal Engineer was again appointed in 1902 in the person of Capt. (later Lieut.-Colonel) E. H. de V. Atkinson (now Major-General Sir E. H. de V. Atkinson, K.B.E., C.B., C.M.G., C.I.E.) who held the post of Principal from 1902 till 1915, almost equalling the record tenure of Colonel Brandreth. After an officiating period of one year by Mr. E. F. Tipple, Professor of Mathematics, the next Principal was Mr. W. G. Wood, C.S.I. (1916-1921), a retired Chief Engineer of the Public Works Department, and finally, after four years' experience as a Professor before the war, the writer was appointed Principal in 1921. Many R.E. officers have officiated as Principal, or have been Military Assistant Principals or Professors, among them being Major Oldfield (1852-1856), Major A. Cunningham (1876), Lieut. (afterwards Lieut.-Colonel) J. H. C. Harrison (1881-1882), Capt. E. D. Bullen (1894 and 1897-1898), Lieut. (afterwards Lieut.-Colonel) H B. D. Campbell (1898 and 1905-1910), Major W. A. Gale (1898), Capt. (now Bt. Lieut.-Colonel) D. K. Edgar, and Lieut. T. H. L. Spaight. It will be seen from these records that, during the 78 years of the existence of the Thomason College, 8 of the 11 Principals have been R.E. officers, and that at least 16 R.E. officers have served on the staff, so that the College has had a very close connection with the Corps. At one period in its history there were as many as 3 Military Assistant Principals (all R.E. officers), but normally there was only one, and in 1910 the post was abolished as there was then a large staff of civilian Professors. Since that date no officer of the Corps has joined the staff, which is now recruited by advertising any vacant post and assembling a Selection Committee in India to recommend a candidate for it.

After the Indian mutiny a new Thomason College was built on the present site, and additions and extensions were made in later years till the building reached its present dimensions, complete with 6 lecture theatres, 2 large engineering model rooms, class rooms, offices, a library, a gymnasium and Convocation hall, scientific laboratories, a large printing press and photo-mechanical department and with mechanical and electrical workshops in a separate block. The classes under instruction have been altered from time to time in accordance with requirements. I will deal briefly only with the existing classes and courses as these are designed for the most modern needs in northern India.

The Thomason College now admits students to the following classes :—

(*a*) Civil Engineer Class (*b*) Overseer Class (*c*) Draftsman Class and of these by far the most important is the Civil Engineer Class. Students who qualify in this class can rise to great heights in Government service in India, several having already reached the rank of Chief Engineer of a Province. The most notable example of success from this class is that of Sir William Wilcocks, the famous engineer of Egypt and Mesopotamia. Admission is gained through a competitive examination held yearly under the auspices of the College at various centres in northern India, including Roorkee itself, and, to be eligible to compete, candidates must at least have matriculated at a University (with certain special subjects such as Drawing), or have gained a corresponding qualification at a European school, must be between 17 and 21 years of age, must be domiciled in the United Provinces, Central India, Bihar, Orissa, the Punjab, or certain other northern territories, and must have the necessary certificates of physical fitness and moral character. Candidates are not taken from the provinces of Bengal, Bombay, or Madras, as these territories have their own engineering colleges at Sibpur, Poona and Madras respectively, nor are any taken from Great Britain or other countries outside India and Burma. Europeans and Indians compete for admission at Roorkee under identical conditions. Only 30 vacancies are offered yearly in the Civil Engineer Class, and the popularity of the College may be gauged by the fact that 274 candidates sat for these 30 vacancies in June, 1925.

The Civil Engineer Class course is one of 3 years' duration. It approximates to the degree standard in engineering at British universities. The first year is devoted mainly to pure mathematics and science, the second year chiefly to more advanced pure and applied mathematics, science, surveying, and some civil, mechanical and electrical engineering, and the third year almost entirely to civil engineering (including designs), with the addition of more mechanical and electrical engineering and surveying (including astronomy). A most important test of a student's practical ability takes place in the 3rd year, in which, after some preliminary projects which are corrected and criticized, a large 6 weeks' engineering project is set by an outside examiner in Irrigation or Railway design. The 3rd year students go into camp for the first 3 weeks of this project period, and each one works alone across country with his own instruments and gang of men, returning to Roorkee to complete his reports, designs, calculations, estimates and survey plates when he has finished his out-door work. This test, which carries a large number of marks, effectually eliminates the pure theorist from the top half of the class, and brings to the fore the man of common sense, ability, and character. Before the end of each session, in June, there is a final examination, in which every student must qualify in the various groups of subjects studied during the session, if he is to remain in the College. Mid-sessional examinations also are held in February. The College session starts on the 16th October and ends on the 15th July, being followed by a vacation of 3 months during the unhealthy monsoon period, and at Christmas there is 10 days leave. The final examinations in the heat of June are rather a trial, but fever is so rampant at Roorkee in the rains that it would probably be difficult to hold the examinations in July, August or September.

When the Civil Engineer Class student (then, say, 23 years old) qualifies at the end of his course, he is given a certificate which is either 'Higher' or 'Ordinary' according to his total of marks,* and he then as a rule goes as an apprentice (or student) to the Public Works Department for one year to learn practical methods of work and the control of labour. At the end of this year, if his reports are good, he is posted to the Department as an Assistant Executive Engineer (or an Assistant Engineer) on probation for another year, and thus he starts his career in Government service as an officer. There is an all-India engineering service, known as the 'Indian Service of Engineers,' which is recruited both in India and from among qualified engineers in Great Britain. Appointment to this service is what every student desires, for in it he can rise to the highest rank and he starts on good pay. Roorkee has hitherto been allotted 9 or 10 vacancies in the I.S.E. (the Indian Service of Engineers) each year, which is greatly in excess of the number given to any other engineering college in India, and thus the top nine or

*The College cannot give a degree, as it does not belong to any University, and has no Faculty of Engineering.

ten qualified students pass into this all-India service and may be employed anywhere in India though they are usually kept in their own provinces. The remaining students of a batch are usually offered appointments (after apprenticeship) in the Provincial Engineering Service of their province on a lower scale of pay, but some of these men may hope to be admitted to the I.S.E. later by selection, if specially brilliant. A few passed students enter the service of Indian States, having as a rule been admitted to the College as 'State students' who have qualified but not gained places in the competitive examination, and whose cost of training at Roorkee is paid by their States in return for a claim on their services when they leave college.

On confirmation as Assistant Executive Engineer in the Indian Service of Engineers a young Indian or a European domiciled in India, starts on a salary of Rs. 375 a month (say £335 a year). After ten years he may be getting Rs. 875 a month and will probably then be an Executive Engineer, in which grade his maximum will be Rs. 1,375 a month at 24 years' service or over. At about 20 years' service, however, and sometimes earlier, a good man should certainly have been selected for the Superintending Engineer grade where his pay rises from Rs. 1,750 to Rs. 2,150 a month, and later he may have a chance of selection to Chief Engineer on the handsome salary of Rs. 2,750 rising to Rs. 3,000 a month, or say £2,700 a year. It is not surprising, therefore, that competition is very keen for entry to the I.S.E. Those who fail to enter this service, but gain appointment in their provincial service as Assistant Engineers, start on a salary of Rs. 250 a month, rising to Rs. 750 a month, but they are not debarred from selection later to the higher service. Pensions are given on a fairly liberal scale, but candidates recruited in India for the I.S.E. are not eligible for the additional 'Overseas Pay' and passage concessions given to men from Great Britain as a set off against the expenses of leave out of India and the education of children in England.

The former Upper and Lower Subordinate classes of the Thomason College were abolished a few years ago, and the Overseer Class was substituted, with a scope and standard of instruction between those of the abolished classes. The Overseer Class offers a good course to men wishing to qualify as subordinates. Many of the more successful students in this class are taken into the Subordinate Engineering Service of the Provincial Government after a suitable apprenticeship. In this service the scale of pay rises from Rs. 80 to Rs. 227 a month, but men are eligible for selection to the Provincial Engineering Service if particularly brilliant. Overseer Class students who fail to get permanent Government appointments often get temporary ones, or service with Indian States or private firms. As in the Civil Engineer Class, certain educational and other

The Thomason College.

COLONEL MACLAGAN, R.E.
(The First Principal, 1847-60).

The Thomason College

The Quadrangle.

The Main Corridor.

The Quadrangle

qualifications are required before a man can appear for the entrance examination for the Overseer Class at Roorkee. Forty vacancies are offered each year, and 250 candidates sat for them in June, 1925. The course is of only 2 years' duration, and much lower in scope and standard than the Civil Engineer Class course, the training being of a less theoretical nature.

The Draftsman Class is of a lower standard again and entirely specialized. A certain number of men are admitted to it annually (about half a dozen) after an elementary examination. There is no limit to the time they spend at the College learning draftsmanship, and they are given certificates when passed as proficient. They work under a special Indian instructor, and pay no fees. Usually the whole Draftsman Class does not exceed about 20 men.

There is no all-India Engineering College to take the place of Cooper's Hill, which was closed many years ago in England. The Thomason College is a provincial institution under the control of, and belonging to, the Government of the United Provinces, but it takes students from certain other parts of India, particularly the Punjab, on special terms, and trains them mainly for Government service, which offers the best prospects at present for the ambitious young engineer. The sons of residents of the United Provinces are given certain concessions at Roorkee, such as scholarships and training at Government expense (except for a small monthly College fee) which other students do not get. Many Punjabi students gain entrance to the Civil Engineer Class, and the Punjab Government pays the cost of training of the first ten Punjabis on the list (about Rs. 10,000 per student for the complete course), but other students domiciled outside the United Provinces have usually to meet this expense themselves. The United Provinces' students of this Class pay an educational College fee of only Rs. 24 per mensem during each session, and Rs. 40 for their final examination, so that the training is far cheaper in their case than that of any University in England. There are, of course, other expenses such as recreation and club subscriptions, and messing for European students, but the United Provinces' Government is liberal in scholarships to its own students and the Punjab Government gives some scholarships to Punjabi students. In addition, all the Civil Engineer Class students are eligible to compete for certain valuable prizes, the top man receiving a prize of Rs. 1,000 on passing out.

Most of the Civil Engineer Class students at the Thomason College are Indians. Nowadays, out of the 90 students of that class, about 70 are Hindus and 10 are Mohammedans, while the remaining 10 may be Europeans. The Indians come almost entirely from the Indian universities such as Allahabad, Lucknow, Aligarh, or the Punjab University at Lahore, and many have already got degrees in Arts or Science before entry at Roorkee. They are thus, as a rule, two or three years older than the European students, who come direct from the few European schools in the hills at Naini Tal, Mussoorie and Simla. The Europeans have not generally the same mathematical and scientific knowledge before entry which the Indians possess, and this accounts partly for the small number now gaining entry to the college in open competition.

The engineering training given at Roorkee is more theoretical than it was a few years ago, and follows more closely the systems adopted in the engineering colleges of British universities, but it still remains, especially in Surveying, rather more practical in nature than the British training, except perhaps in Mechanical and Electrical Engineering. The immediate needs of a country must necessarily dictate to some extent the nature of the training to be given to engineers intended for that country. Machinery, in Great Britain, takes the place of the cheap manual labour of India, hence special training in Mechanical Engineering is more important in these days to the civil engineer in England than to one who will probably remain in India. Mechanical and Electrical Engineering, however, are by no means neglected in the Roorkee course, but form an important part of it. They are likely to take a more prominent place in future years, as machinery gradually replaces manual labour. On the other hand, practical Surveying is more important to the civil engineer in India than in England where trained Surveyors are always procurable. Hence the extra time and attention devoted at Roorkee to Surveying, which find their counterpart in the more advanced instruction in Mechanical and Electrical work in Great Britain. The student from Roorkee has a splendid reputation in Surveying, founded on the fact that he is a trained *practical* surveyor before he leaves the College, where he has been accustomed to use the very latest patterns of tacheometric levels and theodolites, not working in a squad as in England but alone in the field or with only one companion. For the use of the 3rd Year students the Thomason College has now 33 of the latest pattern of Cooke's levels, each instrument being identical and thus allowing of competitive work on equal terms. The Professor of Surveying and Drawing is an ex-officer of the Survey of India Department, and an expert in the design of instruments, with 17 years' experience at the College.

The senior staff of the Thomason College, as authorised at present, consists of a Principal, 7 Professors, and 2 Assistant Professors. Three Professors are authorised for the Civil Engineering Department, one for surveying and drawing, one for pure and applied mathematics, one for electrical engineering and physics, and one for chemistry, geology and mineralogy. The Assistant Professorships are in mechanical engineering, and surveying and drawing. Some of these posts are vacant at the moment. The senior staff includes both Europeans and Indians, as also does the Lecturer staff. Some changes in the number and allotment of Professorships and Assistant Professorships are under consideration. Each Professor is in sole charge of his Department, or sub-Department, but the College Board of Studies offers opportunities for the meeting of the whole senior staff to discuss any educational matters. There are now 10 Lecturers, Indian and European, working under the orders of the various Professors in the instruction of the Civil Engineer Class, and, for the Overseer Class, a staff of 6 Indian Instructors. In addition there is the staff of the College Press and Photo-Mechanical Department (a Government concern, run on a commercial basis and employing trained and paid workmen), a staff of foremen and mechanics for the College workshops and electrical installation, a clerical establishment for the College office, a Librarian for the library of 29,000 volumes, and a Personal Assistant in charge of the buildings, grounds, and servants.

The College has its own dairy, mineral water factory, stores, and hospital, and an electrical supply system giving current for various motors and for electric lights and fans in the main building and the Principal's bungalow. The drinking water comes from enclosed wells whence it is pumped direct by electrical power into overhead reservoirs, while water for other purposes is obtained from the Ganges canal through a separate pipe system. All the students live in hostels grouped in rear of the College, and each student of the Civil Engineer Class has a room to himself, supplied with Government furniture. Most of the staff have detached bungalows with large gardens. In fact the institution is absolutely self-contained, as is required by its situation 500 miles from Allahabad whence it is controlled. It is entirely under the civil administration, and the Principal corresponds only with the Director of Public Instruction and the Educational Secretary, who in turn work under the Minister of Education and Industries of the United Provinces. Till 1924 there was a class of British N.C.O's. under training to become Subordinates in the Military Works Services, but that class no longer exists, and the College now caters almost entirely for the Public Works Department (Irrigation or Buildings and Roads branches) and for the Indian Railways and some Indian States, though the training is designed for utility in any engineering appointment.

The students are encouraged to take part in all recreations, games, and sports. For social purposes there is an Indian Engineer Class Club where all the Indian students of that class can meet to enjoy a game of billiards or read the papers, while the European students have a mess run on lines identical with those of a military officers' mess. The Indian students make their own arrangements for messing according to their castes or religions. Athletic Sports are held annually in December, and a Regatta on the Ganges Canal in June. The College has now four 4-oared outrigged sliding-seated boats.

of clinker build, and a number of double-sculling, pair-oared, and single-sculling boats, all from Salter's at Oxford. Tennis is extremely popular, and also racquets and squash racquets. There are ten concrete tennis courts, and an excellent cricket field where matches are played in the cold weather. Hockey and football are played also, but the latter is not very popular. All the European students, and most of the Indians, are now enrolled as soldiers, either in the Indian Auxiliary Force (Europeans) or the Allahabad University Training Corps (Indians), and form creditable, if small, units. In January each year the College takes on the K.G.O. Bengal Sappers and Miners in an 'Olympic Contest' for a challenge cup, the events being cricket, football, hockey, tennis, racquets, squash racquets, rifle shooting, golf, billiards and chess, and a very keen competition generally results, the College having the greater number of wins up to date. Every endeavour is made by these means to keep the students well occupied physically throughout their time at Roorkee, both for their health and pleasure and to train them for the arduous life of a civil engineer.

The general trend of modern policy is to make India self-supporting and self-contained. The Thomason College tries to further this policy by supplying northern India with engineers born, educated, and trained in India. Whatever may be the advantages of travel and engineering education in Great Britain, the parents of students in India have to consider the enormous expense of sending their sons to be trained in Great Britain (probably at least £1,500 for a degree in engineering); and the training in civil engineering available at Roorkee, which opens prospects in India equal in all respects to those of men trained abroad, is becoming year by year more popular as shown by the rapidly increasing competition. There should be no reason why this training, given by experts with long experience of India, should not be made more valuable for a student destined probably to make his career in India than that available in Great Britain, and this is the ambition of the staff of the Thomason College.

THE EARLY YEARS OF THE ORDNANCE SURVEY.

(Continued.)

VIII. The Survey of Ireland.

The Seventeenth Century Surveys of Ireland.—The modern Ordnance Survey of Ireland was begun in 1825, but this was by no means the first official survey of the country, even if we restrict the meaning of the word to the measurement of the land and its boundaries and the making of maps from such measurements. Of course, in a certain broad sense, even such an examination into the condition of a country as resulted in the Doomsday Book is a survey, and is so quoted by the Select Committee of 1824. But in the seventeenth century the obvious convenience of making maps to illustrate such an investigation was fully realised, and we find that Strafford, who was Lord Deputy of Ireland from 1633 to 1639, caused maps to be attached to his surveys of Tipperary and other countries. In a report on the Strafford survey of Tipperary made to the Comissioners of the Commonwealth, it is stated :—

"We have perused certain small books bound up in parchment . . . on the outside of which books are set down . . . the names of the parishes respectively belonging to that baroney. In the inside of the books, before every parish, are set down the names of the jurors, being generally six in number, and underneath the said names, this memorandum within, that they being all duly sworn upon the holy Evangelists, have set forth the bounds and meares, names and by-names, of all the quarters, plow-lands, and other denominations of lands lying in the parish, together with all the owners and proprietors of the said lands. . . In the next place is sett downe the names of the surveyors who admeasured the said parish . . . the method and proceeding in the description of every parish is as followeth :—

1st The number of surrounds made by the instruments, in each parish respectively. . .

2nd A description of each surround, more particular, according to the name of the land so surrounded ; the quality of the said land. . .

3rd At the end of each surround is an observation made of what castles, houses, mills or other edifices, as also what offices or other emoluments were found upon it.

"We further humbly certifie that, besides the sayd bookes, wee find a very fair county map, containing the several barronyes . . as also smaller maps of particular barronyes, and of particular parishes, most of which, soe far as we can discover, are very entire and perfect. The said plotts or maps expressing also the quality of the said land, whether arable, pasture or meadow, etc."*

* Quoted in Portlock's *Memoir of General Colby.*

Seventeenth century mapping work was fairly accurate when the area mapped was not very large. A seventeenth century parish survey would not differ much from a modern exact survey. The surveyors of that age were well accustomed to the accurate use of the chain in measurement; they were also acquainted with the uses of plane-table, compass, and circumferentor. The latter instrument had, however, no telescope, and was only provided with "sights"; and, of course, the arcs were not very finely graduated. Given the instruments available, they made as good traverses as we, perhaps, should. But, with such instruments, considerable errors accumulated in the traverses of large areas. There exist many admirable property plans dating from this period; the "platts" or "plotts" of parishes, or small properties, stand comparison with modern plans fairly well. Our ancestors of eight or nine generations ago were by no means as unintelligent as we are sometimes inclined to suppose.

The best known of all the early surveys of Ireland, and the first comprehensive large scale official mapping ever undertaken in the British Isles is the Down Survey.

The Down Survey.—This celebrated survey was undertaken to enable a systematic "plantation," or settlement, of English soldiers and adventurers, to be carried out in Ireland. Such a plantation, detestable as it is from a modern point of view, is a proceeding which history often has to record. In the case of Ireland it was Queen Mary who carried out the first systematic plantation, namely, that of Leix and Offaty; and from this example it is clear that religious differences were not necessarily a primary cause of such a policy. The settlement which necessitated the Down Survey did not take place for about a hundred years after Mary's plantation, and was a sequel to the "Rebellion" of 1641, which largely did take the form of a war of religion. For eight years after this date, Anglicans, Presbyterians and Roman Catholics, adherents of King, or Covenant, or Commonwealth, butchered each other with a ferocity inspired by racial and religious hatred. Then, in 1649, Cromwell came over with his disciplined army, and the rebellion was shortly at an end.

In the year 1653 an Act was passed, under the Commonwealth, for the *Satisfaction of the Adventurers for Lands in Ireland, and of the Arrears due to the Soldiery there, and of other publique Debts.* In the preamble it is stated that:—

"Whereas many well-affected persons, bodies politique and corporate, did subscribe and pay in, upon several Acts and Ordinances of the late Parliament, divers considerable sums of money by way of adventure towards the suppression of the late horrid rebellion in Ireland, which said sums of money were, by the said Acts and Ordinances, appointed to be satisfied by several proportions of the lands of the rebels there, as soon as the said rebellion should be appeased; and whereas also several other great sums of money are grown due, and in arrear unto the officers and soldiers who have been employed in reducing the said rebels, and to sundry other persons either for arrears yet unsatisfied, moneys lent, or provisions or other supplies furnished for the publique service; and whereas by the blessing of God upon the forces of this Commonwealth, the said rebels are subdued, and the said rebellion is appeased and ended, and it is hereby declared to be appeased and ended."

The Act appointed a Committee in London for "the drawing of lots for ascertaining to the said adventurers where their dividends of lands shall be," and a Commission in Ireland to arrange for the distribution of the lands. In the Instructions to the Commissioners full power and authority was given to them to put in execution all the necessary steps for the "exact and perfect survey and admeasurement of all and every the honors, baronies, castles, manors, lands, tenements, and hereditaments forfeited," as also those belonging to the Crown of England or the Church; and a surveyor-general and assistants were to be appointed.

An order was then issued, putting Mr. Worsley, surveyor-general, and Doctor William Petty, jointly in charge of the work: "It hath also been ordered that Benjamin Worsley, Surveyor-General, and Doctor William Petty, should be joyntly authorized and impowered to carry on the said work, and to imploy such fitt and able artists in it as they should think fitt." They were to survey the lands belonging to the rebels,

"in the County of Lowth and the County of Leitrim, and also all the lands, tenements and hereditaments of, or lately belonging to all and every the rebels in any of the baronies within the County of Cork, Kilkenny, Longford, Lowth, Cavan, Monaghan, Ffermanagh, Sligo, and Mayo. . . You are to survey, or cause to be surveyed and admeasured with the instrument, all the lands mentioned . . . You are carefully to survey and admeasure with the instrument the out-meares and bounds of all and every the baronies within the counties mentioned. . . You are to give into the office of the Surveyor-General fair plotts and bookes of survey . . . together with bookes of references answering to the said plotts, in which you are at large to describe the boundes and metes of all the said forfeited townes and lands . . . and to set down what you find observable in them." . .

Doctor William Petty was born in 1623, and was the son of a clothier at Romsey, in Hampshire. In 1652 he was appointed physician to the Army in Ireland, and thus came into touch with the question of the survey of the forfeited lands. Before his arrival in Ireland, and before the appointment of the Commission mentioned above, it would appear that Worsley, the Surveyor-General, had been carrying out some surveys for the purpose. Dr. Petty had a poor opinion of Worsley's methods, and proposed a system of his own, which was accepted. He was given the contract for the operation, and made a fine fortune out of it. The work was, considering the methods and instruments available, admirably carried out, and in a short space of time. The difference between Worsley's scheme and that of Dr. Petty was, briefly, that Worsley worked on the unsound principle of surveying small "surrounds" and fitting them together without adequate checks; whereas Dr. Petty realised the importance of working, as far as possible, downwards, from the whole to the part, and of establishing checks at every stage of the survey. He does not appear to have made use of triangulation, although the method was known at the time, having first been employed by Willebrord Snell, in Holland, in 1617.

Sir Thomas Larcom, in his history of *The Down Survey*, says that:

"Worsley was carrying on the survey for grants and forfeitures . . . but it remained for Dr. Petty to originate the idea of connecting the separate operations into a general survey of the three provinces which were not comprised in the Strafford Survey. His great step was making territorial and natural boundaries the main objects, instead of estate boundaries alone."

Dr. Petty introduced a system of checks into the method of carrying out the surrounds or traverses. He instructed the surveyors,

"by intersections, to determine the true place of all townes, churches, castles, known houses, mills, raths, etc., within each respective surround . . . for the better examining and correcting your works." He also laid down the rule that "the common lines of each barony are to be run together by two distinct measurers at once, their respective servants keeping double reckoning of the chains alsoe." Again, "as often as conveniently you can, you shall protract your large surrounds before you doe the inworke of the same."

Most of the barony maps are on the scale of 160 Irish perches to one inch, or 1.6 inches to one mile. But about a quarter are on the scale of 0.8 inch to one mile, and a few on the 3.2 inch scale. The parish maps, from which the barony maps were reduced, were on the scale of 3.2 inches, or 6.4 inches, to the mile.

With regard to the name *Down Survey*, the work was apparently so called because it was set "down" on paper. The expression is used in both the reports of the Committee on Dr. Petty's proposal issued in 1654. Dr. Petty's surveys were carried out in two parts. The first for the settlement of the Cromwellian soldiery, under an agreement between Worsley and Petty, dated December 11th, 1654, and the second for the settlement of the "adventurers," under an Order in Council of September 3rd, 1656.

Until a few years ago it had been supposed that the most authoritative copies of the original barony maps were preserved in the *Bibliothèque Nationale* at Paris, but the Earl of Kerry has shown that most of the originals exist and that the bulk of them are amongst the papers of the Marquises of Lansdowne.

"The maps were at Lansdowne House in an old chest, where, to all appearances, they had long rested. With them were also found some letters and memoranda which show that they had been in Dublin, in the hands of the first Lord Lansdowne's agent, at the end of the eighteenth century. It seems probable that they were sent over to London after his death, and that they have remained there ever since. There can be little doubt that they form a portion of the original survey maps bequeathed in his will by Sir William Petty, of whom Lord Lansdowne is a lineal descendant."*

More than half of the original Down Survey baronial maps are in the Lansdowne collection; almost all the remainder are in the Public Record and Quit Rent Offices in Dublin. The barony maps were never engraved, but were used in the preparation of county and provincial maps. With regard to the French copies, Lord Kerry writes:—

"As is generally known, there are in the *Bibliothèque Nationale* at Paris two large volumes of these barony maps, which, though long recognised as copies, are important as constituting the only complete set in existence. They comprise all the baronies of Ireland (215), except those of Roscommon, Galway, and parts of Clare and Mayo, which counties having been surveyed under Strafford's administration, and afterwards reserved for the transplanted Irish, were not dealt with in the Down Survey."*

The two volumes of the Down barony maps in the *Bibliothèque Nationale* in Paris have a curious history. They were copies of the original maps, and were, apparently, being sent from Ireland to London to be engraved, when they were captured by the French at sea in 1707 and found their way to the *Bibliothèque Royale.* In 1786 King George III. asked that they might be restored to Ireland, but the French Government refused. They were, however, copied by hand and the copies are now in the Public Record Office. Photozincographic reproductions of these copies were made, in later years, at the Ordnance Survey Office, Southampton, where these reproductions can be purchased.

The Select Committee on the Survey and Valuation of Ireland.—This Committee, which reported on the 21st June, 1824, had specially in view the more equal apportionment of the local burthens collected in Ireland. The Committee reported that there were great variations in the methods of assessing the local taxation, and that the assessment was inequitable because areas and values were inaccurately reckoned. Townlands, ploughlands, gneeves, cartrons, tates, and other denominations of land are

* Proceedings of the Royal Irish Academy. Vol. XXXV., Section C, No. 12, 1920. The Lansdowne Maps of the Down Survey, by the Earl of Kerry.

mentioned; and it is stated that however the names might vary, the evil seemed universally the same, and that the inequalities had continued for a very long period to the year of the report. It was stated, also, that a Select Committee of 1815 had reported in favour of rendering the assessments more equal, by correcting the defects arising from the fixing of the county rate according to the old surveys, calculated on land values altogether out of date.

The report mentions the Down Survey in these terms:—

"The most extensive and valuable survey of Ireland was undertaken by Sir William Petty, under a commission dated December 11th, 1654; it was executed in consideration of a payment of 20s. by the day, and of 1d. an acre for the grantees obtaining possession of the lands. This survey was laid down with the chain, and with wonderful accuracy, considering the period at which it was executed."

It is added that the last official survey (up to 1824), of an extensive nature, made in Ireland, was that of the Forfeited Lands, in the reign of William III; it comprised about two million acres.

The area of Ireland was stated to be about 12 million Irish, or about 20 million English, acres, divided into four provinces, 32 counties, 252 baronies, and 2,400 parishes, with further civil sub-divisions, generally known as townlands. These latter "are the ancient and recognised divisions of the country; they form the basis of the Down Survey; they have long been used" for the assessment of local rates. The Committee, therefore, reported that any new Survey must give the boundaries of the townlands. Major Colby gave evidence that the additional time required to plot the townland boundaries on the map would not be very considerable, provided that the boundaries were previously set out on the ground; and Mr. R. Griffith stated that there would not be any great difficulty in ascertaining the boundaries in question. It may be noted that townlands were of very varied sizes, but were most frequently in the neighbourhood of two or three hundred acres.

At this date, 1824, the materials available for assessment were: The Down Survey and the Strafford Survey of the seventeenth century, with some modern surveys in a few cases. No doubt the modern survey of Roscommon, executed by Mr. W. Edgeworth and Mr. R. Griffith was a good one of its kind, but such surveys were few and far between. As to the seventeenth century surveys, not only did they lack the precision to be expected from modern work, but the assessments based upon the ancient values of the land were often very inequitable. The Chairman of the Committee, Mr. Spring Rice, said that, as regards the County of Limerick, where he resided, the contents of the rating book were based upon ancient estimates, which did not agree entirely either with the Down Survey or with any other authority which he knew to be in existence. He also said that there was a general feeling in favour of the old established boundaries, namely, those of baronies, parishes and townlands; they had been, in many cases, ascertained by judgments in courts of law, "and they form the foundation of the Down Survey now in existence, and the best document of the kind which can now be referred to in Ireland." He expressed the opinion that there was no remedy for the evils complained of, "except through the means of a new survey and valuation."

Colby's evidence before the Select Committee is valuable, because it shows the general ideas which he had upon the subject of a large scale survey, before he was actually required to organise such an undertaking. He said that he thought they could complete 2,000 square-miles of survey during the first year and an increasing area in subsequent years. In his opinion a scale of six inches to the mile was large enough to show those divisions of land, called townlands, which varied from 50 to 400 acres. It is interesting to note that he had then no knowledge of the Down Survey. He was opposed to officers of Engineers taking any part in the valuation of the land surveyed. He gave evidence that the work would take at least seven years and would require 25 to 30 officers, with five or six surveyors to each officer. We may say, in fact, that, making allowance for labourers and office staff, he seems to have contemplated an establishment of about 400 officers and men. As a fact, he under-estimated both the time and the establishment necessary.

He was not favourable to the idea of employing surveyors temporarily, and he insisted on the whole staff being under efficient control. He would not accept the idea of allowing the boundaries of the townlands to be surveyed by local surveyors and then fitted on to a scientific framework; he stated that he could not construct a map by fitting townland surveys together and he gave evidence that the cheapest, most rapid and most accurate method of making a large-scale map of Ireland would be to create an organisation for the express purpose and to give up any idea of adapting local surveys.

In all these general considerations his advice was undeniably sound, and it was almost immediately acted upon.

A surveyor called Hyett gave some curious evidence. He had been employed under Mudge some years before, on the survey of the detail for the one-inch map of England; and he says that, "the corps of surveyors, of which I was a member, being disbanded, I was appointed professor of military drawing to the Royal Military College, and one of my duties was to instruct the cadets in surveying and sketching." The corps of surveyors and draughtsmen had, thus, ceased to exist before 1824. Hyett gave the remarkable advice that the survey of the detail should precede the triangulation! Fortunately, no one else was of that opinion.

Mr. W. Edgeworth, the celebrated engineer, gave an interesting account of his surveys of the counties of Longford and Roscommon, and also produced specimens of the large-scale maps of Bavaria. These were on the scale of 1 : 5,000, or about 12 inches to the mile, and were based upon primary and secondary triangulations, the filling up of the interior being "completed by a peculiar species of plane-table and in order to do away with the inaccuracies of the common chain, the triangulation is carried down on paper to the most minute corners of fields." The Committee also mentioned the French 1 : 2,500 *cadastre*, which may be said to have commenced in 1803 and was costing about £120,000 a year. This sum frightened the Committee, which stated that "the delay of the work as well as the increase of expense, seem to have been the result of the minuteness of the survey, which extends to every distinct field; a minuteness which, for many reasons, your Committee consider to be unnecessary and inexpedient to be sought for in the proposed Survey of Ireland."

Before the appointment of this Committee, the House of Commons had, in the same year, 1824, voted £5,000 towards the execution of a Trigonometrical Survey of Ireland, and had resolved, "that it is expedient, for the purpose of apportioning more equally the local burthens of Ireland, to provide for a general Survey and Valuation of that part of the United Kingdom." The Committee had now to make definite recommendations.

Recommendations of the Select Committee of 1824.— "Whilst your Committee express their belief that the execution of the survey cannot be placed in better hands than in those of the Ordnance Officers, they cannot but add, that it is expedient to give much greater dispatch to this work than what has occurred in the Trigonometrical Survey of England. That great work, highly creditable as it is to the individuals by whom it is conducted, has already been 33 years in progress, and yet it still wants one-third part of its completion. It ought to be added, however, that the operations of the Ordnance suffered interruption during the war." . . .

"Your Committee perfectly agree with Major Colby that a central and effectual control is indispensable." . . .

"The best scale for effecting the intended Survey appears to your Committee that of six inches to the English mile." . . .

"The new Survey should supersede all local topographical proceedings, whether under the authority of Grand Juries or otherwise."

The Committee also reported that they had considered what should be shown on the maps, and they stated that a survey showing the boundaries of baronies or parishes would not be detailed enough, whereas a "Survey by Fields" would be too expensive and slow. They, therefore, advised the survey of townland boundaries, but not a field to field survey. This restriction was subsequently removed.

After again pointing out the necessity for proceeding as rapidly with the work as would be consistent with accuracy of execution, the Committee concluded :—

"It is not unworthy of remark that all former Surveys of Ireland originated in forfeitures and violent transfers of property; the present has for its object the relief which can be afforded to proprietors and occupiers of land from unequal taxation. . . In that portion of the empire to which it more particularly applies, it cannot but be received as a proof of the disposition of the Legislature to adopt all measures calculated to advance the interests of Ireland."

The Ordnance Survey of Ireland is Begun.—Armed with the authority of Parliament, the Board of Ordnance, under the Duke of Wellington, took immediate steps to commence the 6-inch survey of Ireland. But, already, in 1824, Colby had been over in Ireland, "to acquire a general idea of the country, and to seek a proper place for the measurement of a new base line." For this purpose Colby chose a site in County Londonderry on the eastern shore of Lough Foyle. The base was not measured until 1827-28.

Meanwhile, the triangulation was started. Whilst the trigonometrical work in the south-west of Scotland had been in progress, various hills in Ireland had been marked by signals and were linked up, by intersection, to the Scottish hills. These hill stations extended from the Mourne Mountains in County Down to Malin Head in Donegal, along some hundred-and-fifty miles of the north-east coast of Ireland. Of the hills used, Colby particularly mentions the importance of Divis, near Belfast, "the triangles of which it is the apex cover a space of about one hundred-and-thirty miles in one direction and about eighty miles in the other—no less than two hundred Trigonometrical Points were observed from it." In 1825 an accurate survey was made of the level stretch of ground on which the Lough Foyle base was, later on, measured.

Colby's first report to the Board of Ordnance on the General Survey of Ireland is dated 2nd February, 1826. In this he states that the officers employed on the six-inch survey of Ireland were supplied, in the beginning of the summer of 1825, with trigonometrical distances computed from observations made at the stations in Scotland, in order that no delay in the detail survey might occur. In this report he mentions Drummond's two inventions, namely, the heliostat and the limelight.

"The first is a Solar Reflector so ingeniously contrived that a soldier is capable of directing it with certainty and facility. . . The first [trial] made with the Solar Reflector was on the Divis, to be observed from Knock Layd, a distance of about forty miles. At this distance it was brilliantly seen with the naked eye at a time when the mass of the mountain was barely visible. . . Some notion of the light given by the lamp may be formed from the circumstance of its appearing more brilliant to the naked eye at the distance of upwards of sixty-six miles [from Slieve Snacht in Inishowen] than another lamp placed at a distance of about fifteen miles . . . the latter being of the description commonly used in lighthouses."

"To complete these trials and to furnish the necessary distances for the local Survey, the Officers and Men continued encamped on Mountains from 1,500 to 2,000 feet above the level of the sea, till towards the latter end of November and beginning of December, and much praise is due to them for the willingness with which they endured the personal inconveniences of exposure on those high situations at that inclement season of the year."

Formation of the Survey Companies.—Until the year 1825 most of the manual labour required in the operations of the triangulation had been supplied by detachments of Artillerymen. This employment of soldiers had been fully justified, both on the score of cheapness and on account of the steadiness imparted to the survey by Army discipline. Colby, when faced with the problem of organising the Ordnance Survey of Ireland, was satisfied that he could not do better than employ soldiers, even more freely, in this new extension of the work. He says :—

"When this Survey was proposed, a large portion of the Engineer Corps was unemployed, and I conceived that the whole of the soldiers in the Corps of Sappers had gone through a course of practical geometry, etc., under Colonel Pasley at Chatham. It appeared a regular Military Body might be formed from these sources, who would soon become capable of executing the greater part of the work, and that the deficiencies might readily be supplied as occasion required. The formation of this Military Body from the Corps of Engineers and Sappers during a period of profound peace, when few adequate objects were presented for the exertion of those peculiar talents which fit them for the duties expected in time of war, seemed to me to possess great advantages with regard to the Corps themselves."

Colby is here talking of the two Corps of Officers of the Royal Engineers, and of the men of the Royal Sappers and Miners, then distinct bodies. He goes on to say that :—

"As far as regarded the advancement of the Survey itself, two circumstances seemed in favour of this arrangement ; the one the unity of the system and facility of direction arising from military discipline, and the other the nature of the information already attained by the officers and soldiers. . . By the Military Body the whole of the work will be performed according to regular instructions, and it is probable that every part will be executed with equal accuracy, at least the instructions are so devised that the work itself will afford facilities by which its errors, if any, may readily be detected and traced to their sources. . . After the Military Body has acquired experience it will also have the further advantage of carrying on the work with much greater celerity than it could have been carried on by the hire of Surveyors."

The Duke of Wellington approved of Colby's scheme, and Colby was given a free hand to select officers and men ; his only difficulties with regard to the officers being his want of acquaintance amongst the officers and the smallness of the Corps itself. With regard to the men, it was found that those soldiers of the Corps of Royal Sappers and Miners who could read and write, and had passed through the course of practical geometry at Chatham, proved excellent material for the new companies. But it was also found that so many men had been enlisted in the Corps who could neither read nor write, that the formation of the three companies authorised was delayed. Colby remarks that " the Artillery recruit very much in Scotland and the North of England, where the spread of education is much greater than it is in South Britain. Twenty-four years' experience on the mountains has enabled me to observe that the Artillery are generally intelligent, hard-working men and good, obedient, trustworthy soldiers." This latter remark was made with reference to an idea, not carried out, that the personnel of the Survey Companies might be filled up by transfers of Artillerymen.

Colby gives the following *Chronological View* of the formation of the Survey Companies :—

" 1824. 1. August 28th.—I proposed the first Surveying Company officially.

2. September 22nd.—Surveying Company ordered. [13th Coy. R.E.]

3. November 26th.—First detachment of Surveying Company went to Chatham.

4. December 8th.—Surveying Company complete at Chatham.

1825. 5. March 18th and 31st.— Surveying Company went to Ireland.

6. February 16th.—Second Surveying Company began to assemble at Chatham. [14th Coy. R.E.]

7. July 16th.—Part of Second Surveying Company sent to Ireland. N.B.—The greater part of these were taken to supply the place of the Artillery on the Trigonometrical Survey.

8. December 27th.—Another part of the Second Surveying Company sent to Ireland. N.B.—It is still incomplete. (January 30th, 1826.)

9. September 10th.—Third Surveying Company ordered. [16th Coy. R.E.]

Throughout this period of the formation of the Survey Companies, Colby was in constant correspondence with Col. Pasley, who commanded the School of Military Engineering at Chatham. These two officers were always on excellent terms, and Pasley materially helped in the creation of the new military establishments of the Survey. He wrote to Colby on the 19th February, 1825 :—

"I have received a number of Men, who, I think, will form a very good Nucleus to the 2nd Surveying Company, which will be numbered the 14th. I have to request that a Captain and a First Lieutenant may be named for it as soon as possible. Dalton has exerted himself so much in forming the 13th that I expect that much emulation will arise, and the Duty of Instruction of the 14th Company will be well done, when Officers are appointed. . . . I will do everything to forward the Service of the 14th Company, but the sooner the Permanent Officers join the better."

On the 23rd July, he writes to Colby :—

"I take this opportunity of requesting that you will restore their Arms to the men of the 13th Company. From my experience in the Military Duties of the Corps, I am quite persuaded that the Men of that Company will be ruined as Soldiers, and lose not only their own *Esprit de Corps*, but will be disgraced, or say *completely lowered*, in public estimation' unless their arms be restored to them. . . The 13th and 14th Companies . . . . are each organised military bodies; and if deprived of their arms, I am sure that the evil consequences I prognosticate will follow.',

And again, in August, 1825, Colby having made some objections as to the political capital that might be made out of soldiers under arms being engaged on the work, Pasley replies :—

"Peaceably employed in surveying . . it must be quite impossible for them to come in collision with the People of the Country at all. I sincerely hope that you will take an early opportunity of restoring their Arms."

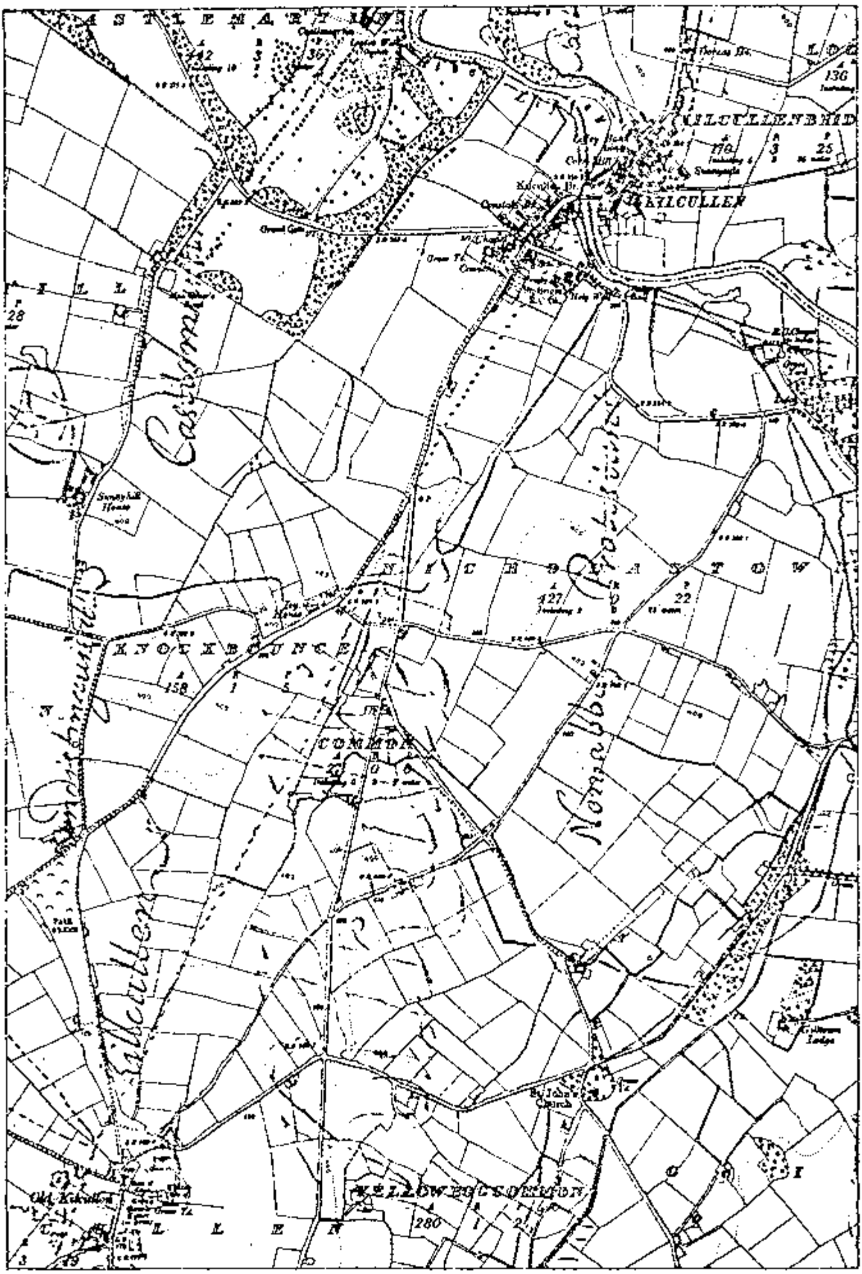
In this controversy it cannot be doubted that Pasley was right and Colby was wrong. Colby seems to have admitted the error; anyway, the men of the Survey Companies have always had their arms like other soldiers.

Some Details of the Administration.—On the 7th April, 1826, the total strength of the Survey establishment was 203, made up of 28 officers, four candidates and cadets, 106 sappers and miners, and 65 labourers. The total expenditure for the year 1825 was £16,218, and for the half-year, January-June, 1826, £9,560. We may say a strength of 200 and an annual cost of about £20,000. The rates of pay were low, "inferior assistants," or labourers, to drag the chain, receiving from 9d. to 2s. a day; the 9d. rate being probably given to boys on probation. There were originally no superior civilian assistants, except one clerk on 2s. 8d., and two draughtsmen on 4s. a day. The officers and sappers received survey pay in addition to regimental pay. The field work was concentrated in the north of Ireland; at the end of 1826 there was a Headquarter Division at Mountjoy, Phœnix Park, Dublin, under Major W. Reid (afterwards Sir William Reid, Governor of Malta); and five survey districts at Belfast, Coleraine, Londonderry, Maghera and Lisburn, under Captains T. F. Lancey, P.

Mountjoy, Phœnix Park, Dublin.
Headquarters of the Ordnance Survey of Ireland, from 1825.

MOUNTJOY PHOENIX PARK, DUBLIN

A portion of the
Down Survey of Co. Kildare 1655.



Scale:- 80 Irish Perches to 1 Inch or 3-2 Inches to 1 English Mile

Over-printed with the modern 6 Inch Map reduced to the same scale

Yule, M. A. Waters, C. Wright, and Lt. English, respectively. J. E. Portlock, who some thirty years later wrote the *Memoir of General Colby*, was among the subalterns. In addition to the officers at Mountjoy and in the five districts, we must reckon those employed on the triangulation—Drummond, Larcom, James and others. There were five Artillery subalterns on the strength of the Survey.

Mountjoy House.—An admirable house was selected as the headquarters of the Ordnance Survey of Ireland. Mountjoy stands in Phoenix Park, in sixteen acres of its own grounds. It is a substantial comfortable house, just the kind of house that one might expect a well-to-do Irish gentleman to have built in the old days. It was, as a fact, built about 1728, by the Rt. Hon. Luke Gardiner, when he was Castleknock Keeper of Phoenix Park. His grandson became Lord Mountjoy, and was killed in the rising of 1798, when Colonel of the Dublin regiment. Musgrave, in his *Rebellions in Ireland* says that Mountjoy "had the gentlest manners, and the mildest affections, warm and sincere in friendship, and so benevolent and humane that he never harboured revenge." It is said that Mountjoy added a theatre to the house in 1778, in which *Macbeth* was acted. At the end of the eighteenth century the house was bought by the Government for the Secretary at War.

By 1812 the house had been turned into a barrack and the land adjoining was known as the Barrack Demesne. In 1825 the Board of Ordnance handed it over to the Ordnance Survey as the headquarters of the Survey of Ireland. Major Reid seems to have lived there; and certainly, in after years, the house was the dwelling place of successive officers, who had, under the Director, charge of the Irish Survey. Only part was used as a dwelling house. The rest was converted into offices for the various indoor operations of the survey; and, year, by year, other buildings grew up round it; barracks for the men, workshops, stores, machine shops, and so on, until it became a very complete establishment. It remained under the Director of the Ordnance Survey of the United Kingdom until 1st April, 1922, when the establishment at Mountjoy, with the rest of the Survey of the Irish Free State, was handed over to the Government of that State. The value of the buildings and machinery was then estimated at about £160,000.

Many an old Ordnance Survey official will retain kindly memories of the big, red house and the survey buildings amongst the trees, the home for a hundred years of much good work and loyal service.

Boundaries.—The chief and original object of the Ordnance Survey of Ireland was the marking exactly on paper the boundaries of counties, baronies, parishes and townlands, and the ascertainment of the areas of these divisions. From the beginning, Colby refused to take any responsibility for the determination of the situation of these boundaries on the ground, only promising to survey them accurately when pointed out. The duty of ascertaining the boundaries of the ground fell to the lot of a Boundary Department, under Mr. Richard Griffith. Colby's early reports are full of complaints as to the way in which the Boundary Department carried out its duties. He says, in February, 1827, that that Department was "in a peculiarly defective state, and a great deal of time was lost through the want of proper Boundary Surveyors"; also, that he "found persons had been appointed as Boundary Surveyors who did not consider the duties they had to perform as of any great importance."

Some of the Meresmen, "being ignorant of the Boundaries, went round with my officers, enquiring of the inhabitants as they went along . . and the boundaries were frequently pointed out wrong"; and again, "it is my virtual dependence on the progress, and correctness, of the Demarcation Department that renders it so extremely difficult for me to calculate the time required for the Survey." But matters improved, and, in February, 1828, Colby reported that, "the Boundary Department, under the direction of the Irish Government, is becoming much more effective, and is now nearly adequate to the present rate of progress of the Ordnance Survey." But it can hardly be said that Colby and Griffith worked altogether amicably together, even after this date. Thus, in a letter written by Griffith to Colby, and dated Sligo, September 26th, 1828, there occurs this passage:—

"According to the Arrangement entered into between the Irish Government and Sir Jas. Smith, I am only to be six months in advance of the Ordnance. Will Capt. Waters undertake to complete the survey of the whole of his present district within six months after November next, if not the arrangement will have been broken through by him, and any casualty among the meresmen or expense incurred by calling back the boundary surveyors from distant parts subsequently to that period must be charged to the Ordnance.

With regard to the allied question of the marking of property boundaries, the principle of the Ordnance Survey has always been to show any features visible on the ground, from which such boundaries may be measured or inferred, but not, except in the case of administrative divisions, to mark ideal, or invisible, lines. In a draft of a memorandum written by Colby about this period, it is stated that:—

"If any boundaries are to be inserted, those boundaries should be first rendered distinctly visible in the country by the erection of well defined marks of a nature sufficiently permanent to be appealed to in case the accuracy of the survey should be hereafter called in question. And if the Ordnance make a faithful representation of what can be seen in the country without inserting invisible boundaries . . . they will perform all that can be required of them."

It is a good, practical rule, not, in general, to show invisible boundaries, and it resulted from this rule that property boundaries, as such, are not shown at all. But since property boundaries depend on fences, walls, hedges and similar visible objects, there is no difficulty in using Ordnance maps as property maps, indeed they are universally used for this purpose; although the hedge or fence may not be the boundary proper, which often, indeed usually, runs a few feet distant from, and parallel to, it.

Colby's Intention with Regard to the Civil Staff.—Colby intended to form a military department, in which all the principal operations out-of-doors, and most of those in the office, would be carried out by soldiers. He contemplated, in addition to the officers and the survey companies, an establishment of labourers to drag the chain and do other work of a purely manual nature; but he had also in view an establishment of a few civilian engravers and some civilian draughtsmen to supplement the military draughtsmen. He complains, in a report written in February, 1828, that when he was necessarily away in England a kind of discretionary power was allowed to the branch office of the Board of Ordnance in Ireland, and that things were done in his absence of which he disapproved. He says,

"If no such Board [the Irish branch] existed, I feel convinced that the Irish Survey would not have been suddenly overwhelmed in the winter of 1826-27 with an influx of uninstructed civilians. And the disorganization and expense attendant on that violent local measure would have been saved. When I visited the Districts in October, 1826, it was observed to me that draughtsmen were wanted, and I certainly did desire the District Officer to look out for a few men who could assist in drawing. But how was this want supplied? Advertisements were put in all papers, unknown to me, and a great many persons were engaged who had everything to learn. . . That this measure, so far as it produced for the Survey a few Civil Draughtsmen, was beneficial there can be no doubt, but thus far it was my intention from the very commencement of the Survey to adopt it."

The Royal Sappers and Miners.—In the same report Colby writes:—

"On the whole the Royal Sappers and Miners have proved a highly efficient force, and it is much to be regretted that they are not more immediately identified with their Officers by being called Engineers instead of Sappers, etc. They are deprived of the encouragement of being mentioned in Public Despatches by having no officers of the same name. And it cannot be doubted but the means of obtaining good recruits is greatly diminished by this apparently trivial circumstance of having to bear a long and obscure name which has no reference to the greater part of their duties.

Pasley says in a letter to Colby :—

"The different name has been and is the greatest possible impediment to the Recruiting of the Corps. In fact it deters the men most qualified for our Service from entering it. I wish to God, that vile *labour-like* name could be abolished."

The change of name advocated by Colby, and even earlier by Pasley, was not sanctioned until 1856. In the *London Gazette* for the 17th October, in that year, appeared the following notification :—

"The Queen has been graciously pleased to direct, that the corps of royal sappers and miners shall henceforward be denominated the corps of royal engineers, and form one body with the existing corps of royal engineers."*

The Lough Foyle Base, 1827-28.—As we have seen, bases, in the early operations of the Survey, were measured with wooden rods, or glass tubes, or steel chains. It now became necessary for Colby to consider how he should measure a base in Ireland; for it was certain that a new base was required, not only on account of the distance of the Irish work from any of the previously measured bases, but also because it was desirable to stiffen the old triangulation and to attempt a higher degree of precision.

In 1825 Colby hit upon the idea of compensation bars; the reason for adopting such a contrivance being that, in the measurement of a length with a metal chain or bar, an ever-present difficulty is the impossibility of ascertaining accurately what the temperature of the metal is. Colby, therefore, thought that the principle of compensation, which had long been in use in the construction of clocks, might be applied to the measurement of bases. As worked out by Colby and Drummond the base apparatus was thus designed.

Two bars, one of brass and one of iron, were laid parallel and close to each other. The bars were firmly connected at the centre, and were free to expand or contract from, or to, this point. Now, approximately, at ordinary temperatures, brass will expand .00001 of its length for every increase of 1° F.; and, similarly, iron will expand .0000065 of its length; so that the expansion of brass to iron is approximately as 100 to 65. If then, the ends of the bars are firmly connected by metal tongues, fixed to the bars by pivots, so as to allow the bar to expand, there will be a point on each tongue which does not move with reference to the central points of the bars. The immovable point will be about 100 units from the centre line of the brass bar, and 65 units from the centre line of the iron bar, the actual distances depending upon the space between the centre lines of the bars.

* *History of the Royal Sappers and Miners*, by T. W. J. Connolly, Vol. II., p. 492.

Each bar of brass, and of iron, was 10 feet $1\frac{1}{2}$ inches long, $\frac{1}{2}$ inch broad and $1\frac{1}{2}$ inches deep, and the bars were placed $1\frac{1}{8}$ inch apart, and firmly connected at their centres. The metal tongues connecting the ends were about 6 inches long, and on a silver pin at the extremity of each, was marked the compensation point. With the figures given, it will be seen that the compensation point was about 3 inches outside the iron bar.

There were six of these compound bars; in the field they were placed on trestles, with elaborate arrangements for aligning and levelling. The bars were placed end to end, but not touching, and the distances between the compensation points were fixed by two microscopes attached to the cases which held the bars; the two microscopes lying parallel to each other and connected together in such a manner that the outer foci of their object glasses were compensated points exactly six inches apart.

The authoritative account of this apparatus, and of the measurement of Lough Foyle Base, and of the many experiments necessary to determine the expansions of the metals and the positions of the compensation points, and of the calculations for the definitive value of the length of the base itself, will be found in *An account of the Measurement of the Lough Foyle Base*, by Captain William Yolland, R.E. This account was not published until 1847, about 20 years after the measurement was made, and just at the time that Colby was retiring from the Survey. The lateness of the publication of this account is evidence of the reluctance which was, apparently, always felt by Colby to publish anything connected with the work; and this reluctance may have been partly due to his remembrance of the refusal of the Board of Ordnance in Mudge's time, in 1811, to publish any more reports of the work of the Trigonometrical Survey.

The Measurement.—The officers employed upon the measurement of the Lough Foyle Base were Lt.-Col. Colby, Captain Pringle, and Lieutenants Drummond, Henderson, Murphy and Mould, all of the Royal Engineers. About half the soldiers working under them were Artillerymen, and about half Sappers and Miners; the largest number employed at any one time (in October, 1827) consisting of 27 Artillerymen, 25 Sappers and three civilian labourers.

The site selected by Colby was a stretch of ground along the eastern shore of Lough Foyle, at an average height of 18 feet above mean sea level. The chief difficulty to be contended with was the crossing of the River Roe at about the middle of the line. The length was nearly eight miles. Drummond writes on the 24th June, 1827:—" The encampment is by the side of Mr. Gage's park wall, near the Roe."

The actual measurement began on the 6th September, 1827;

this was continued until the 25th October. Work was resumed on the 7th July, 1828; continued until the 25th of the same month, when it was suspended to avoid damage to the crops. It was again resumed on the 13th September and completed on the 20th November, 1828. The number of days spent in measuring was 95, and the average daily progress was about 460 feet. Sir John Herschel and Babbage visited the work, and the former made a sketch showing the method of measurement.

The Standards of Length.—Two new standard wrought iron bars were made by Messrs. Troughton and Simms in 1826-27. These bars still exist, and are 10 feet long between the measuring dots. Each bar is 1.45 inches broad and 2.5 inches deep. The distance of 10 feet was marked when each bar was at a temperature of 62° F. These bars are known as O_1 and O_2; O_1 was sent to Lough Foyle to enable comparisons to be made with it; and O_2 was retained in the Tower of London, in case any accident might happen to the first bar.

Yolland quotes no fewer than eleven other bars and scales which, up to 1846, had been used as standards in Great Britain, and had been compared by the Ordnance Survey. These include Bird's Standard Yard of 1760, which was destroyed in the fire which consumed the Houses of Parliament; the Indian 10 feet iron standard bar B, the Cape 10 feet iron standard bar B, Roy's brass scale, Ramsden's 20 feet triangular iron bar, Simms' 10 feet iron bar, and others.

Accuracy of the Base.—The length of the Lough Foyle Base, in terms of feet of O_1, was found to be 41640.8873 feet. This base has never been re-measured, so that there is no direct test of its accuracy. But an indirect test exists. The net-work of the Principal Triangulation connects the Lough Foyle Base with the Salisbury Plain Base, which was measured in 1849 with the same apparatus. If we assume that the latter base is errorless, the length of the former base, calculated through the triangulation, differs from the measured length by 5 inches. Clarke, in his reduction of 1858, took the errors of these bases to be inversely as the square roots of their lengths, and the discrepancy of the measured, as compared with the calculated value, of the Lough Foyle Base is, then, about 2½ inches.

On the lengths of these two admirable bases, given in feet of the bar O_1, depend all Ordnance Survey measurements to this day.

Some Letters about the Base.—Capt. Pringle to Colby, Trig. Survey Camp, Magilligan, 13th September, 1827:—

"The severe gale which we experienced on Sunday morning and which is represented by the residents on the plain as what may be frequently expected to occur in the course of the Autumn, has convinced me and the Officers employed on this duty of the expediency, or rather, necessity of being enabled to augment the night guard. . . The guard cannot be trusted to the civil labourers whom we can hire for day work. . . . The Artillerymen here have conducted themselves with the greatest regularity and are particularly fit for the duties required."

In another letter he asks for a corporal or sergeant and 8 or 12 Artillerymen.

" For as the season advances storms will be frequent." " Drummond and Murphy were out at six this morning, Henderson and I relieved them at eight, but still only two moves . . . 12 or 15 Artillerymen would be only so many shillings a day."

Magilligan Camp, 3rd July, 1828 :—

" The Detachment of Artillery, 13 men, have just arrived. . . . Corporal Young and the other men who were with us last year have not arrived. Pray order them without delay . . otherwise we shall have all the annoyance and delays of teaching to repeat. Lieut. Murphy we have heard nothing of, and are anxious about him. Lieut. Henderson writes he is to be here on Sunday, and Capt. Waters that Lieut. Mould is to come when he has finished his station. Lieut. Drummond has finished all the comparisons and made the adjustments, and has also set up marks on the line, so we are quite ready to commence when two more Officers join. . . You took . . a memorandum to order another Smith from the party in the hills, which I hope you have done, as we shall have a great deal of Smith's work.

" We have been examining the Roe and considering the easiest mode to measure across it. Driving piles appears on the whole the best, so I shall order piles, etc., from Derry. We are experimenting with a frame filled with sand bags, or stones." . . . .

On the 16th July, 1828 :—

" We now hope to pass the Roe the end of this week. We have been pushing very hard to do so, commencing at 3 a.m., as the tides will answer best—being high water at mid-day. . . There is only about a quarter mile beyond the Roe until we come to continued crops. . . I have been too busy to think of the Geological Memoranda."

26th July, 1828 :—

" Lieuts. Henderson and Drummond have been advocating the policy of buying the Crops—this season is, no doubt, the most advantageous for measuring, morning and evening. But I think the appearance of what would be judged unnecessary damage, is much against it. . . . The men are employed now in drawing up the piles in the Roe. . . The party of Artillery . . will march for Charlemont on Tuesday. . . P.S.—Sergeant Sim has come to tell me that the men would rather remain here even without pay than go to Charlemont and [I] propose to retain them on half-pay /6, if we commence in six weeks."

In a letter to the Board of Ordnance written in February, 1828, with reference to the possible employment of Captain Pringle on temporary duty in Canada, Colby asks that he may not "be deprived of the services of that excellent officer" beyond the period which might be necessary.

From Lieut. Hastings Murphy, R.E., to Colby, Magilligan Camp, 18th July, 1828 :—

"I left my calculations, etc., with Portlock. . . Portlock was very well and in good spirits, but had seen nothing to the South, except Ardan Erin. . . I remained with them about four hours on Friday and pushed on to Enniskillen, and here next night. We are getting on famously, having last night reached the Roe; if this day were not so very windy we should be across this evening. We have been at work about 16 hours a day."

Murphy to Colby, Ballykelly Camp, 12th November, 1828 :—

"I hasten to reply to your kind enquiries after our friend Drummond. I have just been to see him in his comfortable quarters at the Glebe, and am happy to say he is doing very well, having sat up to-day for three hours and eaten part of a chicken. . . Certainly he gains strength every hour compared with the extreme state of debility to which he had been reduced by fever, bleeding (30 ounces at once), medicines, etc., etc. . . Dr. Dice, of Newtown, has been his physician . . and bled him very freely at first, and said it saved him from a bad typhus or rheumatic fever or both."

The writer of these two letters, Lieut. Murphy, did much excellent work on the Ordnance Survey, not only in the measurement of the Lough Foyle Base, but also in the observation of angles on Divis, and at other stations, and in the comparison of standards. He left the Survey in 1834 to accompany Colonel Chesney's expedition, which was to examine into the possibility of establishing communication with India by way of the Euphrates. He died at Bussora in July of that year.

DAM CONSTRUCTION IN TIDAL CREEKS.

(Continued.)

By MAJOR E. ST. G. KIRKE, D.S.O., R.E.

IN the December issue of 1923, an article under the above title was published in this Journal describing the construction of two monolithic concrete dams near Shoeburyness, both of which were built upon open foundations by direct labour.

These dams, marked C and D on sketch map, were part of a scheme to reclaim New England Island (which the sea broke into 28 years ago) with the object of making a reinforced concrete road direct from the mainland to Foulness Island. The latter is a War Department estate, and hitherto the only access to it was by boat, or along the "Broomway," a track over the sands, available at low tide. This use of the sands was a constant source of interference with the Artillery Ranges.

Two views of the reclaimed island will be found in Photos 11 and 12, before and after reclamation. The trestle bridge, which is shown in them had to be made for the conveyance of man and materials on to Foulness. It is 2,000-ft. long, and has been the innocent cause of the purchase of two or three hundred bicycles by the islanders, many of whom had never previously visited the mainland.

A third dam has now been constructed, known as "B" dam, upon subaqueous foundations, which were rendered necessary by the fact that the tide never entirely receded from the site. The essential difference between the construction of dams in creeks, and those to control rivers, was well illustrated in the case of this dam. This difference lies in the fact that the former are exposed during construction to the full attack of the sea twice every twenty-four hours; whereas the latter are not fully stressed until months after the work is complete.

In the previous article the considerations governing the design of the various dams were given, but it may perhaps be as well to give a short summary of them.

In the case of "C" and "D" dams the tide could fall away on the sea side down to the levels of 2.66 and 4.3-ft. above Ordnance Datum respectively, and drain away altogether towards the river Crouch on the land side. The above, therefore, were the maximum heights to which the dams could impound water between themselves and the "Broomway." These dams could thus be raised, course by course, to the requisite height.

New England Island was flooded completely at spring tides to a depth of four feet, by water entering the creek from the Crouch, and thus formed a reservoir of very great extent. The problem at "B" dam, therefore, resolved itself into making provision for shutting out the sea on one tide. Had it been raised course by course like the other two dams, it would have impounded this water. Another consideration was the possibility of a "freak" tide occurring, two feet higher than high springs. These exceptional tides are caused by strong N.N.W. winds in the North Sea, S.W. gales in the Channel, heavy rainfall in the Thames Valley, or easterly gales occurring at full moon. It was a tide of this kind which originally broke into the island in 1897, since when it has remained derelict, and a similar tide occurred a couple of years ago, rising to a level of 14.3-ft. above O.D.

Very much higher levels than this have been recorded further up the Thames, owing to the water being banked up as the width of the river decreases, and in 1876-77 three tides rose to 16.75-ft., flooding large districts around London. In the Medway, too, heights of nearly 16-ft. above O.D. have been recorded at Rochester Bridge.

So far as "B" dam was concerned, a tide of 14 feet would have taken the dam in reverse, if it occurred before the broken sea-walls of New England were raised to full height, 15.5-ft. It was, therefore, necessary to leave the water a way of escape, until the walls were repaired.

DESIGN.

The extent to which the waterway in these creeks could be restricted without rapid scour taking place (in the absence of heavy stone or chalk pitching) was found to be about half the original area, and this governed the amount which had to be left open until the time for closing it permanently arrived.

Several methods of closing the waterway suggested themselves, such as lock gates; sluice gates sliding in vertical grooves; or wooden shutters hinged at the top, on the principle of the ordinary tidal flap valve, but propped open until required. Of these, the lock gates would require heavy piers to carry them, owing to the lateral thrust imposed; the gates sliding in vertical grooves would require elaborate operating gear; whereas the flap shutters, while probably not so watertight, would open of themselves, should an exceptional tide take them in reverse. Further, they were the cheapest, and half the weight of corresponding lock gates with their heavy hinge-posts, mitre-posts, and waling.

The piers to carry the flaps could either be of reinforced concrete, or steel structures of suitable design. The latter would have been quicker to erect, but the greater weight and stability of the former decided in their favour.

The foundations for the piers raised several interesting points. To enable work to be carried on every day it was desirable for them to be above low water level on neap tides, *i.e.*, about —2.5-ft. O.D. On the other hand, it was not possible to block up so much of the tide-way, while piling was in hand, without excessive scour taking place. The level —3.5-ft. was fixed upon as a compromise.

A curtain wall of sheet piling was essential to prevent underscour or infiltration, and use was made of 8-in. "Simplex" interlocking piles which had been bought for the original scheme for damming the creeks, referred to in the previous article. (This was to shut the sea out by a wall of piles so that an earthen dam could be built behind it. Its disadvantages were discussed.)

A second curtain of piles was driven on the inner side of the dam, so as to protect the foundations from scour during construction, and as an additional safeguard against infiltration.

Considerations of space have prevented a section of this design being given, but the pile line shown in Figs. 13 and 14, driven down to 19.5 ft. below O.D. is the front pile line of the first design.

Aerial Cableway.

For carrying the hammer to drive these piles across the creek, an ordinary gantry was discarded in favour of an aerial cableway, owing to the latter being so much quicker to erect. This cableway appears in most of the photographs. The legs of the shears supporting it were of 10-in. x 10-in. pine, 50-ft. long, bolted together at the top and rigidly connected at the bottom, so that they could be traversed laterally across the site of the dam. This method was safer than the usual luffing gear, having regard to the unskilled nature of the labour employed.

Two 3-in. steel cables were used to span the creek, in place of one of larger circumference, as they were in stock. They had a breaking strain of 18 tons each. At the top of the shears they ran over a cast iron bearing plate and were anchored to 18-in. x 18-in. timbers, 12-ft. long, buried 8-ft. into the ground. They were adjusted by two differential tackles on the Havengore end, so that a three-ton load would cause no more than a nine-ton strain in the two cables, giving a factor of safety of four.

Hoisting was done by a 2-in. steel cable running over the drum of a 2-ton petrol winch. This was also arranged to do the travelling in one direction, the other being worked by a hand winch on the far bank when slow speeds were required, and by a winding engine on the barge for running out stone and ballast.

Pile Driving.

Photo 1 shows the hammer resting on the pile which it is driving, and the ripple on the water indicates the pile line already driven between the barge and the piles appearing in the foreground. To minimise the loss of time caused by the tide rising, each pile was driven only so far as would allow of the next one being interlocked, which again was driven so as to remain six inches above water. All such piles partially driven were finished off as the tide receded.

The back line was driven first, so that the waterfall which it would cause in the ebb tide would wash out the mud from the site of the foundations. The water cushion formed by the impounded water prevented similar action taking place on flood tides.

The hammer used at first was a " No. 5 McKiernan-Terry Patent Double-acting Automatic Pile Hammer," supplied by the British Steel Piling Company, weighing 1,500-lbs. This would under normal circumstances drive two 8-in. " Simplex " piles at a time, with a delivery of about 300 blows per minute. In this instance, however, the accumulations of oyster shells in the creek offered such resistance that it sometimes failed to drive home even one; instead, crippling the head of the pile. For this reason 12-ft. piles were put into the back line, while a heavier hammer was obtained on hire from the same firm to drive the front line and the piles round the sluice pipe. This was a " No. 6 " weighing 2,900-lbs. and delivering about 200 blows a minute, which could drive three piles at a time most of the way. It nearly always succeeded in smashing a way for single piles through the oyster shells, but failed on a few occasions, and the piles were then levelled off with an oxy-acetylene cutter.

Steam for the hammer was provided by a boiler on the barge, which was kindly lent by the Royal Artillery. The maximum number of piles driven in the few hours allowed by the tide in one day was forty. Working at this speed, however, made it difficult to keep a really straight line, which was hard enough in any case when working from a swinging aerial, with a strong tide running in alternate directions. The wind, too, was frequently boisterous enough to move even the heavier hammer a couple of feet off the line. Another disadvantage of working from an aerial is that the hammer cannot develop its full blow, since a portion of its weight must be sacrificed in keeping it vertical. This must be set off against the extra speed of bringing it into action from an aerial instead of from a piling frame on a gantry.

The steam pressure used was 80-lbs. on the boiler, but 100-lbs. is recommended when the rest of the outfit will stand it.

The policy of keeping the pile line down to —3.5-ft. O.D. was amply vindicated as the far bank was approached. Even at this level the scour round the end kept pace with the pile-driving for a couple of days. However, by interlocking several piles above water level and driving down the shutter thus formed during neaps, and at half tide when the rush of water somewhat relaxed, the line was made good from bank to bank. If the line had been a foot higher, it is doubtful whether this would have been possible without recourse to chalk pitching. Chalk would have taken at least a fortnight to obtain and the sea would have had the extra time in which to develop a scour.

Both front and back pile lines were taken half way up each bank, where drop-walls could easily be excavated in the clay.

In the front pile line were incorporated special holed piles through which passed the bottom members of the reinforcing frames for the piers. To fix the frames rigidly into the piles, steel wedges were driven hard in with a 7-lb. hammer. These wedges also permitted slight adjustments in level. In addition, 1½-in. steel pins were driven through the bottom member outside the pile lines. This was the simplest way of fixing the reinforcement to the pile line, so as to prevent the piers overturning when the flaps were closed, but contained elements of weakness as will be seen later on. Single holed piles were driven in at 11-ft. intervals, as near the back lines as possible, to fix the back of the frames before they were embedded in the concrete floor. (It may be mentioned that 11-ft. intervals admitted the largest flaps which could conveniently be constructed and handled on the aerial.)

Four special tapered piles had to be put into the front line to correct for vertical, as the piles gradually inclined sideways towards the far bank owing to their free end offering less resistance to driving than that interlocked. These tapered piles were four inches wider at the bottom than at the top, and were made by cutting and riveting together two ordinary piles.

Pile-driving was carried on between 25th September, 1922, and 26th November, 1922, and again between 6th January, 1923, and 28th March, 1923. During these periods 1,003 piles were driven by 14 men, including the Military Foreman of Works, in 84 working days. The cost of driving both pile lines was somewhat less than an estimate received from a contractor for driving one, namely, £700.

Sluice Valve.

The 42-in. sluice for carrying off rainwater was placed at the Havengore end for convenience in construction and subsequent operation when the dam was completed. Two extra pile lines were driven underneath it as an additional safeguard against infiltration. A few X-piles were added in case it proved necessary to connect up further lines. The centre line of the sluice was placed slightly off the right angle, to lead the water draining out away from the bank.

With the pile-lines completed, it was possible to start on the foundations proper, and to put the sluice pipe into position. To convey concrete to the latter from the mixers, a narrow-gauge (2-ft.) line was run out over the sea-wall and supported on piers made of one yard cube concrete blocks. These blocks were taken out on the aerial and the piers placed at 15-ft. centres.

The piles in front of the flap-valve were driven down nearly to low water level, so that the compartment prepared for the foundations of the sluice would drain itself without pumping. The piles were not sufficiently watertight at this stage for the available pumps to keep the water down. This was primarily due to some of them not being long enough to be driven sufficiently far below a scour which had been caused by the steam barge remaining too long in one position during the early days of pile driving.

When the first length of pipe had been concreted in and the flap valve attached, the latter kept the water out and allowed an appreciably longer time for fixing the remainder before the rising tide stopped work.

The back line of piles opposite the sluice pipe was cut out by oxy-acetylene after the pipes had been concreted in. A clay cofferdam was built behind this section of piles, so that water could be pumped out while the cutting was in progress. This was cheaper than hiring the heavier hammer, for another fortnight, to drive the piles down to the level of the invert.

FOUNDATIONS.

The general plan for making the subaqueous foundations was to fill up the space between the two pile-lines with ragstone and ballast to a level of —4.5-ft., and on the top of this to lay two-ft. of concrete into which the bottom member of the reinforcing frames would be embedded, the whole forming a floor on which to build the piers. The ragstone was then to be grouted up to form a homogeneous mass down to the floor of the creek.

The ragstone and ballast were run out on the aerial in bottom-emptying skips, holding over two tons, and dropped through the water at high tide when other work was stopped. The material thus deposited was levelled off at low tide in readiness for the concrete, which was tipped from the Decauville down a shoot. This concrete was protected from the ebbing tide by a wall of bags filled with clay, which ensured still water, and this was gradually displaced as concrete was pushed forward into it from the near side. (Photo 2.)

PIER CONSTRUCTION.

Before covering up the freshly deposited concrete with sailcloths and rails, etc., to protect it from the incoming tide, a wooden frame corresponding to the bottom of the pier-casings was let into it. The impression left in the concrete by this means can be seen in the foreground of Photo 2. This and Photo 3 also show the wooden and steel trestles which were carried forward on the aerial, as required, to support the Decauville for running out the concrete, ahead of the piers. The bottom members of the trestles straddled the pile lines, and rested upon them.

The reinforcing frames were made of old 60-lb. rails, which provided the necessary section of steel in a cheap form, and had the additional advantage of being very easily handled on the aerial and kept in place during concreting. A near view of one being embedded in concrete is given in Photo 2, and a still nearer view of the back member of a frame which has already been embedded.

In the best fortnightly tide-cycle four reinforcing frames were fixed and wedged into their holes in the piles, four piers were built, and the equivalent length of floor laid, namely, forty-four feet. The average was nearer three pier-units.

Photo 3 shows the piers half way across the creek, and the force of the returning tide rushing over the newly-deposited concrete in the floor just beyond the pier-casings.

These casings had to be made of something which would not float, and, for rapidity in assembling, of as few component parts as possible. Each side was, therefore, made as a complete unit consisting of "Simplex" piles laid horizontally, and kept in position between an 8-in. x 6in. timber on the inside, and a 60-lb. rail on the outside, bolted together. The function of the timber was to leave rebates and grooves in the concrete: on the front face for housing the flaps; in the middle to form a key for the concrete subsequently placed between the piers; and on the back to fix the casing for this concrete. For the bottom six feet of the casing an extra vertical support had to be given to the centre of the piles to prevent them bulging outwards under the weight of concrete when the casing was filled to the top. The two sides were held together by tie rods passing through slots in the piles, which were made of unequal length for convenience in fixing chain slings and were each handled as complete units on the aerial. Each side weighed approximately two and a half tons. The front and back faces were wooden shutters in two parts, held in position by wedges driven in behind the tie-rods. These various features are shown in Photo 4. Two sets of casings were sufficient, and were left in place a minimum of 48 hours after concreting.

Photo 4 also shows the last reinforced pier on the far bank being concreted, and the hopper of the shoot from which the floor concrete was poured, ahead of the piers.

The ragstone and ballast foundation, although a clear foot below the top of the pile-line, was thought to give the sea an opportunity of bursting the floor upwards when the flaps were closed if there were any leak between the concrete and the piles, or any undetected weakness in the floor. This danger was obviated by filling up the interstices with neat cement grout, and for this purpose wooden funnels were left in the floor, which passed down below the level of the concrete. A 2-inch rubber hose was used for grouting, which could be slipped over a pipe let into the bottom of an ordinary skip containing the grout. The outflow was controlled by a tapered wooden plug. Forty-five tons of cement were used in this operation.

The solid ends of the dam presented no particular features, and were quickly built. Where necessary, piers of yard-cube concrete blocks were made to support the Decauville. In some cases these blocks were incorporated in the dam, and in others they remained outside.

In order to ensure the flaps fitting well into the floor, sills were added, raising the height to —2.1-ft. These took some time to get in, as it was then well on into winter, and the water not low enough on spring tides, owing to the short working day, to allow of much work on the floor. When light permitted, this was best done between 5 and 9.30 a.m.

The wooden flaps to close the spaces between the piers had in the meantime been made up of elm, all ready to fit into their places. They were taken out on flat tops along the dam to their places, and picked up on the aerial by a single ring-bolt at the point of balance, a suggestion of one of the gangers. When thus suspended, they could easily be turned up from a horizontal to a vertical position and let down into place so that their hooks rested on the rails running between the piers provided for the purpose. This operation, including the fixing of keep-bolts to the hooks, took from five to ten minutes for each flap, and was done at low tide. The props were then added, and any adjustments noted. No more than six gates were placed in position in any one day, so that 14 spaces between the piers were available for the incoming tide. When it ebbed again, it swung open the flaps, which were once more picked up on the aerial, and the props allowed to drop into place.

As it turned out the twenty flaps could all have been run out and hung in position on one tide, but, in view of the possibility of a hitch occurring through any slight subsidence, it was safer to make certain of their all fitting correctly by trying each one in turn. Photo 5 shows the central portion of the dam with all the flaps propped open, and the last of the ebb running out.

On the first suitable day the flaps were let down into place, this operation taking an hour and twenty minutes. Back casings were fixed by passing tie-rods through them and the flaps, and securing them by cotters, which were much quicker to tighten and release than nuts would have been. The flaps acted as the front casing, and the thickness of concrete was regulated by the rebates in the piers already mentioned. To enable the tie-rods to be readily released they were passed through pipes placed between the casings. Condemned boiler tubes proved very useful for this purpose.

To give each pier the benefit of assistance from this additional concrete as soon as possible, the panels between them were filled in alternately instead of consecutively from the Havengore end. Two mixers were used simultaneously, and extra speed was ensured by a separate engine running up boulders to add to the mass. These alternate panels were concreted in before the return of the springs.

The maximum rise of water behind the dam after the flaps were dropped was ten inches, but this all ran out again at low tide. To enable concreting to be started at once in the morning, whatever the state of the tide, the crevices round the particular flaps concerned were stuffed up with strips of old blanket, and the bottom three-feet of the compartment concreted in overnight. Into such crevices as were too wide for blankets, bags filled with clay were rammed.

Concreting the panels proceeded at the rate of three a day, and a point was reached when only five more remained to be filled, *i.e.*, one-and-a-half days' work.

DAM BREACHED.

At this juncture the elements put in a concentrated attack. During the night a tidal wave swept up the Channel. The wind which had been blowing steadily during the day from the south-west, a safe quarter for this particular work, veered round to the north-east and increased to a velocity of over fifty miles an hour. Heavy snow fell all night in the Thames Valley, and the tide, which had been falling off from maximum springs, suddenly rose three feet higher than its level on the preceding day. Huge holes were torn in the concrete-faced walls of Foulness, those of Canvey Island were breached, and barges were stove in up the Thames.

The dam in its incomplete state did not survive, and about 180-ft. of it was destroyed in the centre, namely, from pier 4 to 21.

From the position of the debris, some of it carried over fifty yards away, it was clear that the unconcreted panels were the first to give way. These pulled over the adjoining piers, which were tied together at the top by the horizontal rails supporting the hinge of the flaps, until a sufficient waterway was provided for the inrushing sea. It was also clear, from the fact that some of the reinforcing frames, of six square inches section, had snapped in two, that the battering of the waves had subjected the dam to a far greater dynamic force than the static weight of even a record tide.

The one bright feature of the wreckage was the fact that the front pile line remained intact, and sufficed to prevent scouring of the site from reaching unmanageable dimensions before proper precautions could be taken. Even so, on each side of the pile line scour-holes formed to within four feet of the bottom of the piles. (*Vide* Fig. 13 showing maximum erosion.) Another fact was that the sluice was undamaged.

RECONSTRUCTION.

The problem of damming the creek was now more complicated than it had been, both because of the scour and because it was impossible, without undue expense, to replace or remove the back pile-line which had been flattened out *in situ*, and thus obstructed the driving of any more piles. The position was further complicated by masses of debris which were lying athwart the site (Photo 6). These could not be blasted out of the way without great risk of injuring the front pile line, and upon this every hope of reconstruction depended.

It was decided, therefore, to replace the back pile line by a mass of boulders across the breach, upon which to found the new dam; to rely upon the single surviving pile line as a seal against under-scour; and to incorporate as much as possible of the debris in the fresh structure. The first step was to protect the exposed ends of the old dam from being undermined, and this was done by depositing stone from cutters manœuvred into position at high tide.

As about two thousand cubic yards of stone was required to fill the various scour holes behind, and up to the level of, the pile line, *i.e.*,—3.5-ft. O.D., some quicker method of dumping had to be devised than handling it on the aerial and in any case the barge containing the winding engine had been returned to the R.A. Also for subsequently running out concrete a high- and low-level railway would be required. The trestles shown in the various photos of reconstruction were, therefore, designed to suit all purposes. The legs and sills were 6-in. x 5-in. R.S.J.'s and the two transoms 12-in. x 6-in. R.S.J.'s, with 3-in. x 3-in. angles as bracing for the lower half. The upper part had, of course, to be left clear to take the construction trains, and could not, therefore, be cross-braced.

Photo 6 gives a good idea of the ten trestles and the position of various portions of the destroyed dam. The sill of some of the trestles can just be seen above the water. The front legs rest on the pile-line, and the back ones upon the wall of stone. (Fig. 13.)

The stone for this wall was run out along the top of the surviving portion of the dam in front-tip trucks, and shot down a 30-ft.

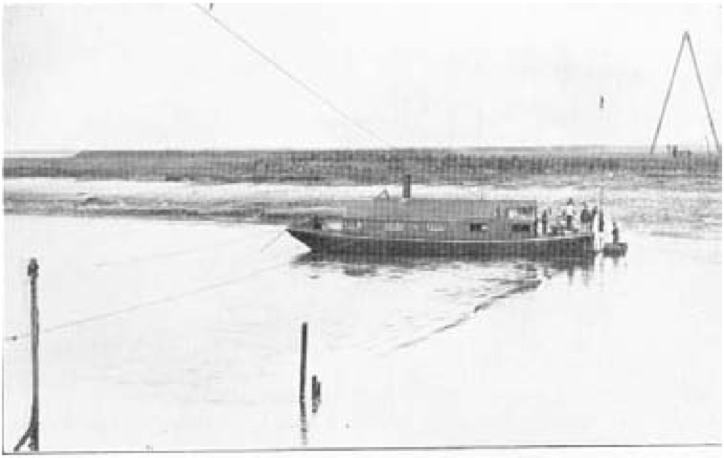


Photo 1.

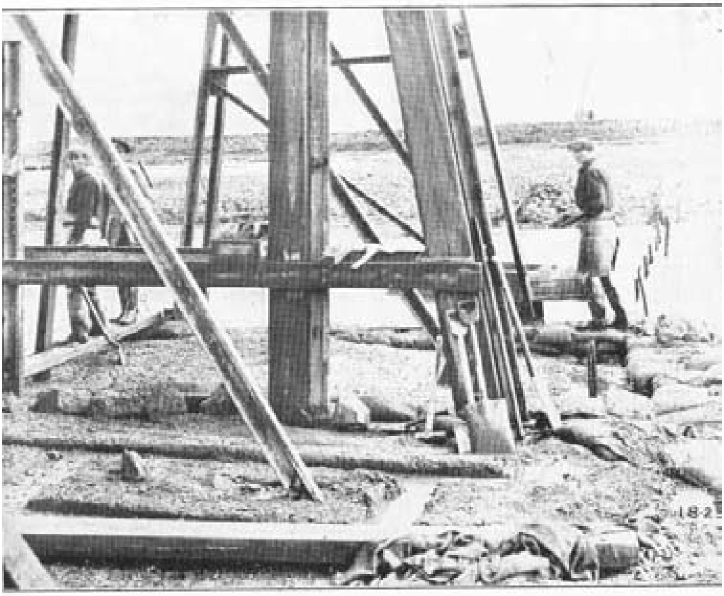


Photo 2.

Photo 1 & 2

Photo 3.

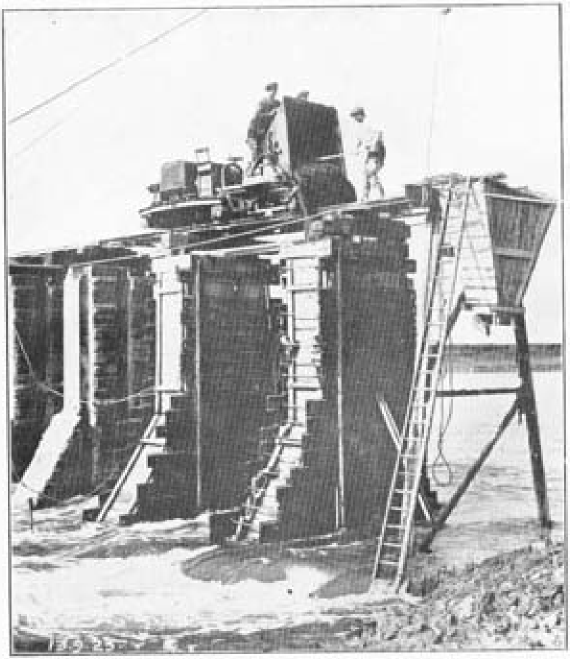


Photo 4.

Photo 3 & 4

Photo 5.

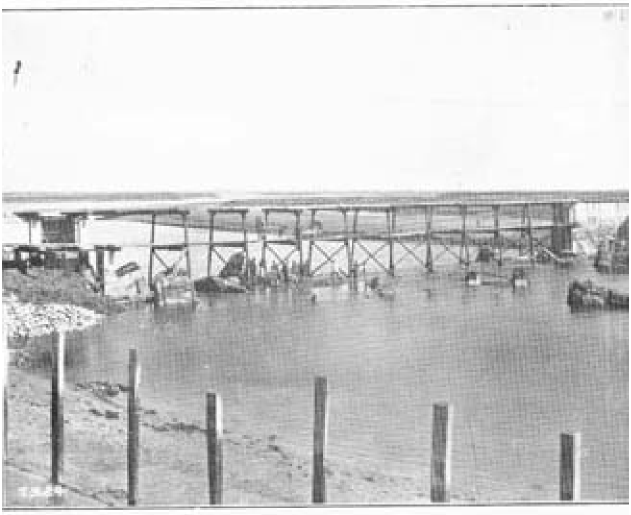


Photo 6.

Photo 5 & 6

Photo 7.

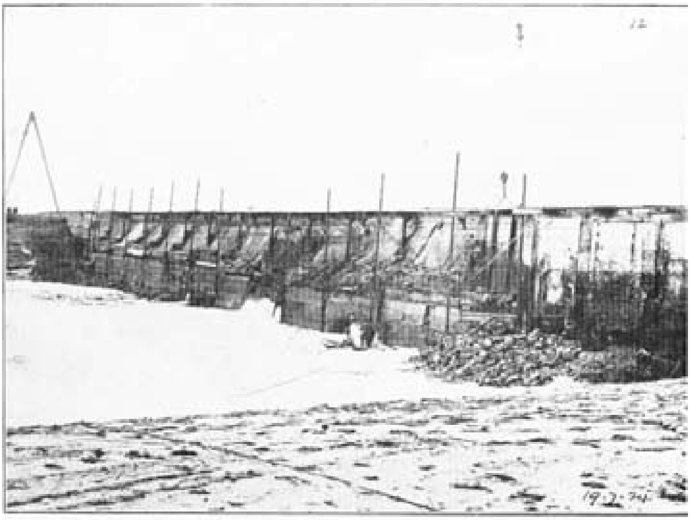


Photo 8.

Photo 7 & 8

Photo 9.

Photo 10

Photo 9 & 10

Photo 11.
The Flooded Island.

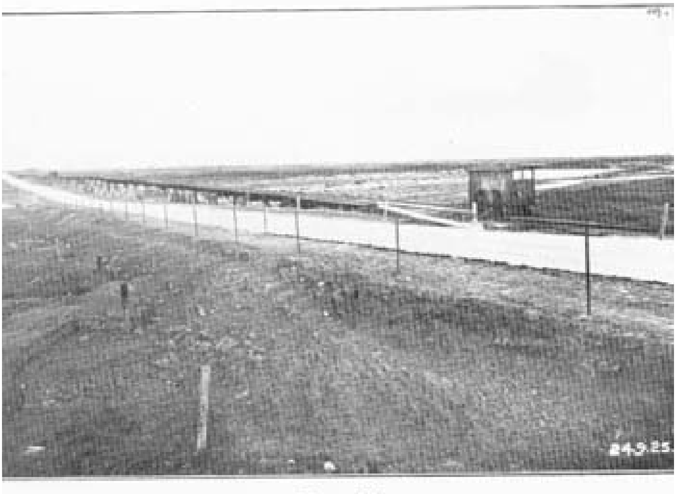


Photo 12.
The Island Reclaimed.

Photo 11 & 12

shoot suspended from the aerial. As soon as enough stone was deposited to form a support for the rear leg of the first trestle, the latter was placed in position by means of the aerial, the line was extended on to it, and stone shot forward as before to form a heap upon which to rest the next trestle. The process was repeated until the line was restored across the creek. The weight of the trestles was distributed on the boulders by a layer of piles laid flat under the back legs, giving an area of ten square feet

It was about six weeks after the destruction of the original dam that the first trestle arrived from the manufacturers, and another five weeks before communication over the top of the dam was re-established. This was at the beginning of April last year, and as the days were now lengthening and "Summer time" imminent, it was possible to look forward to more rapid reconstruction.

Fig. 13 gives a section of the new dam. The intention was to concrete up to + 5.5-ft. O.D., erect piers at 16½-ft. intervals, *i.e.* the same as the trestles; and drop shutters between them as before. The extra weight of concrete in the dam before closing was one of the factors relied upon to prevent a repetition of the previous failure before full weight could be added, and the second was that the water impounded behind the dam would prevent the front face from being subjected to more than a portion of the pressure due to the head of water against it at high tide, until the dam was completed. The impounded water could then be run out through the sluice.

Such was the plan, but the sea had other views.

In the early stages of concreting, it was comparatively easy both to deposit concrete in water and to protect it from the rush of the tide in the way which has already been described. To take full advantage of low tide, four concrete mixers had been installed on Havengore, and in one week as much as 250 tons of concrete were deposited, with 50 tons on each of two successive days.

As, however, the available waterway became reduced, owing to the dam rising, the velocity of the tides increased to such a point that no amount of loading with stone and rails sufficed to prevent the tarpaulins, protecting the newly deposited concrete, from being displaced. The outgoing tide, in particular, became a miniature Niagara (Photo 7), and in addition to removing the fresh concrete, swept away the stone apron which had been placed in front of the dam to prevent the bed of the creek from being still further eroded. (At this stage bays 1, 6-11 were up 5.5-ft., 2 and 3 were 2.2-ft., and 4 and 5 were one course higher at 3.7-ft.)

As a result of this waterfall effect the bed of the creek was scoured right up to the pile line, and the sixth profile rail in the photo has already dropped about 10-ft. from its original level, thus measuring the depth of the hole. Clearly no time was to be lost if the inevitable deepening of this action to the bottom of the pile line and the destruction of the dam a second time was to be prevented, and some means of shutting out the sea altogether had to be improvised.

EXCLUSION OF THE SEA.

The trestles were peculiarly adapted for the rapid erection of the necessary barrier, Photo 8 and Fig. 14 showing how this was done. Timber baulks 14-in. x 14-in. were laid horizontally along the middle transoms and strutted back by smaller timbers to the back legs. Against these baulks sleepers or piles were inclined and covered over with tarpaulins, while sandbags were laid at the bottom to keep them from lifting as the tide rose. Outside the front trestle legs 100-lb. rails were laid on the concrete to prevent the possibility of the foot of the sleepers and piles being pushed inwards.

Most of the baulks were suspended over their true position by tackles on the evening before the day fixed for erecting the barrier. It was fortunate that an attempt was not made to do the whole task in the one day, because it took longer than was anticipated, owing to the impossibility of getting more than a certain number ot men on to the dam at the same time. As it was, it required seven hours to close the opening, and the flood tide was actually running through when the last piles were being put into position. Four thousand sandbags were used in holding down the tarpaulins and closing the gaps between the sleepers and piles on each side of the trestle legs. The men were knocked off for a rest while the tide rose, so as to be fresh to meet any emergency which might arise at high water.

A high tide was expected as the wind was in the north-west and freshening rapidly. Both continued to rise until nearly an hour after the predicted time of high tide, and the water level was then 11½-ft. above O.D., with wave lap up to 13½-ft. This was higher than parts of the sleeper barrier, and a double row of sandbags had to be laid along the top to keep the sea out. Even then a certain amount splashed over, but without doing any damage, except to the feelings of the constructors, who could only hope that the water would rise no higher.

At last the tide began to fall, but the sea was not done with yet. As the water dropped below the level of that impounded behind the dam, it was seen (Photo 8) that there was a large outflow from back to front. For a short time it looked as if the pile line had been undermined, but as the tide fell still further, the rush of water was seen to be coming over the top of the piles, and it then became evident that two large masses of comparatively green concrete in bays 2, 4, and 5, had split off along lines of cleavage caused either by the debris of the old dam or the top of the pile line. This was sufficiently unpleasant, but at least manageable, which would certainly not have been the case if the pile line had been undermined.

The position now was that the barrier, the dam, and the impounded water between could keep the sea out, but that it was not possible to close the "blows" (another smaller one had made its appearance) by tipping earth on the front face, or by any other means, because it would be at once displaced at low tide by the water rushing out. The "blows" could, therefore, only be closed after the impounded water had been allowed to run out, but it was not safe to remove its weight from the back of the dam until corresponding weight had been added in its place, in the form of concrete and earth. At the same time it was inadvisable to allow the sea to rush in and out of the blows a day longer than could be helped, as it was certain to enlarge them in the process.

Several things wanted doing at the same time, namely, making good the scour in front of the pile line, particularly in front of the blows, raising the concrete on the dam to a uniform level, and depositing as much earth on the back face as was possible, in case any higher tides came along.

About 1,500 cubic yards of earth per week were run out to meet the first and last of these requirements, and the best day's concreting produced 84¾ yards.

When about 8,000 yards of earth had been tipped, it was considered safe to run the water out from behind, and the blows through the dam were then almost completely stopped for the time being by tipping more earth in front. It now appeared that the foundation of the dam upon ragstone, underlying the concrete, instead of upon concrete right down to the bed of the creek, proved of the very greatest advantage, for the water rushing in through the blows could distribute itself and lose its velocity in the interstices of the ragstone throughout the length of the dam, if it so desired, instead of forcing an outlet opposite its entry by scouring out the bed of the creek.

With the question of the blows momentarily disposed of, it was possible to continue concreting the dam, and this was done bay by bay, the sleeper barrier being removed and the old concrete being chipped clean of creosote which the sleepers left behind.

When this had been completed there was nothing to prevent the concreting of the dam being continued. The foundations in bays 2, 4, and 5, were restored by driving down a cofferdam of piles round them, excavating the apron to -4-ft. and filling in with concrete, which was strengthened over the pile line by B.R.C. fabric (figure 13). Neap tides were selected for removing the barrier in each bay, and replacing by mass concrete. This was necessary because the lowest point of the concrete in front of the barrier was only two feet above Ordnance datum, and the casings would have bulged if the height of concrete put in at a time had exceeded six feet.

Even on neap tides, however, there was no certainty that high water would not exceed 8-ft. O.D., and on one occasion it rose during the night to nearly 10-ft. without, however, doing any damage beyond washing away a considerable amount of earth behind the bay being concreted. (Sandbags were always lined along the top of the concrete up to 9-ft., but in this case the height was insufficient.)

It was unfortunate that at this time "Ferrocrete" cement had not been put upon the market, for its use in the dam would have entirely prevented all the trouble and anxiety caused by the blows, seeing that a few days after placing, it would have had the strength only attained by the ordinary cement used in some weeks. It has since been used on sea-wall work, requiring rapid hardening, with complete success, and is undoubtedly a most valuable addition to an Engineer's resources. It must, however, be used within six weeks of manufacture, after which its quick-hardening properties gradually disappear. Its price, under £3 10s. per ton delivered at Shoeburyness, places it in an entirely different category as a practical proposition to "ciment fondu," which was over £9 a ton at the time in question. (English "ciment fondu" has just been put on the market at £6 1s. 6d. a ton.)

The low level railway over the dam was retained to remove the 14-in. x 14-in. baulks which had supported the barrier, and was then dismantled to make room for further earth backing. Photo 9 shows the barrier in position in the first five bays, (with concrete behind it up to + 8-ft. O.D.); the barrier removed and the baulks being used for casing in the next four bays; while beyond, the low level line has been pulled up and the earth backing is well advanced. Towards the left of the photograph, water will be seen trickling through between the piles. This was encouraged, as it served to saturate and distribute the earth behind the dam and helped it to settle to the angle desired, thereby saving a great amount of shovelling.

Work proceeded according to plan (though somewhat retarded by the withdrawal of twenty men to put through an urgent requisition for the Royal Air Force), until it was noticed that no amount of earth filling on the front entirely prevented a small trickle through the dam at the Havengore end near the sluice. It became evident that this water penetrated at a point thirty feet from the dam (where a scour hole caused by the steam barge used in the early days of pile-driving had been filled in partially with ballast and stone) and, passing up through the stone pitching of the sluice outfall, then found its way through one of the piles holed to take a reinforcing frame of the old dam. The only remedy for this was to extend the front apron right over the sluice, in the hope that the weight of water would force the earth into the interstices of the stone and so seal the leak.

This was accordingly done, with the result that no water whatever now gets through the dam, but the water level in the creek behind it has risen over three feet to Ordnance datum. This is of no real consequence, as the catchment area draining into the creek is small, being only a portion of Havengore Island and New England.

If upon re-opening a channel from the sluice, which is now closed, it is found that water starts once more to penetrate the dam, the sluice can be covered over again, and the drainage from Havengore diverted to another outlet into Havengore Creek. Similarly, if water rises behind the dam, as a result of rainfall on New England alone, to 6-ft. above O.D., the level of the road just completed over the Island, it can be released by making a new outfall into Shelford Creek. Such a rise, however, is most improbable, in view of the area of the creek and that of the land draining into it.

Photo 10 shows the completed dam as reconstructed. On reconstruction alone 2,500 cu. yards of ragstone boulders, 2,100 cu. yards of concrete, and 19,000 cu. yards of earth were used, the net cost of this work being approximately £7,000. Concrete was 1 in $7\frac{1}{2}$, except where laid in water or places where the tide was exceptionally strong, when it was strengthened to 1 in 5. This point was elaborated in the previous article.

As the result of experience gained from the vicissitudes of this dam, it would appear that the best method of building any similar dam in future, would be by a combination of the two systems described above. It is certain that the bearing power of the piles should be utilised to the full, as in the reconstructed dam, for not even the minutest sinkage has taken place in it, whereas the other two dams, the construction of which was described in these pages two years ago, have sunk, with a maximum in "C" dam of six inches. It is also certain that the first method of shutting out the tide at a time of one's own choosing is better than the second, at the bidding of the sea.

It is clear, too, that all calculations must be based, not upon the finished work, but upon the conditions prevailing immediately the flaps are closed; and to ensure the necessary strength at that time under the most unexpected circumstances, the base of the dam must be wider than it was made in the first case, and heavier. The latter can be ensured by raising its height before closing the flaps, and the weight of the impounded water is also a valuable factor. The height to which concreting can be carried out depends upon the rate at which the bed of the creek is being scoured by the outfall over the dam. It seems that about half tide on the springs is the point beyond which it is unwise to go. In the present case this would be represented by + 3-ft. O.D., instead of the +5.5-ft. attempted.

SMALLER DAMS.

So far the construction of dams ranging between 200 and 400-ft. long has been considered, and the reasons (in the former article) which led to the adoption of concrete.

In smaller dams, such as can be built on one fortnightly tide-cycle, it is possible to make use of earth without keeping the sea out by a preliminary wall of piles.

The northern end of New England Island is separated from the remainder by a horseshoe-shaped sea-wall, "F" on the plan, and was flooded independently through a breach in the main sea-wall at "A." This breach divided into three main channels, of which the largest was 65-ft. wide, and in depth 2-ft. below O.D. The other two were 40 and 30-ft. respectively. Calculation showed that the first would require about 1,600 cubic yards of earth, and it was clear that if this one could be stopped by tipping earth into it, there would be no difficulty about the remainder.

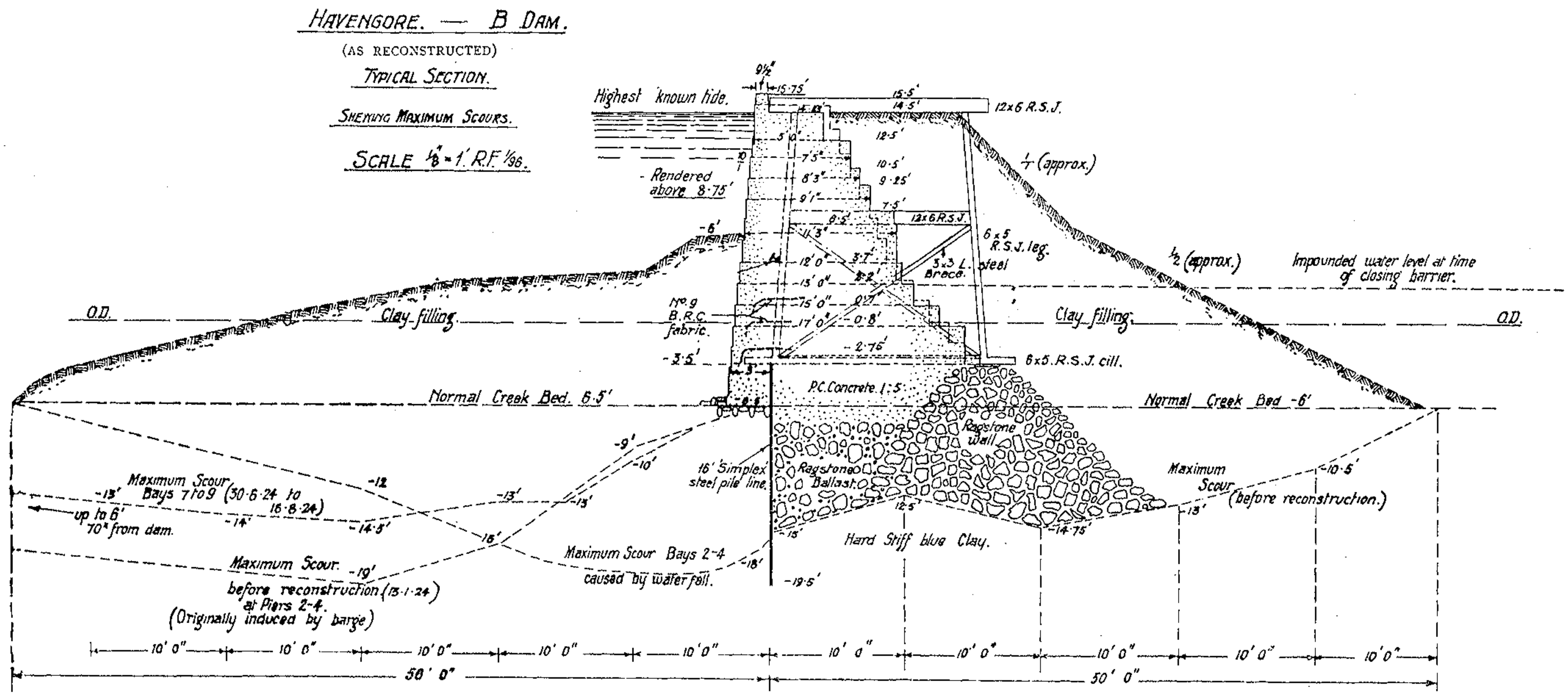
The method of closing this portion of the island was as follows: The 2-ft. gauge railway running out on to "B" dam was extended across the island and taken across the three gaps on 14-in. x 14-in. timbers, with an intermediate trestle in the case of the largest. The line was kept as high as possible over the gaps with the object of giving the earth the maximum drop when tipped so as the better to consolidate it, and to reduce the dressing of it afterwards as much as possible.

Six borrowpits were laid out on Havengore (from which earth was also taken for "B" dam) with a siding into each. Although these were half-a-mile away from the breach, the earth therefrom was much more suitable than that from the island, and they were not subject to being flooded at high tide, with the attendant difficulty of drainage.

When all was in readiness, earth was run out in tip wagons of one cubic yard capacity, and dumped into the largest gap as rapidly as possible. Three 20 h.p. "Simplex" petrol tractors were employed on this service, each being responsible for two trains of four wagons. Twelve diggers were detailed to each pair of trains, and filled one while the other was away being emptied.

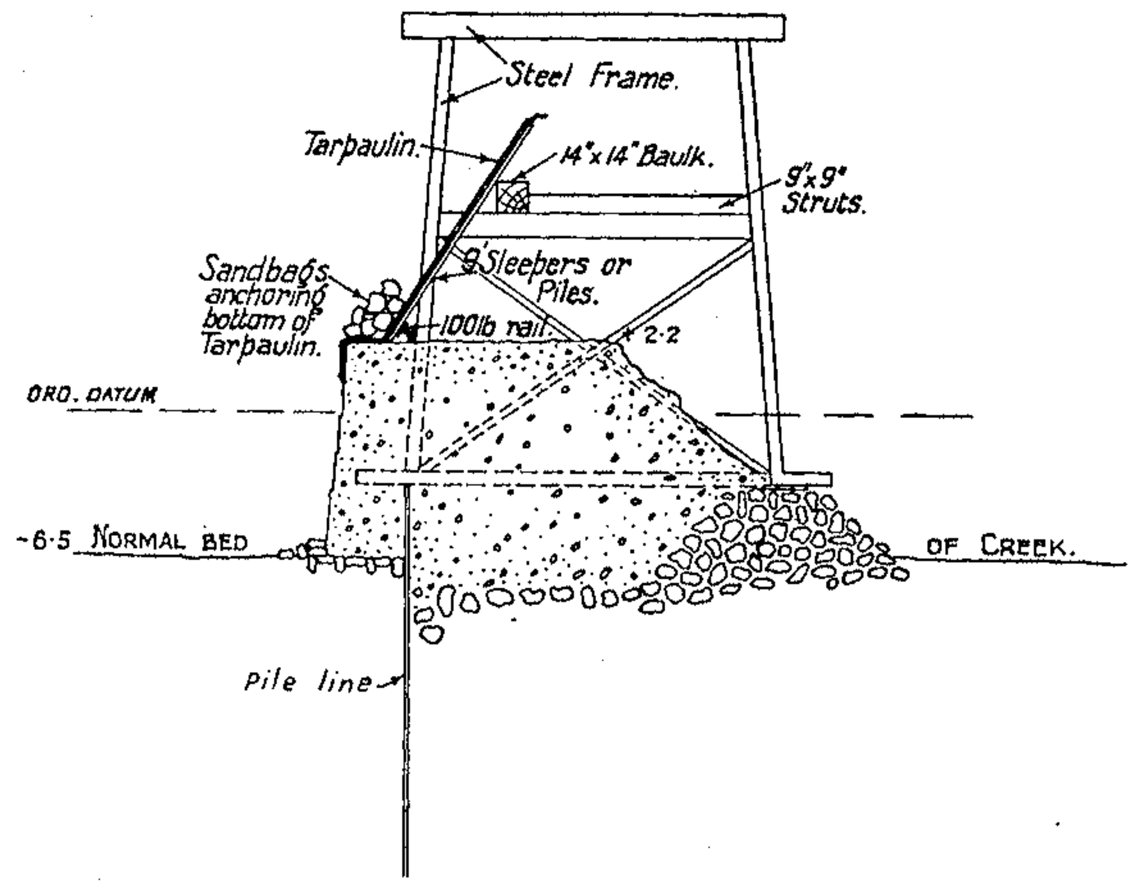
The chief difficulty encountered was the frequency of derailments owing to the line being laid over mud, semi-liquid to a depth of two feet in the worst places. A special re-railing gang had to be

FIG. 13.

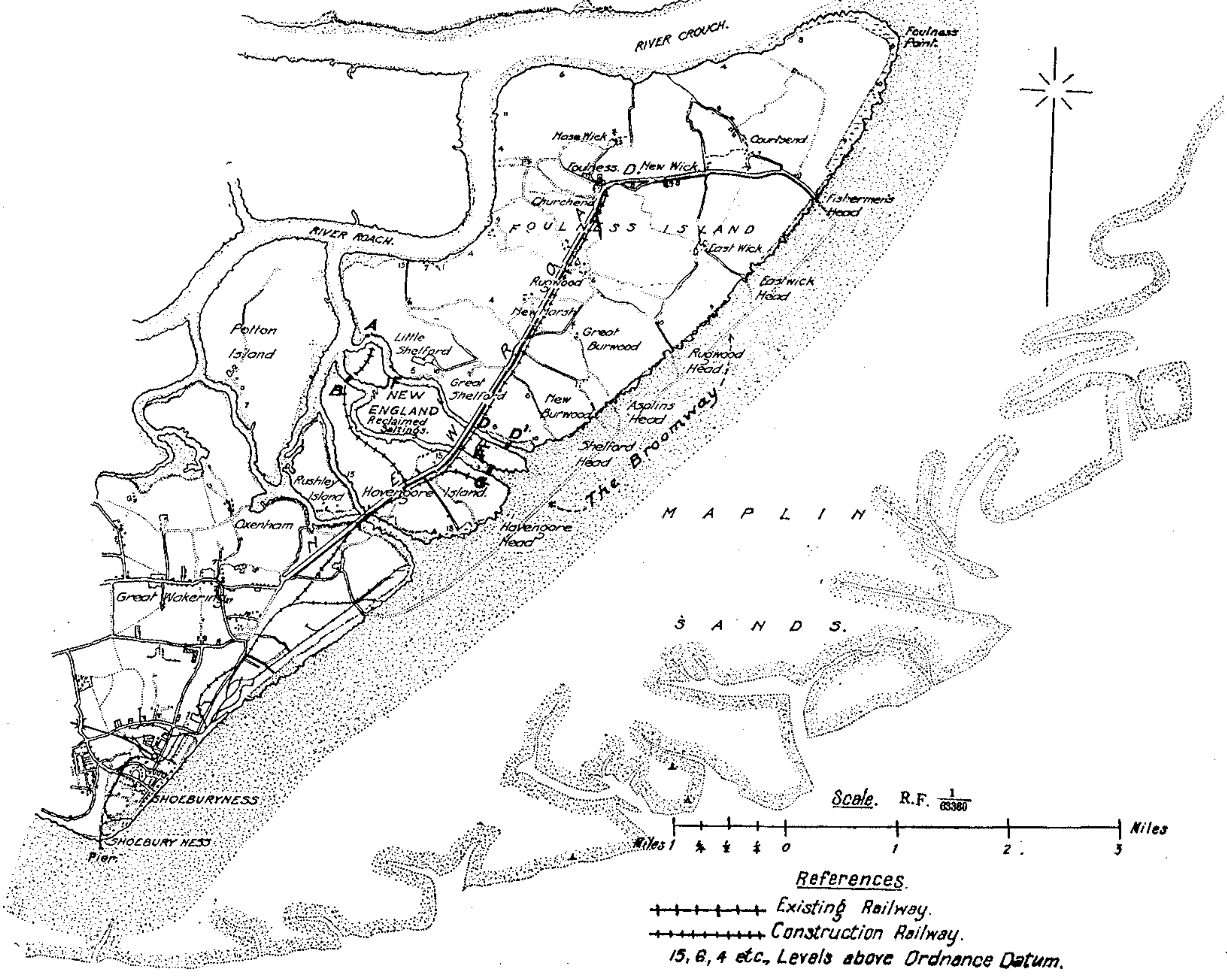

HAVENGORE. — B DAM.
(AS RECONSTRUCTED)
TYPICAL SECTION.
SHEWING MAXIMUM SCOURS.
SCALE 1/8" = 1' R.F. 1/96.
Highest known tide.
Rendered above 8·75'
12x6 R.S.J.
1/4 (approx.)
1/2 (approx.)
Impounded water level at time of closing barrier.
6x5 R.S.J. leg.
3x3 L. steel Brace.
No. 9 B.R.C. fabric.
Clay filling.
O.D.
6x5.R.S.J. cill.
Normal Creek Bed. 6·5'
Normal Creek Bed -6'
P.C. Concrete 1:5.
Ragstone Wall
Ragstone Ballast
16' Simplex steel pile line.
Hard Stiff blue Clay.
Maximum Scour Bays 7 to 9 (30·6·24 to 16·8·24)
up to 6' 70' from dam.
Maximum Scour Bays 2-4 caused by water fall.
Maximum Scour. -19' before reconstruction (13·1·24) at Piers 2-4. (Originally induced by barge)
Maximum Scour (before reconstruction.)
10' 0"
50' 0"

DAM CONSTRUCTION—SECTION OF BARRIER.

Fig. 14.



DAM CONSTRUCTION IN TIDAL CREEKS.



detailed until the weak places had been dealt with by packing up on good soil brought from Havengore. It was particularly hard to keep the rails level round curves, which could not altogether be eliminated. At the same time, since the line would only be required for a fortnight or three weeks, it was not worth while doing more than the minimum levelling and packing.

The original idea was to spread the first day's earth, about 200 cu. yards, to a depth of three feet, so as to restrict the waterway only a little, and to cover up with sailcloths till the next day. The earth was so stiff, however, that spreading it required as much labour as the original excavation. This task was accordingly left to the tide to perform when it burst over the top of the day's work. This it did very satisfactorily, and the net gain on the first day was the impounding of two feet of water behind the dam.

On the second day the dam was raised almost high enough, but not quite, to top the tide. The irruption was not so violent as on the former occasion. A further rise of the impounded water showed that the dam could be made good on the third day, and this was done. The next few days were devoted to getting as much earth into place as possible, both to raise and widen the dam, but also to make good the loss of height as the soil subsided to its natural angle of repose. When the springs came round again the dam was too strong for them to destroy.

Water trickled through the dam for over a week, but these weepholes gradually sealed themselves as the earth became consolidated. The impounded water started at a level of about two feet below the general level of the island, but this was reduced as it scoured its way out through the other two outlets. (It is an advantage to impound as much water as possible during operations of this kind in order to minimise the amount which has to pass to and fro. It can always be evacuated when the dams are complete; in this case by making a passage for it through the sea-wall behind "B" dam, whence it can escape through the sluice.)

The scour of the two subsidiary channels, alluded to above, was checked by stone pitching, and the dams were put in hand on the first day of the next neap tides. The larger one was successfully dammed in one day, but was nearly topped by the tide next day, owing to subsidence during the night. The smaller one, which had been dammed at the same time, had been left slightly lower to act as a safety valve, and this was swept out by the tide, which was 18-in. higher than normal for its position in the fortnightly tide-cycle. It was made good next day and men concentrated to build the intermediate portions of wall which were required to complete the new defences round the original breach to a height of 4½-ft. above the island as a first step. This raised it a foot above any except a "freak" tide, leaving it to be raised to the full height of 16-ft. above O.D. (6-in. allowed for settlement) as soon as possible.

The soil at this end of Havengore was much harder to excavate than in the vicinity of "C" dam, and each man could only dig 8 yards a day as against over 13 yards at the latter. Even so, on the shorter winter day they were doing over a yard per man per hour. Three men to a truck was the best number to balance the trips. The maximum output per man was achieved when three engines were hauling for two gangs of twelve men, the third gang adding little more than 50 per cent. of a gang's output owing to traffic delays.

For sea walling proper the best arrangement is to have three men digging and wheeling to one "builder." Any larger number of men working at one point get in each other's way and send up the cost per yard proportionately. On this reclamation work, the cost averaged 7s. 6d. a yard, excluding the three deep breaches above mentioned, the closing of which cost £1,400. As against the original scheme of building a fourth dam at "A," the scheme adopted showed a saving of at least £5,000.

It is not generally possible to select the time of year for closing creeks or breaches in seawalls, but, if it should be, the bird-nesting season is the best. What are called "bird-tides" occur then, during which, by a wise dispensation of Nature, spring tides are much lower than usual. This allows birds of a nautical turn of mind to build their nests on the saltings without fear of being flooded out, and quite near one section of seawall which was being repaired, a wild duck hatched out her brood, unmolested by man or sea, at a level no higher than 10-ft. above Ordnance Datum.

NOTES BY A CHIEF ENGINEER DURING THE GREAT WAR OF 1914-1918—(*continued*).

By BRIGADIER-GENERAL W. BAKER BROWN, C.B.

ON arrival in London in March, 1915, I reported at the War Office and saw Major-General G. K. Scott-Moncrieff, the Director of Fortifications and Works. On 20th March I received notification that I had been appointed Chief Engineer Eastern Command and should report for duty on the following Monday.

In order to shorten these notes and to present an outline of the work done and the methods we adopted, I propose to make, first of all, a summary of the various changes of organisation of the Eastern Command itself, and then to deal with the Engineer work under various headings, such as organisation, defences, hutting, etc.

THE EASTERN COMMAND.

On the outbreak of War the Eastern Command comprised the twelve counties of Norfolk, Suffolk, Essex, Cambridge, Huntingdon, Northampton, Bedford, Hertford, Middlesex, Surrey, Kent and Sussex, except the areas included in the London District and part of West Surrey, which came under Aldershot. To this was added during the War the greater part of the county of Buckingham. The Command included the defended ports of Harwich, Chatham, Dover and Newhaven, and the peace stations of the 4th Division of the Field Army with Headquarters at Woolwich. Two Territorial Divisions—the East Anglian and Home Counties—also had their Headquarters in the Command.

The Headquarters office of the Command was at the Horse Guards, and the Administrative work was on the usual peace footing with a Major-General of Administration to whom the heads of Services and Departments reported on administrative questions, and through whom all funds were allotted. The G.O.C. in March, 1915, was Lt.-Gen. C. L. Woollcombe, C.B., and the General of Administration was Major-General J. Adye, C.B. The sub-division of work followed the ordinary peace routine, but all the senior appointments except that of the C.G.S., the Chief Engineer and the Deputy Director Medical Service were filled by retired officers.

The position of the London District was peculiar, as not only did the main portion of the District constitute an island in the middle of our Command, but it also administered detached areas which were occupied by the Brigade of Guards at Caterham, Windsor and Purfleet. On the other hand, London being the only possible centre from which the Eastern Command could be worked, it followed that the Headquarters of the Command had to be situated in the London District, with the result that all services connected with our own office, such as lighting and repairs, had to be carried out by the London District staff.

In addition to the troops in the Eastern Command, which numbered nearly 300,000 men, and may be considered as an expansion of the peace garrison of about 45,000 of all ranks, there was living in our area a separately organised field Army called the "Central Force." This was composed of about nine Divisions of the Territorial Army with two Cavalry Divisions of Yeomanry and various cyclist units. The Central Force was organised on a war footing similar to that of the Expeditionary Force, and was commanded by General Sir Ian Hamilton, with a staff organised in the three sections of G.A.Q.

The Headquarters of the Central Force was in the Horse Guards alongside those of the Eastern Command and the London District. The Central Force was divided into three Armies with headquarters at Cambridge, Dunmow (Essex) and Tunbridge Wells. No provision was made for an Engineer-in-Chief at the Headquarters of the Force, but it was soon evident that some Engineer organisation was essential, and Major-General R. M. Ruck, C.B., was appointed Chief Engineer of the Force, with a suitable staff and with an office in the Institution of Civil Engineers. A Chief Engineer was also appointed to each Army. The infantry of the force was distributed on a line roughly north and south through London, while the cavalry and cyclists formed a line of outposts ten to twenty miles from the coast, the idea being that if a landing took place, the outpost line would retire on certain selected positions, where the infantry could be concentrated as required. This force, for purposes of administration, at first acted as an independent force in a friendly country, and made its own arrangements for supplies, quartering, hutting, etc., quite apart from the Command in which it was placed, going direct to the War Office on all financial questions.

London Defences.

To add to the complications of areas there was a separate organisation at work digging the defences of London. This organisation was controlled by the C.E. of the Central Force, Major-General Ruck, who was appointed G.O.C. London defences. The organisation was controlled by retired R.E. Officers and the work was carried out by local organisations. The whole of these defences was in the area administered by the Eastern Command.

To revert to the Eastern Command, on the outbreak of war the Chief Engineer was Brig.-General C. F. Anderson, C.B., and the staff officer appointed on mobilization was Major E. H. Hills, C.M.G., R.E. Hills was in the Reserve of Officers, and on the outbreak of war was in Russia in connection with the observation of an eclipse of the sun. He returned via Sweden and Norway and took up duty about 15th August, to find that Anderson, who was a great authority on "ciphers," was away a great deal in consultation with the General Staff at the War Office. The personal supervision of the engineer services of the Command thus fell to Hills, and when Anderson was withdrawn altogether for duty at the War Office in September, 1914, Hills was appointed temporarily to act as Chief Engineer with the rank of Colonel. In November, 1914, Col. E. Roper, who had been withdrawn from South Africa, took up the duties of Chief Engineer, until I relieved him in March, 1915.

The principal work carried out up to this date was the hutting for the troops during the winter of 1914-15. This I will deal with a little more fully later on in these notes. Meanwhile the arrangement under which the Central Force carried out their own administration had been found very difficult to work, and proposals were being discussed between the staffs of the Central Force and the Eastern Command, under which the administrative arrangements of the Central Force would be handed over to the Eastern Command, leaving the staff of the Central Force to deal with defensive arrangements, and the ordering of movements necessary for defensive reasons.

In connection with this reorganisation the Chief Engineers of the Central Force and Eastern Command had prepared detailed proposals for the transfer of Engineer Services, and for the formation of new C.R.E.'s Districts to deal with the extra work. This scheme was only in the rough, and my first job was to put it into shape, rearrange Districts, appoint new Division Officers, and so on. With the amalgamation of the Central Force the ration strength of the Eastern Command in the middle of 1915 exceeded 550,000 men, and I found there were in the Command about 85 officers of the rank of Brig.-General and upwards.

When we began work under the new organisation it was found, as might have been expected, that handing over the duties of Administration to the Eastern Command involved practically direct communication between the Eastern Command heads of services and the heads of the fighting organisations, such as Divisions or Armies. In fact the Q staff of the Central Force had become a fifth wheel to the coach.

On the other hand, in the case of general staff work there was an obvious inconvenience in questions of defence in the Fortress areas being dealt with by the general staff of the Eastern Command, while similar questions affecting the field areas came to the general staff of the Central Force.

For these and similar reasons General Sir Leslie Rundle, who had succeeded Sir Ian Hamilton in the command of the Central Force, put forward a proposal to amalgamate his command with that of the Eastern Command, with a concentration and reduction of staff. This was approved. On working out the details of the amalgamation it was considered necessary to retain the Chief Engineer of the Central Force to deal with all questions of field defences, including the field defences of London. All other branches of the staff were amalgamated. The peace form of staff organisation was adopted and the Major-General of Administration was retained. The head of the Q branch of the Central Force staff was made Assistant to the M.G.A., with the special duty of supervising the work of the special inspection staff for Q.M.G. services, who visited barracks, hutments and camps, and reported on the efficiency of the accommodation, rations, cooking, etc. The Assistant to the M.G.A. did not act as an intermediary between the M.G.A. and the heads of services, and the latter reported direct to the M.G.A. when necessary. In practice we all tried to relieve the M.G.A. of as much detail as possible, and the Chief Engineer, as well as the other heads of services, had full authority to act for the M.G.A. in an emergency, provided we kept him informed on all important questions.

In October, 1915, Major-General Sir J. Adye left the command to take up the appointment as I.G.C. to the forces in the East, and later in Egypt, and Major-General R. M. Ruck was appointed M.G.A. in his place, being a little later relieved by Col. F. H. Horniblow as C.E. Central Force. This arrangement of duties continued during 1915, and under this régime a large amount of useful work was carried out; among others the anti-aircraft defences were entirely remodelled, hired houses were organised into groups to suit the organisation into Divisions and Brigades, hutted camps were completed and improved, a large programme of summer camps was carried out, roads attended to, hospitals enlarged and improved, and all the financial, contract and other detail involved was put on a thoroughly business-like footing.

Among other changes of importance, the Headquarters of the Canadians in England was, early in 1915, shifted to Shorncliffe, and they rapidly accumulated a strength of 30,000 in that neighbourhood. On the whole we may fairly claim that by the winter of 1915-16 we had tackled all our problems and had placed the accommodation for troops on a thoroughly good and sanitary basis.

Towards the end of 1915 a change took place in the appointment of a G.O.C. Home Forces which affected our organisation and work very considerably. The ostensible reason for such an appointment was the desire of the General Staff at the War Office to be relieved of the work of corresponding with individual Commands at home, so that they might have more time to attend to the numerous campaigns which were in hand overseas, though this result was not obtained in practice. It was also desired to form a special staff which might have more time to superintend the details of training of the very large number of troops at home, and on this point the new organisation was quite successful. On the other hand it did not appear that the other branches of the War Office were anxious to delegate any part of their work to a new authority, as it was fully realised that though these Islands had their own problems of Home Defence against attack by sea or air, they were also the principal base from which all our overseas campaigns drew supplies of men and material. And in connection with this there was a very marked tendency in both the Civil and Military branches to concentrate control at Headquarters. It was therefore decided that the G.O.C. Home Forces would have no financial responsibility, and that this would continue to be exercised by the Major-Generals of Administration of the various Commands under direct instructions from the War Office. The staff of the G.O.C. Home Forces was formed on a war basis with G, A, and Q branches, but had at first no Engineer-in-Chief, or, indeed, any representatives of technical services. The Q branch of this Force was, therefore, as regards Engineer services, only an office to communicate the wishes of the G.O.C. Home Forces to the various commands, and the latter had the responsibility of approaching the War Office, getting financial approval of any proposals and collecting the necessary material and labour to carry them out. As there was from this time onward considerable shortage under both these heads, the work involved in getting proposals worked out and approved was very considerable. By this time also the London District had overgrown its bounds, and was frequently calling on us to provide camps, hutments and schools in our area. Among other details the divisional hutment at Seaford was handed over as a convalescent centre for the Brigade of Guards, but the Eastern Command remained responsible for administrative services. At the same time we often got orders direct from the War Office to provide special accommodation, such as venereal hospitals, storage for one-and-a-half million rifles at Weedon, or the large mechanical transport depot at Kempton Park, all of which made further calls on our staff and on our limited supplies of material and labour. But somehow or other the work was done.

The advent of the G.O.C. Home Forces also produced other changes, as he reverted to the earlier organisation under which the G.O.C.'s of the Field Armies reported direct to the G.O.C. Home Forces, and not through the G.O.C. of the Command in which they were stationed. At the same time the number of the Armies in our Command was reduced from three to two, with headquarters in

Norfolk and Essex. The appointment of Chief Engineer, Central Force, was abolished, but each Army had a Chief Engineer who was responsible for the training of the R.E. Field units and the construction of the Field Defences. Up to this time the responsibility for the supply of stores and tools for the construction of these defences had rested with the Chief Engineer of the Central Force, who had a special officer for stores in his office. With the abolition of this C.E. the responsibility for the supply of these tools and materials was transferred to the Eastern Command, and arrangements were made for their supply through the local C.R.E.'s.

The Administrative services of the Field Force remained under the Eastern Command, but were carried on under rather more difficult conditions, as the General officers commanding Armies and Divisions not having any personal responsibility were apt to demand the immediate execution of services, which we were either unable to carry out or which required considerable time for their execution. These difficulties were gradually met by a series of personal visits and local discussion with officers concerned.

Another change made by the G.O.C. Home Forces was an alteration of the tactical scheme for the distribution of the troops. I have stated above that the original scheme prepared by the War Office and followed by Sir Ian Hamilton was to watch the coast with Cavalry and Cyclists, while the Infantry Divisions were kept well back ready for concentration in certain prepared positions. Under Sir Leslie Rundle the infantry was pushed forward, so as to be able to support the outpost line more quickly, and the accommodation provided during 1915 was based on this scheme. Now Sir John French ordered that the line of high water mark along the coast should be adopted as the main line of defence, thus abolishing the line of outposts. The Cavalry was concentrated on the north flank in Norfolk and the Cyclists distributed among the armies. These changes gave a great deal of work both for summer camps and winter quartering. In the summer, instead of re-occupying the camps prepared in 1915, many of which had been kept standing, a large number of new camps had to be made in new positions involving accommodation for 200,000 men. This was successfully completed. But the winter accommodation was not so easy, as it involved a very considerable hutting scheme all along the coast. By this time the supply of timber was getting very short and the War Office was unable and unwilling to provide a big programme of hutting to meet a change in the distribution of the troops which was not vitally necessary. But after much discussion, I obtained 1,000 small wooden huts of a new type just evolved by Col. Armstrong, capable of accommodating about 15,000 troops in all, and by using these to supplement the accommodation in villages we managed to establish a fairly strong outpost line in the neighbourhood of high water mark.

In order to provide office accommodation for the G.O.C. Home Forces it was decided to remove the Headquarters of the Eastern Command from the Horse Guards. Fortunately we were able to obtain the use of a new seven-storied office building at 50, Pall Mall, into which we were able to put the whole of the Command staff. Further, as the interior sub-division into rooms was not completed, we were able to arrange this to suit the various requirements. The whole of the fifth floor was allotted to the Engineers, and for the first time we had the whole of our staff within easy call. The number of the C.E. staff at this time was 13 officers and 19 other ranks, including five girl typists. The saving of labour compared with the scattered accommodation at the Horse Guards was very marked, while the proximity to the M.G.A. and the other heads of services made all inter-departmental discussion much easier.

The change in the organisation of the Field Force involved the withdrawal of Sir L. Rundle from the Command, and in March, 1916, he was replaced by Lt.-Gen. Sir J. Wolfe-Murray, and in June, 1916, Major-General R. M. Ruck was replaced as M.G.Admn. by Major-General Sir F. Robb, K.C.B.

In addition to the work for the field forces and for the various organisations of the Eastern and London Commands, there was during 1916 a considerable increase in work for the Flying Corps and in connection with the anti-aircraft defences. The hospitals also required almost continual improvement and expansion.

In October, 1916, the War Office decided to bring over to England all the recruits under training in Canada, so that they could avoid the winter in that country. The first we heard of it was an order to evacuate the hutted camps at Crowborough and neighbourhood and to arrange, with these and other accommodation in Sussex, to accommodate 30,000 men, to be increased later by an equal number. The order was accompanied by an intimation that the first 6,000 men had already left Canada and were on the high seas, and might be expected in six days. At the time the only organised area in the Command which would take the training brigade from Crowborough, was at St. Albans, which had been vacated a few months earlier by a Division of Territorials despatched to Ireland in April, 1916. For the remainder I pointed out to the M.G.Admn. that the only important town in the area which was not already occupied was the town of Hastings with St. Leonards, and it was decided to concentrate on this area. The President of the Quartering Area and my nearest C.R.E. from Ashford moved into the town to superintend operations; five valuers were collected from neighbouring areas, and all the empty houses and important public buildings were taken over, organised in suitable groups, each with central dining and cooking, recreation rooms, baths and accessories. The War Office arranged for the supply of cooking stoves from the manufacturers in Scotland and for their despatch south in a special train. As a result, on the arrival of the first contingent arrangements were sufficiently advanced to enable them to be received in comparative comfort.

This was the last job of the kind with which I was personally connected in the Eastern Command, as in November, 1916, at my own request, I was ordered to France to take up an appointment under the Director of Works.

ORGANISATION OF C.E.'S OFFICE.

On the outbreak of war the staff of the C.E. consisted of one Staff Officer R.E., with a Superintending Inspector of Works, one Lands Officer, and an Inspector of R.E. Machinery, attached for special service, and the usual subordinate staff of clerks, draughtsmen and mechanists.

Soon after the outbreak of war, some of the senior Engineer clerks were given commissions and appointed assistants to the S.O.R.E., and the senior clerk in the Eastern Command was commissioned at this time. I found, however, when I arrived in the Command that this officer, Lieut. and Qr.-Mr. R. T. Gough, R.E., was still acting as Chief Clerk, opening all letters and distributing to branches of the office, while the S.O.R.E. was signing practically all letters which left the office, of whatever their importance. My first effort was, therefore, directed to a rearrangement of duties, and after some discussion we settled down to a routine under which the Staff Officer, in addition to understudying the C.E., dealt with all papers connected with quartering and general works services, while the Assistant Staff Officer took charge of all papers connected with the R.E. personnel and civilian subordinates, and also engineer stores, rifle ranges and telephones. The personnel by this time had increased very considerably, and was to increase much more later. Officers were posted to the Command by the War Office, but were posted to Stations by the Command. Subordinates were selected by the Command, usually on the recommendation of C.R.E.'s and Division Officers, but all appointments were finally approved by the C.E., acting for the Major-General of Administration, and a monthly report had to be made to the War Office of all such appointments. Under ordinary peace procedure such appointments require W.O. approval in each case, and the delegation of authority to Commands was a most valuable concession to War conditions. As the total of our staff reached about 200 officers and 1,000 subordinates before the end of 1916, it will be seen that this item involved considerable correspondence.

At the same time, with the approval of the M.G.A., I gave the S.I.W. and Chief Lands Officers authority to correspond direct with C.R.E.'s and their own subordinates in the Command on questions of detail, an arrangement which at once relieved the S.O.R.E. of much routine labour. This was the more necessary as the various officers of the C.E.'s staff were scattered in various parts of the Horse Guards building, so that communication between the various rooms of the office was slow and laborious.

Contracts. The superintending Inspector of Works was Col. H. W. Elton, whom I had known for many years, and who had served for some time in the Eastern Command. He had on the outbreak of war arranged direct contracts for the construction of four large divisional hutments in the Command, and after a few months in France had returned and rendered invaluable service in closing up these contracts and in organising the contract branch of the office.

The four big contracts were for the new Divisional hutted camps at Halton Park, Seaford, Shoreham and Sandling, and for these a direct contract was placed with Messrs. Robert McAlpine & Sons on a general specification prepared by Col. Elton. This involved the discussion of a good many extras due to irregularity of site, but the whole of these were settled by Col. Elton with one exception, and the final bill as agreed by the Command was a little over £956,000. The exception was a general claim by the Contractors on a clause in the specification that the sites should be assumed to be level, any departure being paid for in extras. In addition to the extras for foundations which were allowed in our final bill, the contractors made a general claim for an extra for haulage and for getting material on to the sites, amounting to about £90,000. This I did not feel able to accept, as, though the sites were not named in the original contract, I thought the contractors should have anticipated ordinary conditions of country. This question remained under discussion till 1919, when it was settled at the War Office by the payment to the Contractors of about three-quarters of their claim.

Under ordinary peace procedure the powers of the M.G. Admn. of Commands at Home in connection with Engineer Contracts for new services were limited to a maxiumm of £100, every contract above this amount requiring War Office acceptance. The powers of a C.R.E. were limited to £50. On the outbreak of war the limit of powers of a M.G.A. was raised to £2,000. Towards the middle of 1915 this was reviewed and reduced to £200, the argument being that the supply of material was limited, and that it was therefore necessary to control expenditure, and that before an expenditure exceeding £200 was actually incurred there would be ample time to obtain W.O. approval. It was, however; clearly understood that in case of real emergency the

M.G.A. could order work to be commenced, reporting at once to the War Office. This arrangement worked quite satisfactorily and no case occurred of any delay in the execution of essential engineer work. And on the other hand, when we did order services of an urgent nature we always received the fullest support from the D.F.W. and the War Office.

In connection with the question of contracts, I instructed C.R.E.'s to make the fullest use of their peace powers of entering into small contracts with local firms, and further, gave them authority to delegate to D.O's the power of making a small contract under £25 with a single firm. Under this arrangement, when a service such as latrines for a small camp for a detachment was required in a hurry, the D.O. could make a short lump sum contract with a local builder, the necessary writing taking only a sheet of foolscap, and all necessity for elaborate forms and measurements was avoided. All contracts over £50 arranged by C.R.E's came to the C.E's office for review and all contracts over £100 had to be passed on to the Contract branch of the War Office. Fortunately the War Office Contract branch had obtained the assistance of Mr. J. E. Drower, a well-known Civil Surveyor, with whom we established the most friendly relations.

The number of contracts passed to the War Office for review during the first 12 months of my tenure exceeded 3,000 and sometimes 20 or 30 were dealt with in a day. To deal with this mass of work the Superintending Inspector of Works had a staff of one assistant (with the rank of Lieutenant) three experienced, and, I may add, elderly clerks, and one girl typist.

Lands. Under the peace routine before the war the control of all lands and property in a Command was vested in the Chief Engineer, who had a "lands" office in charge of a senior draughtsman, where all plans and documents were kept, this office being under the direct supervision of the S.O.R.E. There was also in each of the large commands at home a Lands Officer, who was a qualified civilian, who acted as an adviser to the Chief Engineer, prepared all technical documents connected with land, but did not perform executive duties. The Lands Officer of the Eastern Command—Major Thompson—also assisted the London District.

In the War Office the control of "Lands" questions had been withdrawn from the D.F.W. and put under a civilian controller.

With the occupation of new areas under war conditions the work connected with land increased enormously, especially in connection with the occupation of land for field defences constructed round our defended ports. When I joined I found the staff of the Lands Officer had been increased by six temporary officers, of whom three were in the London office and three were working outside London.

The Chief Engineer of the Central Force had a staff of six temporary

Lands Officers, who looked for technical guidance to the permanent Lands Officer of our Command.

To deal with claims quickly in the War Office a special commission had been appointed, known as "Duke's Commission," from the name of the President, which did most excellent work in handling claims quickly and economically, and gradually laid down a set of precedents and decisions which were most valuable as a guide to local officers. The Lands Officers of the Command attended before this Commission to explain details of claims under consideration.

On the transfer to the Command of the responsibility for the provision of accommodation for the Central Force, I suggested a reorganisation of the Lands organisation, and the six Lands Officers of the Central Force were transferred to my control. Up to this time the Lands Officers had no executive powers, and all the correspondence was conducted in the C.E's "Lands Office," and all letters and minutes were signed by the S.O.R.E. One of my earliest recollections in the Command is about 6 o'clock one evening seeing the Chief Clerk of the Lands Office and his assistant enter the room of the S.O.R.E., each staggering under a pile, several feet high, of "lands" papers, all of which had to be dealt with by the unhappy S.O.R.E. before he left the office. The number of papers dealt with daily often exceeded 150. Only an officer of the ability and remarkable mental powers of Colonel Hills could have dealt with this mass of correspondence without a breakdown.

To remedy this I gave the Chief Lands Officer the authority already referred to to sign letters to his own subordinates in the Command on technical details, and obtained the approval of the M.G.A. to his signing letters to the War Office on minor claims, under £100, which were covered by previous decisions of Duke's Commission, and were of a simple character. All claims over £100, or which involved a new principle, were submitted by the Chief Lands Officer personally to the S.O.R.E., who exercised his discretion as to whether he would deal with the paper himself or reserve it for the consideration of the C.E. and M.G.A. The number which reached the M.G.A. seldom exceeded 6 or 7 daily. By this arrangement the mass of papers was quickly and effectively handled. The Lands Branch finally employed 40 officers and a larger number of subordinates.

Technical Officers. In addition to the four officers described above who formed the staff of the C.E., there was a group of technical officers with special duties.

Electrical. Before the war no provision was made in the peace organisation outside the War Office for any technical control of Electrical services, except that the officers employed in connection with Defence Lights did frequently prepare schemes for barrack and other lighting. For our big hutted camps it was early decided that electric light should be installed, and at first all schemes for this were prepared at the War Office. I found, however, that those of the Eastern Command and London District were being prepared by a civilian Electrical Engineer, Mr. Wright, and I suggested that if this gentleman could be transferred to the Command we could relieve the War Office of some detail, while Mr. Wright, in addition to new schemes, could deal with the many questions of maintenance and repair which were increasing in number. This was approved, and before the end of 1916 Mr. Wright had prepared and superintended the execution of over 80 schemes for power stations and electrical distribution in our hutted camps, all of which were working efficiently.

Mechanical. The general supervision of machinery in the Command was carried out in 1914 by an Inspector R.E. Machinery with the position of Qr.-Mr. R.E., assisted by mechanists distributed throughout the Command, and this work was continued with an enlarged staff. There was considerable use of small machines, such as pumps, for various services in camps and hutments.

Telephones. The work connected with the administrative telephone system in England is carried out by the Post Office, and while the Central Force was in existence all additions or alterations to telephones were arranged by the Chief Signalling Officer of that force, who was Col. Hippisley (late R.E.). On the amalgamation of the Central Force with the Eastern Command, this appointment was abolished, but a junior officer from the Post Office was appointed to the staff of the C.E., who acted as an intermediary to arrange with the Post Office for the carrying out of any work required. The increase in the use of telephones was very great both in the H.Qr. and throughout the Command, and all our requirements were very promptly met by the Post Office authorities.

Sanitation and Water Supply. In times of peace there are, in the Department of the Government which approves local schemes of sanitation, water supply, etc., a body of highly-qualified technical inspectors, who investigate local schemes and report on them to the Minister concerned—now the Minister of Health. As the work of these gentlemen decreased on the outbreak of war, it was suggested early in 1915 that they might be usefully employed in military engineering work connected with hutting, etc. Eight of them were allotted to the Eastern Command and were detailed as Division Officers in some of the larger hutment centres. After a few weeks a suggestion was made by the War Office that these officers, from the nature of their peace duties, were admirably qualified to assist Commands in dealing with the problems of water supply and sanitation which arose in connection with the numerous hutments and camps. Five of these Officers were then withdrawn for this duty, and posted to the various Home Commands. The arrangement proved most successful.

The officer posted to the Eastern Command was Lt. E. Hetherington. He was employed in advising C.R.E's and D.O's on all questions of water supply and sanitation, and he was especially useful where questions arose connected with the use or extension of local sewage and water services. He also established a useful *liaison* with the sanitary expert in the office of the D.D.M.S. of the Command, and frequently made joint inspections with this officer. He did most of his work by personal visits and interviews with local officers.

Chief Engineer. It may be observed that in the above distribution of duties no specific work was assigned to the Chief Engineer, and this almost necessarily follows in a large Command, where the Chief Engineer must act as the final reference on all important questions, and must therefore be ready to meet any members of his staff who want to bring questions to his notice. I found also one of his most useful spheres of work was in visiting out-stations and getting in personal touch with the C.R.E's and other officers.

In visiting stations I made a point of encouraging officers commanding units and formations to apply to the R.E. for assistance, and instructed my own officers to keep units informed of the progress of engineer works, so that the troops might realize we were doing our best. Further, I found that the somewhat inexperienced Division officers we had to employ were helped very much by a personal visit from headquarters, and that many small misunderstandings were avoided by a personal visit. I, therefore, from my first introduction to the Command, definitely allotted two or sometimes three days in the week to inspection work away from headquarters. To enable me to do this it was essential that I should have a deputy at Headquarters who could carry on the work in my absence and ensure that there was no accumulation of arrears, and I was extremely fortunate in having the assistance in this capacity of Col. E. H. Hills, who was a " persona grata " with all branches of the staff. I have dwelt on this point at some length, as the appointment of a Deputy Chief Engineer in the larger Commands has now become a part of the peace organisation of the Army.

With every wish to see as much as possible, it was not possible to visit more than the larger stations or places where some definite want had arisen. But I was immensely helped by the reports of the Inspectors of Q.M.G's services who visited camps and hutments to inspect rations, cooking and barrack organisation, and also by the reports of the D.D.M.S. and his Sanitary Officer. It became a regular routine to pass on to other branches reports of any defects which were brought to notice, and these often resulted in joint visits which saved a lot of correspondence. When I was in the office, in addition to daily interviews with the Major-General of Administration, I made a point of seeing the head of the general staff and the A.Q.M.G. every day, while the D.D.M.S. was often in our office. All this interchange became much easier when we were all together at 50, Pall Mall.

R.E. ORGANISATION IN THE COMMAND.

There was never any question as to the form of the R.E. organisation which should be adopted, as the peace arrangement of C.R.E's and Division officers was admirably adapted for our needs.

What had to be done was a rearrangement of existing areas so as to bring the work within the compass of the capacities of individuals. This arrangement was always going on as the troops in the Command increased and multiplied. In making any change we always endeavoured to make the R.E. areas fit in with the subdivisions of the Command, but owing to the frequent changes of the organisation of the Field Armies already referred to, this was rather difficult.

It was found essential to make each Coast fortress area a definite R.E. unit of administration. This was already the case at Chatham, which had a Chief Engineer, appointed in peace, with C.R.E's under him at Chatham and Sheerness. Dover was more difficult to arrange, as in peace this was the centre of a C.R.E's district, which included the whole of Sussex and the greater portion of Kent. A new C.R.E's area was formed in January, 1916, to include the county of Sussex, and a new area for South East Kent was formed later with headquarters at Ashford. This included the important Shorncliffe area. The work of the C.R.E., Dover was then limited to the area of the Fortress. Harwich in peace was in charge of a D.O.R.E., who was given the full status of a C.R.E. At Newhaven the D.O.R.E. was given full authority as regards work connected with defences, but for the purpose of hutting and works remained under C.R.E., Brighton.

A new district was formed at Hounslow to relieve C.R.E., Woolwich and took over Middlesex (outside London) and West Surrey. Further north, new districts were formed at Bedford for the counties of Bedford, Herts and Northampton, and at Cambridge for the counties of Huntingdon, Cambridge and Norfolk, both of these in relief of C.R.E., Colchester.

Under the C.R.E's each district was divided into three to six Divisions, each with a Division officer in charge, and in some cases an Assistant D.O.

To staff this organisation we collected a body of engineers, including active and retired officers R.E., inspectors of works and civil engineers from all parts of the world. The backbone of the organisation was the retired officers of R.E., and it is difficult to exaggerate the value of their work, while I owe them a deep debt of gratitude for the personal assistance they gave me, which I shall never forget. There was no age limit, and many of these officers were much my senior, both in age and experience. Not only was their experience of the greatest value in dealing with the multiplicity of demands from the troops, but their knowledge of the best methods of work and their absolute command of the procedure for its execution, enabled me to rely with confidence that any instructions I might send out would be properly and promptly carried out. Coupled with this there was a capacity for work which never failed.

All the appointments as C.R.E. were filled by R.E. officers on either the active or retired list. Under them, we had Inspectors of R.E. services, several Quartermasters R.E. and civilian Engineers. The Inspectors of R.E. services were at first employed as D.O's, in accordance with a peace organisation which started about 1906. As the work increased, several of my C.R.E's reported that they were overwhelmed by the increase in routine papers, such as bills and contracts, and this difficulty was enhanced by the withdrawal for service overseas of most of the expert subordinate staff. Fortunately here, as in the case of officers, we were able to draw on retired R.E. and on the very valuable group of permanent civilian staff. On going into figures I found that several of my C.R.E's were handling 4,000 bills every month, and it was quite the usual practise for a C.R.E. to reach his office at 6.30 p.m., after a long day's work outside, to find 150 bills waiting his inspection and signature. To meet this want I decided, after consulting the D.F.W., to give each C.R.E. the assistance of an Inspector of Works, and to allow C.R.E's to delegate to these officers much of the routine work connected with contracts and bills and the signing of routine papers.

The arrangements for the custody and record of R.E. stores proceeded on peace lines, and finally each C.R.E. had the assistance of an "Officer in Charge of Stores," usually a Qr.-Mr. R.E. The Qr.-Mrs. R.E. who were not employed with stores were employed as Division Officers, and were generally detailed to Divisions in Fortresses or in barrack areas, where their special knowledge of details was most valuable.

The civilian Division Officers were selected by the D.F.W. at the War Office and posted to the Command, where we distributed them to the best advantage. These gentlemen had considerable engineering experience, some having held high positions in India or the Colonies.

In addition to the above, each C.R.E. had the services of two to four Land agents and House Valuers, and had power to settle small claims without reference to Command Headquarters.

Execution of Work.

In the execution of work outside the Coast fortresses it was necessary at first to rely entirely on contract labour. Inside the fortresses there was a small nucleus of military labour available, though this was soon drafted away. In the summer of 1915, as men wounded or sick in the earlier fighting began to drift back to the depots, a letter was received from the War Office suggesting that among these might be found some men with qualifications at a trade who might be formed into "Infantry works companies," of 100 men each under a subaltern, and authorising *one or more* such companies being formed in each Command. On obtaining the names of suitable men from reserve battalions, depots, etc., the first list exceeded 1,000, so the M.G.A. approved at once of the formation of ten companies, and this was rapidly extended to twenty-five companies in all. These were distributed to C.R.E's and useful employment was found for them in such work as levelling aerodromes, preparing sites and making roads.

This development went rather faster than the War Office had intended, but after a conference at the War Office of Chief Engineers of Commands affected, the organisation was approved, with the addition of a Captain to each company and a further addition of a Major for each four companies, who could relieve C.R.E's of the duties usually done by a Battalion Commander.

A reference must also be made here to the very valuable assistance given us by the Road Board under the direction of Mr. Maybury (now Sir H. Maybury, K.B.E.) their Secretary. This body practically acted as contractors for all road services. In busy areas the Road Board appointed representatives called Roads Officers, and C.R.E's and D.O's were authorized to apply direct to these officers for all ordinary road services, whether the repair of a public road or the construction or maintenance of a road in a hutment or camp.

Excluding the above we did most of our work through Contractors of all sorts and conditions.

(*To be continued*).

TUNNELLING IN THE SAND DUNES OF THE BELGIAN COAST.

By CAPT. H. TATHAM, M.C., A.R.S.M.DIC.

Republished by the kind permission of The Institution of Mining and Metallurgy.

THIS paper is intended to describe the work of the Tunnelling Companies in the sand dunes of the Belgian coast, where, in the writer's estimation, the engineers had to contend with the most difficult ground, and, therefore, the most interesting on the whole of the Western Front.

The sand dunes in the Nieuport area run along the coast in a belt, from three-quarters of a mile to two miles in width. The sea is very shallow near the coast, and the sandy beach rises rapidly from about half-tide mark to a ridge of sand dunes, which reach an average height of about 40ft. above high-water mark, and gave good cover to many dug-outs constructed in them. On the land side of these is usually a swamp, with little ranges of dunes running parallel to the coast in it; this was called the " Brackpan," and in it most of the wells were sunk. On the further side of this the dunes rise again and again, giving good cover for dug-outs.

This is only really true for the country behind the Oust Dunkirk-Oust Dunkirk Bains Road, as the " Brackpan" dies out in front of the road giving place to a third range of dunes between the other two, which in front of Nieuport Bains all merge into one.

This is best illustrated by a rough section shown in Fig. 1. In the distance will be seen Olympus, which was a large sand dune standing nearly 100-ft. high, and affording an excellent position for the numerous observation posts which were constructed in it.

The work done in this area can most conveniently be divided into three main headings—(1) Wells; (2) Dug-outs, and (3) Sinking Elephant Shelters.

(1) *Wells.*—These were mostly sunk in the " Brackpan " though we actually put down one well on the seashore and obtained fresh water at about high-water level.

The water level in the " Brackpan " was only 6-in. to a foot below the surface, and as all the ground was running sand, the caisson method, which we adopted, was necessary right from the surface.

The largest size of ready-made caisson which we could obtain was only 4-ft. 6-in. in diam., and as this was considered to be too small for the requirements, we had to resort to making our own. These consisted of a number of circular sets (made like a "Bull Wheel" of a standard drilling rig) studdled apart and lagged externally with corrugated iron; the bottom 18-in., or cutting edge, was

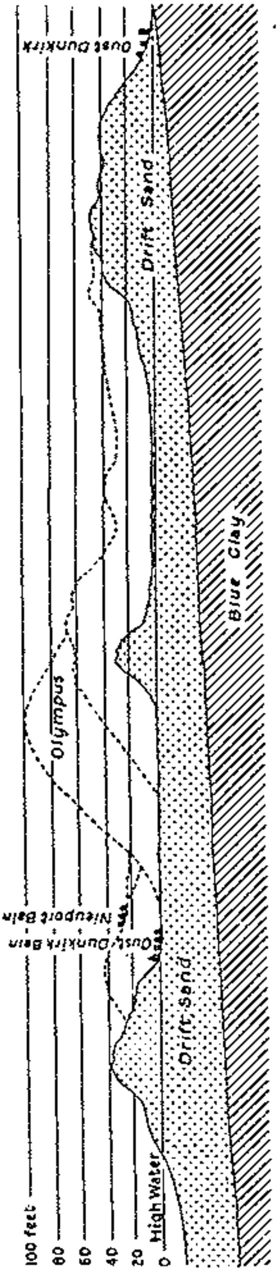


Fig. 1.

strengthened with two iron sets, composed of two angle irons each, bolted together.

The external diameter was 9-ft., and each section was 7-ft. high, and fitted into the one below. (See Fig. 2).

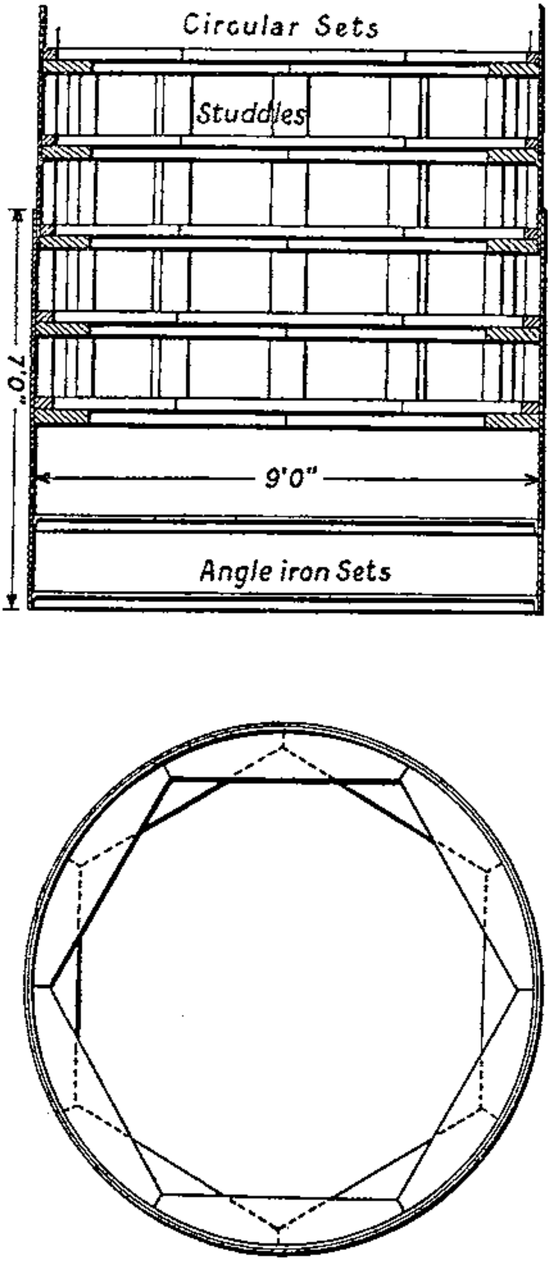


Fig. 2.

The method of sinking was by hand excavation, which gradually allowed the whole caisson to sink; to aid this it was weighted internally with wet sandbags, which completely filled the well, with the exception of a small central hole about 2-ft. × 2-ft., extra weight being added by a large heavy superstructure of pit props and sandbags. The sand was hoisted up the central hole in buckets.

Water was very heavy right from the surface, and was at first dealt with by "Dando" hand pumps, but though as many as twenty-four were working at one time in one well, the water beat them at about 12-ft., and the suction pipes nearly filled the central hole, making hoisting extremely difficult.

Finally electric "Pelepone" pumps were installed, worked from a central generating station, and the wells were sunk to 25-ft., which gave about 20-ft. of water. Below this it was impossible to go, as we only had two pumps available for each shaft, with a capacity of 2,000 gal. per hour each, and at this depth they were only able to contend with the water at low tide, as the well made more than 4,000 gal. per hour when the tide was up, though it was nearly a quarter of a mile from the sea.

When the wells reached this depth a close-boarded bottom of 3-in. timber was put in under the last timber set, to prevent the sand from boiling up. Some 15 wells were sunk by this method.

(2) *Dug-outs.*—It was only possible to make dug-outs in sand dunes which rose to the height of 30-ft. above high-water mark, as 20-ft. of cover was necessary for their safety; the galleries were 6-ft. high, which allowed 4-ft. for undulations in the top of the dune.

Galleries and Inclines.—The standard size of gallery driven was 6-ft. × 2-ft. 6-in., widening out to 4-ft. for chambers which could not be made wider with safety with the timber available. Though the system employed—piling boards and face boards—is common throughout the world for bad ground, and is probably known to every member of the Institution, a short description may be given to illustrate our method of employing it in this area.

In the first place the sets used were only 4, 5 and 6-in. wide, but later, as our miners became more skilled in this method of timbering, sets up to 11-in. wide were used in fairly damp sand.

The dunes mostly consisted of perfectly dry silver sand, which would run if left unsupported for one moment; so bad was it in some places that it would run like water from the smallest hole. For instance, on one occasion one of my men was knocked down and buried over his head in less than a minute by a stream of sand issuing from a hole which could have been blocked by a closed fist could it have been reached in time. As it was he was buried for over an hour and face boards had to be worked back over him before he was freed.

The entrances were driven level into the dunes until 2 or 3-ft. of cover was obtained, then, by inclining the sets in the head and side and top lagging, the level was converted into an incline of 60° dip, which was carried on until the sand became damp, which was usually at about 2 or 3-ft. above water level, then the gallery was driven level once more (Fig. 3), which meant that the bottom of the gallery would be about 6-in. above water level, thus taking advantage of the full height of the dune.

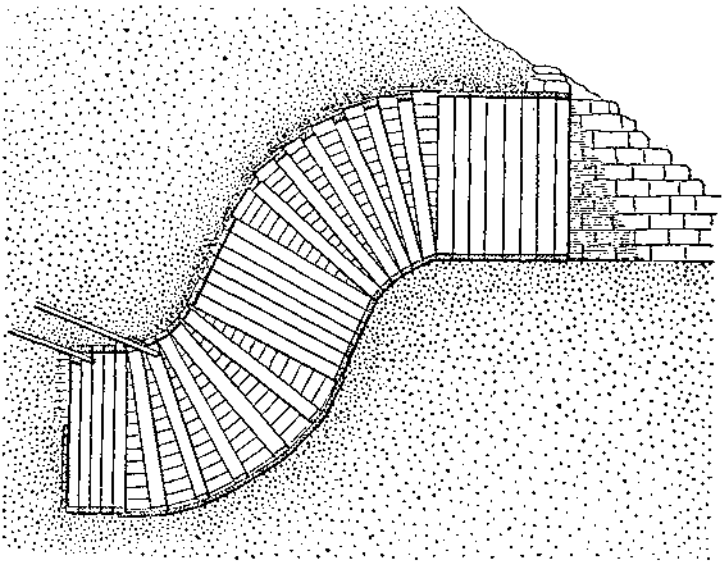


FIG. 3.

The face boards had to be inserted when part way round this bottom bend, and used from this time forward ; the piling boards were put in over the first vertical set (or sometimes earlier), and the cap of the previous set lifted to allow them to pass. After this they were set on a false cap resting at an angle on a pair of legs nailed to the permanent legs and driven forward at a fairly steep angle to allow a cap to be put under them on the legs of the second or third set forward.

The face boards were worked forward, one at a time, for the width of one set and held in place by " chocks." When the whole face had been advanced in this manner, the sill was laid and a " soldier " was set (consisting of an upright and sprag) to take the weight (see Fig. 4) while the chocks on one side were removed, and the leg quickly inserted, and held in position by wedges between it and the face boards. Then the operation was repeated and the cap put on, if there was sufficient room below the piling boards ; if not they were spragged apart with a stretcher. Each shift drove up their own piling boards, which they put in on the previous day, that is to say, some 9-ft. back from the face. For, if each set of piling boards were driven up as they were finished with, the hammering would disturb the face and cause a run. The caps left off to allow the piling boards to pass through were inserted as the latter were driven up out of the way.

Shafts.—For observation posts it was necessary to sink vertical shafts, to connect with the dug-outs, and as suitable places for observing the enemy were also suitable places to be observed by him, it was impossible to do any surveying by daylight and impracticable by night as no lights could be shown, not so much on account of the risks run by the officer making such a survey, but for fear of giving away the position of the observation post. So we were faced with the problem of how to make a good holing between the bottom of our shaft and the dug-out, as obviously it was impossible to timber from the bottom upwards, as is the usual practice in normal ground.

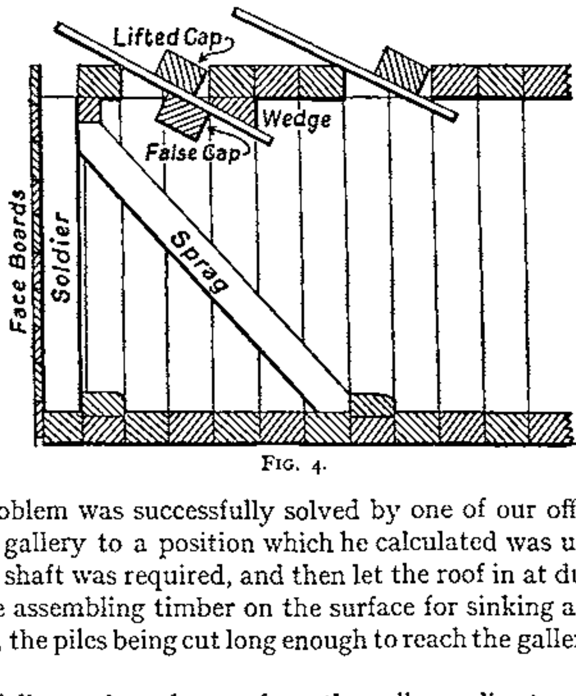


FIG. 4.

This problem was successfully solved by one of our officers, who drove his gallery to a position which he calculated was underneath where the shaft was required, and then let the roof in at dusk, at the same time assembling timber on the surface for sinking an ordinary pile-shaft, the piles being cut long enough to reach the gallery without an inset.

As the fall was cleared away from the gallery, allowing more sand to come in, it ran up to the surface, forming a fairly small vertical hole, at first. The first set was laid over this and the piles quickly placed round and pushed down rapidly, carrying the set with them. All the spoil was removed through the gallery, allowing full scope for the timbermen in the shaft. By this method shafts were sunk 18 to 20-ft. deep in a night, and no signs were left on the surface of the dune in the morning in the shape of wet sand, timber, etc.

Surveying.—One of our great difficulties was surveying in this part of the line. The only instruments provided were a 4-in. prismatic compass and "Abney" level. A number of the holings made were bad in direction, and closed traverses never closed. Sometimes back sights and foresights differed by as much as 20° and seldom checked.

This, we discovered, was due to the enormous amount of iron, in the form of shrapnel, shells, etc., just under the surface of the sand, for when certain winds blew, these were exposed in such quantities, that it is no exaggeration to say that one could not put one's foot to the ground without treading on iron. The greater deflections were usually caused by hidden reserves of ammunition buried a few inches below the level of the sand, to conceal them from German aviators and unwary surveyors.

(3) *Sinking Elephant Shelters or Trench Cupolas.*—These were in sections of ⅔rd of a circle of 4-ft. 6-in. radius, that is to say, that the centre was situated 18-in. above the chord, which formed its base; they were built up of sections 3-ft. wide (excluding lap) and made of heavy section iron, corrugated into 6-in. channels. Each section was composed of two half sections with channel irons bolted on to the upper ends and angle irons to the lower.

A full-size Elephant was 18-ft. 3-in. long, and this was the size which we usually sunk. In the process of sinking, the pressures to be contended with were almost entirely lateral and end pressures, and to resist these the whole structure was built and bolted down to a strong timber frame, strengthened longitudinally by steel I-beams, studdled apart to distribute the lateral pressure, and prevent the whole from bending and breaking its back. The I-beams used were 11-in.×5-in., and all the timber of the frame was 9-in.×3in. (except the distance pieces between the studdles in the web of the I-beam, which were 10-in × 2-in.) as nothing heavier was available. (Detail drawings are shown in Figs. 5 and 6.)

The ground was first excavated to an average depth of 6-ft. to give cover for the erecting gang, then the frame and Elephant were built exactly over the spot where they were required.

The sand was then excavated from under the frame from inside, and at first thrown out at both ends, leaving the frame supported on pillars of sand in the corners until last. When the sand had been removed for a foot clear underneath the frame, the four pillars were simultaneously but gradually withdrawn, and the whole structure was allowed to settle down, and then the operation repeated.

When the Elephant had been sunk in this manner some 5-ft., one end was completely, and the other partially, lagged up. Usually one end of the Elephant was to be connected to a drive, from a dug-out, which had already been driven to within a foot of the final resting place of the Elephant, and the other end was to be connected to an inclined entrance, which was to be constructed after the lephant had reached its final depth. (See Fig. 7.)

In this case the following method of lagging was found to save much time and trouble. A set, 5-ft. 9-in. × 2-ft. 6-in. of 6-in. × 3-in. timber, was placed on each of the end dividers and in the last

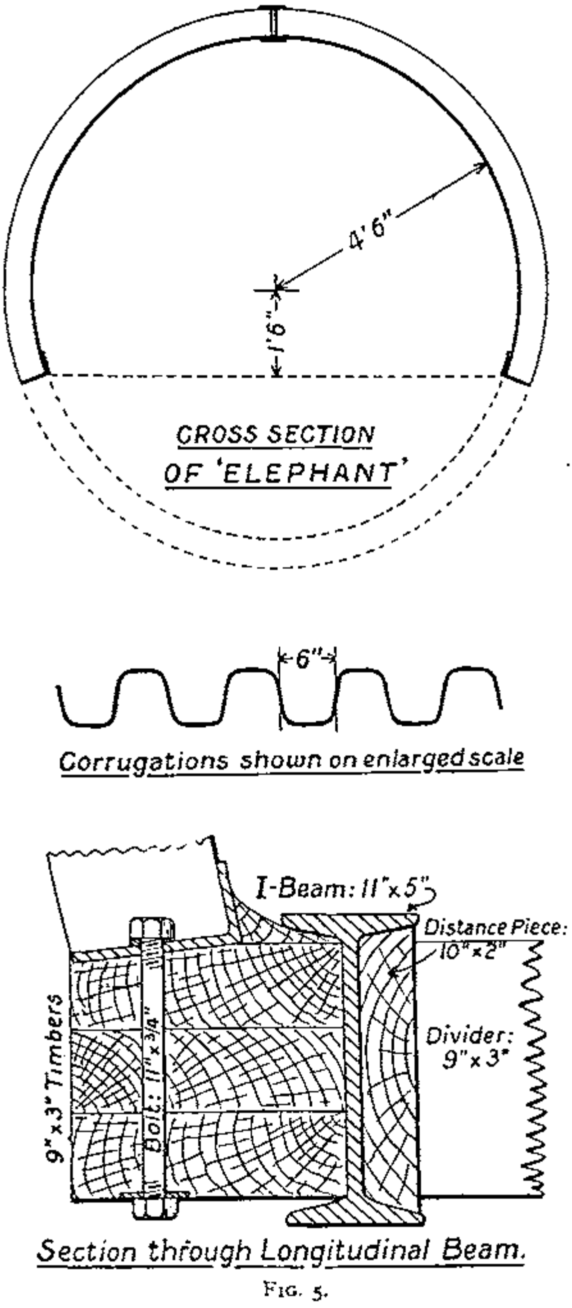


Fig. 5.

corrugation of the Elephant, and vertical lagging set on each side nailed to the end divider at the bottom and held together at the top by diagonal braces nailed to them on the inside, which also kept the sets square. The set on the end to be closed was boarded across horizontally with lighter lagging, lightly nailed in place from the

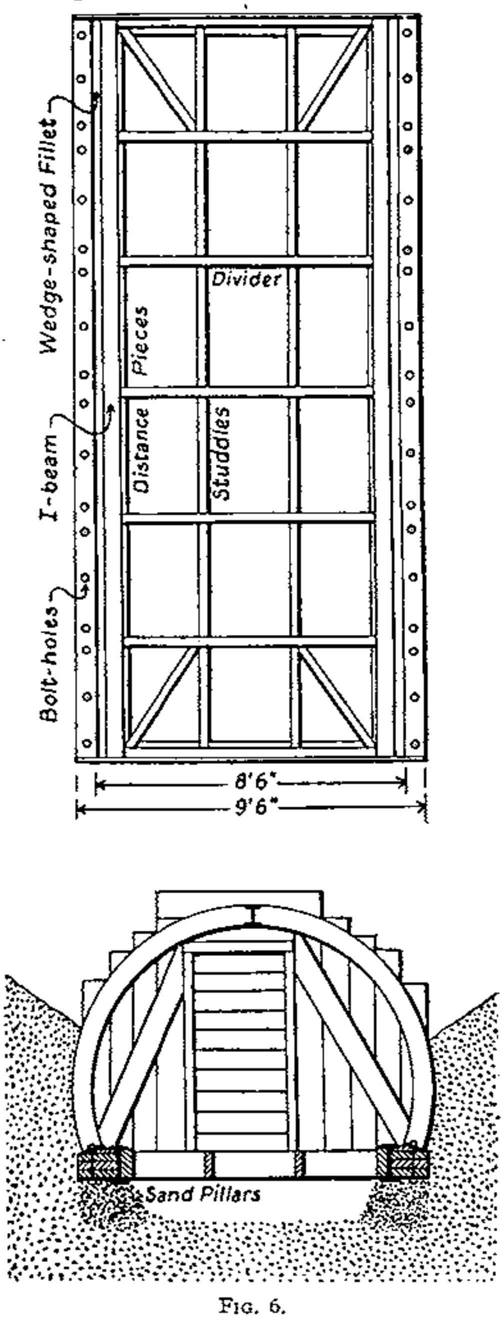


FIG. 6.

outside, so that they could be knocked out from inside afterwards, and used as face boards.

The two sets were prevented from collapsing inwards by a 9-in. × 3-in. stretcher running from the one to the other in the crown of the arch, under which pit props, with their feet on the frame, were set to strengthen the roof and hold this stretcher in position. (See Fig. 8.)

From then onwards all the sand excavated was taken out to one end only, and as much as possible built on top of the Elephant. In order to keep this end open as the Elephant sank, Canadian mud scoops, drawn by pairs of mules, were used with considerable success.

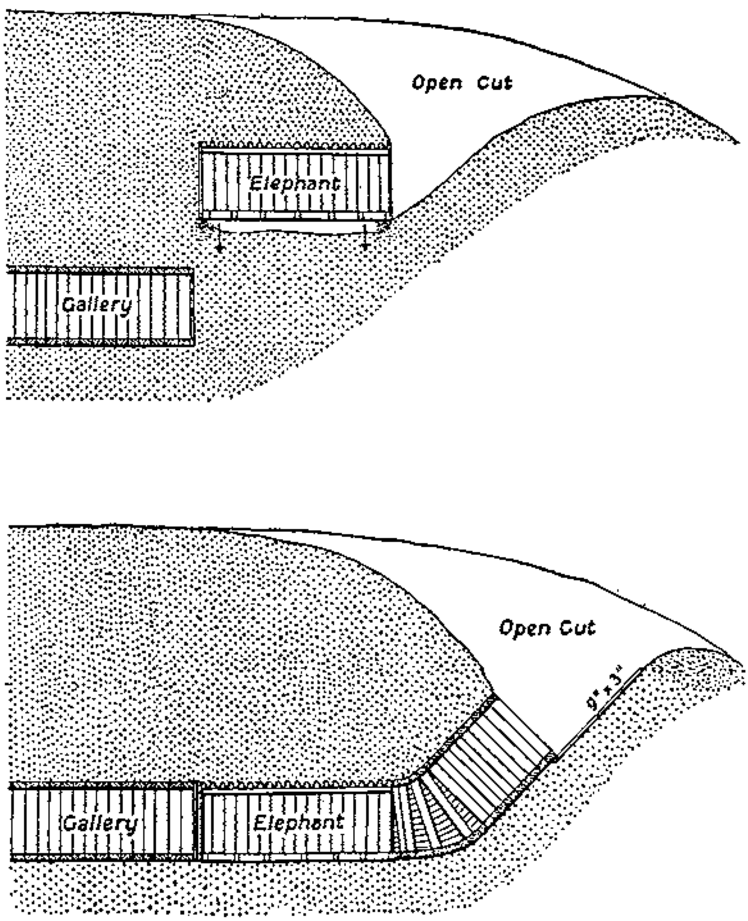


FIG. 7.

Towards the end of the operation the incline became too steep to use these efficiently, and the sand had to be shovelled up from bench to bench.

When the Elephant arrived level with the gallery, which was determined by driving an iron rod through the sand between the lagging, the sinking operations ceased and sand was well grouted in under the frame to prevent settlement.

The closed end was next opened up and connected with the gallery, and then the incline was built up from the bottom, and mud scoops were again employed with great advantage to replace the sand.

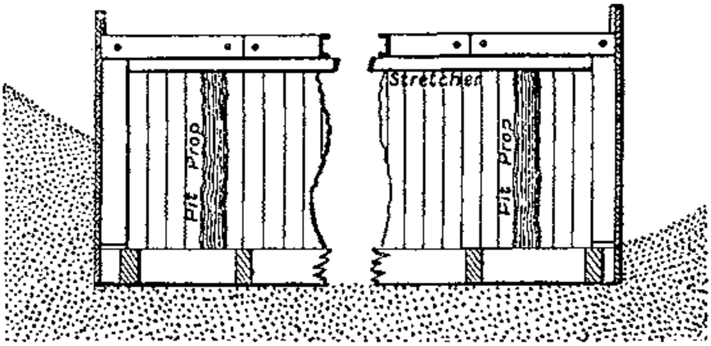


FIG. 8.

By this or similar methods, varying only in detail, a large number of Elephant shelters were sunk in the area to a depth giving from 18 to 25-ft. of cover, and thus overcame the difficulty of chambering in sand.

ENGINEERS IN THE RETREAT TO CORUNNA.

By BREVET-MAJOR R. H. DEWING, D.S.O., M.C., R.E.

THE retreat to Corunna is not a bright page in the story of the Corps. Fortescue in summing up the campaign says " the destruction of the bridges . . . . failed with discreditable frequency through the inexperience of the engineers. Matters which to the French were elementary knowledge were absolutely strange to the British."

Possibly for this very reason the engineer work of this period is dealt with very sketchily in most of the accounts of the operations, and all that is now possible is to piece together such disjointed details as are to be found amongst the numerous stories of the retreat.

When we come to consider the conditions under which the retreat was carried out, the small number of engineer personnel with the army and the inadequacy of the training they had received before proceeding to the Peninsula, we cease to wonder at their failures. Rather we are amazed that under the circumstances so much work was done and any successes at all were achieved.

The conditions under which the work had to be carried out appear fairly clearly in the narrative which follows. What we are told in detail of one or two episodes is probably true of a great many others, of which detailed accounts are lacking.

The total engineer personnel with Moore's army of 25,000 men numbered about 14 Royal Engineer Officers and 34 rank and file of the Military Artificers. In our Army to-day the Royal Engineers number about one to every thirteen rifles; at its apex during the Great War the proportion rose to one to every seven rifles. Sir John Moore had one engineer to roughly five hundred rifles.

The officers of the Corps at that time passed as cadets through the R.M.A. at Woolwich; but they underwent little practical instruction there likely to be of any value to them on service. " They were sent on service without ever having seen a fascine or gabion, without the smallest knowledge of the military passage of rivers, of military mining, or of any other operation of a siege, excepting what they might pick up from French writers."(1)

Among the Royal Engineers who served in this campaign were several who rose superior to these handicaps. Fletcher, afterwards of Torres Vedras fame, was the Commanding Engineer. Charles Pasley was serving in the rank of Captain, and John Fox Burgoyne in that of Second Captain.

(1) Report by Sir Chas. Pasley. See Porter's History of the Corps of Royal Engineers.

The Military Artificers for the force were provided by drafts grudgingly supplied from the companies of that Corps which occupied permanent stations in England, Gibraltar and the West Indies. The state of vegetation into which these Companies naturally degenerated, and the purely garrison duties on which they were employed, were not conditions calculated to prepare the men for service in the field.

Though practically all the Military Artificers available in Spain at the time were with Sir John Moore's Army, their meagre numbers made any organisation in companies quite impossible, and they were distributed through the force in small detachments of a few men each. Under these circumstances it was necessary to depend very largely on infantry working parties for labour, even of a semi-technical nature.

For the purposes of this sketch it is enough to follow the operations from December 23rd, 1808. On that date the greater part of Moore's Army was concentrated at Sahagun, whither he had moved forward preparatory to attacking Soult at Carrion and Saldana.

With Moore were Lord Paget's Cavalry Division and the divisions of Sir David Baird, Sir John Hope, and Lt.-Gen. Fraser, the Reserve Division under Maj.-Gen. E. Paget, and the two Light Infantry Brigades under Crawfurd and Alten.

On the 23rd Moore received news which led him to cancel his intended offensive against Soult, and issue orders for withdrawal westwards. About noon on the 24th, when the first of Moore's divisions started back from Sahagun, the great retreat had begun.

Baird's Division moved by the northern road to cross the river Esla at Valencia de Don Juan. Hope, Fraser and E. Paget moved via Mayorga, and by the 27th were safely across the Esla at Castro Gonzolo, leaving Crawfurd's brigade to cover the bridge until Lord Paget's cavalry, which had been holding off superior numbers of French cavalry, had withdrawn through it. The cavalry finally withdrew through Crawfurd's Brigade on the 28th (2).

Meanwhile Burgoyne had been sent back to prepare the bridge at Castro Gonzolo for demolition. The road here was carried across the Esla on a bridge of some ten or twelve narrow stone arches, the solid masonry of which proved difficult to cut.

The work was not begun until the 27th and was then carried out in torrents of rain and snow by men of Crawfurd's light infantry, while the rest of the brigade held a covering position on the east bank.

It had at first been intended to cut a single arch, but later it was decided to cut two arches and then blow up the central pier between them.

(2) Oman. Napier says 27th.

From Napier's account it appears that the actual cutting of the arches was done by manual labour, powder only being used for the pier. This possibly explains the inordinate time taken over the demolition, for the preparations were not complete until early on the morning of the 29th.

Indifferent equipment may also have contributed towards the delay, for Captain Charles Boothby, R.E., who was down at the bridge shortly before it was destroyed, notes in his diary that "The teeth of the cursed saws refused to do their duties, and hours are spent in sawing the woodwork."

When at last all was ready the troops withdrew silently from the heights on the left bank, where they had been in contact with the French Cavalry for the past twenty-four hours, and passed across the broken arches on planks placed over the gaps.

The darkness of the night, the noise of the storm and the roar of the flooded river combined to conceal the withdrawal from the enemy, who did not interfere in any way.

When all were safely across Burgoyne fired the charge and demolished the central pier successfully. It was not until the 30th that the French restored the bridge sufficiently for the passage of artillery.

While the French pursuit had been held up at Castro Gonzolo Soult had begun to move by the more direct route from Carrion via Mansilla on Astorga. Romana's Spanish force at Mansilla failed to break the bridge at that place, and, though criticism of this failure does not come well from the English who themselves failed so often in their own demolitions, the danger of being cut off at Astorga to which Moore was thereby exposed forced him to hasten his retreat.

Our own historians make no mention of demolitions between Benavente and Astorga, but if we may accept the story told by Baron de Marbot it would seem that our Sappers suffer an injustice here.

De Marbot was at that time a Captain on the Staff of Marshal Lannes, and he recounts that in the course of the French pursuit from Benavente to Astorga on December 31st their men were five or six times compelled to strip, place their arms and clothes on their heads, and go naked through the icy waters of the streams, as all the bridges had been broken by the English.

About this time a certain number of the Royal Engineers, and among them some of the more experienced ones, were despatched on various reconnaissances. The number of R.E. Officers remaining for the vital work of demolition at the rear of the retreating army was thus further reduced.

Major Fletcher was sent to Ferrol and Corunna to report on the capabilities of those places for the embarkation of troops. He reported on January 5th that he had examined the ground between

Ferrol Harbour and the bridge at Puente de Humo and had found no favourable ground where a vanguard could cover the embarkation. In a second report he wrote much more favourably of Corunna.

These reports, together with that of Burgoyne, who had been sent on a similar mission to Vigo, reached Sir John Moore at La Herrerias and decided him to make his embarkation at Corunna.

Captain Carmichael Smith had been sent to report on positions between Astorga and Corunna where the Army might find favourable ground for a stand. He reported that a position west of Cacabellos was by far the strongest position between Astorga and Villa Franca.

Another "very sensible Officer of Engineers" (3) reported on January 1st from Puebla de Senabria, whither he had been sent to promote the defence of the place, that little was to be expected of the Spaniards there, whose attitude was a purely passive one, relying on "hopes of protection from God and the English Army."

At Astorga Crawfurd's and Alten's Brigades separated from the main army to march via Orense to Vigo.

The main army continued on the road to Villa Franca, where it arrived on January 1st.

No mention has been found of any further attempts at demolition of bridges east of Villa Franca. Sharp fighting took place on the 3rd at the crossing of the River Cua at Cacabellos, which would have seriously interrupted any preparations for the demolition of the bridge there. The time gained by the Reserve Division on the Cua was probably used by the engineers for the concentration of their efforts on the bridge on the western outskirts of Villa Franca.

The Army had halted for two days at Villa Franca, and here discipline completely broke down. Already on the retreat disorder had been common enough; very severe orders against indiscipline had been issued, and drastic punishments had been carried out, but these were not enough. Bitter disappointment at being forced to turn their backs on an enemy whom they had been confident of beating, the laxity of some of their officers, and the hardships of the retreat now combined to destroy the last vestiges of discipline in many of the battalions. Many of the troops got entirely out of hand and devoted themselves to plunder, murder and drunkenness.

The main body marched on the 3rd leaving drunken stragglers in the streets behind them. The story told by a Commissary who remained in the town till the last gives a picture of the state of affairs at the tail of the column.

"On the afternoon of the 4th January (4) some sharp firing, intermingled with gunshots was heard just outside the gates of the town. Many of the rearguard marched in and told us as they went by that things were very warm out there .... A Sapper

(3). Capt. Charles Boothby, R.E.
(4) 3rd, according to most authorities.

Officer then galloped through the streets shouting that by 6 o'clock everybody was to be over the bridge as it was then to be blown up. Now the uproar began! Women, children, the sick, and baggage waggons all tried to get across at once. The troops making their way across by force slowly marched away regiment by regiment, while other troops fresh from the battle outside, arrived in the town . . . .

" The sun sank towards the horizon. The fire of the skirmishers became so fierce at the entrance to Villa Franca, where I happened to be standing, that the bullets rattled on the surrounding roofs. The rearguard poured in in masses. One or two Sapper Officers ran hither and thither, urging everybody to proceed to the bridge, for the gate of the town was not going to be held after the bridge had been blown up. Now all who still happened to be in the town made haste to escape . . . .

" On the bridge, which was somewhat elevated and narrow, I and my horse were carried shoulder high by the throng, and were frequently almost crushed by the ammunition carts. At last I reached the other side. . . . Night soon fell, and we marched slowly forward in the darkness. A loud report in the direction of Villa Franca announced that the bridge had been blown up, and at the same moment the horizon was illuminated as if the town were in flames."(5)

Unfortunately the Commissary's conclusion was wrong, for the demolition had actually failed.

On the 4th (6) the Reserve Division reached Nogales after a forced march. On the 5th they marched on to Santa Maria de Constantin.

The engineers made two unsuccessful attempts to blow up the bridge at Puente Ferreira. (7) Perhaps their powder did minor damage, as the French cavalry are said to have been somewhat delayed at the bridge.

Napier's explanation of this failure reads too much like special pleading to exonerate the engineers. He says the failure was of little consequence " for the river was fordable above and below, and the general was unwilling, unless for some palpable advantage which seldom presented itself, to injure the communications of a country he was unable to serve; the bridges also were commonly very solidly constructed, and the arches having little span, could be rendered passable again in a shorter time than they could be destroyed. Moreover the road was covered with baggage, sick men, women and plunderers, all of whom would have been thus sacrificed."

These arguments might justify the General in ordering no demolitions to be attempted, but in no way explain failure when charges were actually laid and fired.

(5) Schaumann. "On the road with Wellington."
(6) Oman and Fortescue. Napier says 5th. (7) Fortescue.

On the evening of the 5th yet another failure was experienced. At Constantin the road crossed a deep sunk river by a stone bridge, but the attempt of the engineers to blow up the central arch was unsuccessful.(8) Paget's rearguard held the French in check on the line of the river until nightfall.

On the following day the Reserve reached Lugo, where Moore had halted his main body on a position east of the town.

Somewhere between Constantin and Lugo the Commissary who has already been quoted, passed across "a magnificent bridge composed of three arches, which looked like an aqueduct, and led across an abyss through which foamed a mountain torrent. Both the ravine and the bridge were regarded by many as a bulwark which, the moment the bridge had been blown up, would protect us for a few days from the French, who were hard on our heels."

There he saw an officer and a party of sappers who had bored two holes into the centre of the bridge, and were preparing to blow it up; but this charge, too, was destined to fail.

The Commissary says that " a good deal of fun was poked at the English Sapper Officers, owing to their obvious incapacity and lack of skill; and it was deserved, for it was unpardonable and caused our army an incalculable amount of harm."

In front of Lugo Moore's Army stood throughout the 7th and 8th in the hope that Soult would attack. The French Marshal decided to wait until he was concentrated in superior force before committing himself against the strong English position.

On the night of the 8th-9th Moore continued his withdrawal. Although careful preparations had been made to ensure that units should be able to move back by night without loss of direction, pitch darkness and a severe storm combined to obliterate the marks which had been put out to guide them, and many lost their way.

It is a relief to find that in spite of the resulting confusion the sappers succeeded in making a good job of the destruction of the bridge over the River Minho about 8 miles north of Lugo. (9) The French pursuit was thereby delayed on a day on which every hour's respite was of value, and it was not until noon on the 10th that Soult's engineers completed its repair.

The march of the Army from Lugo to Betanzos was marked by indiscipline and disorder even worse than any that had occurred earlier. This is enough to account for failure to carry out Moore's orders for the destruction of the bridges over the Rivers Ladra and Mandeo on the 9th. Powder spoilt by the rain and lack of skill in the laying of the mines are given as contributory causes.

The Army halted at Betanzos, still covered by Paget's staunch Reserve Division, until the 11th, when the main body withdrew to Corunna and the rearguard to El Burgo.

(8) Oman. (9) Fortescue.

At Betanzos there were two bridges, the one a stone structure of fourteen arches across the Mandeo and the other of timber, across the Mindo. The line of retreat lay across the latter, but the Mandeo bridge was also mined ready for blowing up.(10)

Sappers were still at work on the wooden bridge on the afternoon of the 11th when the French arrived on the scene and interrupted them. A battalion of the 28th drove the enemy's skirmishers back, but even then the mines failed, and so little damage was done that two French divisions were able to cross the bridge before dark.(11)

The withdrawal on the 11th brought the army to the west bank of the Mero, the last river to be crossed in the retreat. Here at last demolitions were carried out thoroughly.

On the night of the 11th the bridge by which the *chaussée* crossed the Mero at El Burgo was successfully blown up. The French needed forty-eight hours to repair it sufficiently for infantry, and it was not until the afternoon of the 14th that they got guns across.

Simultaneously with the destruction of the El Burgo bridge Lieutenant Davy R.E. blew up another bridge across the same river at Cambria.

This final success was accompanied by tragedy, for Davy lost his life in the explosion. Perhaps, as Napier suggests, mortified by previous failures, he remained too near the mine in his anxiety to ensure success; perhaps he lost his life through simple ignorance of the precautions necessary when firing the train of a mine.

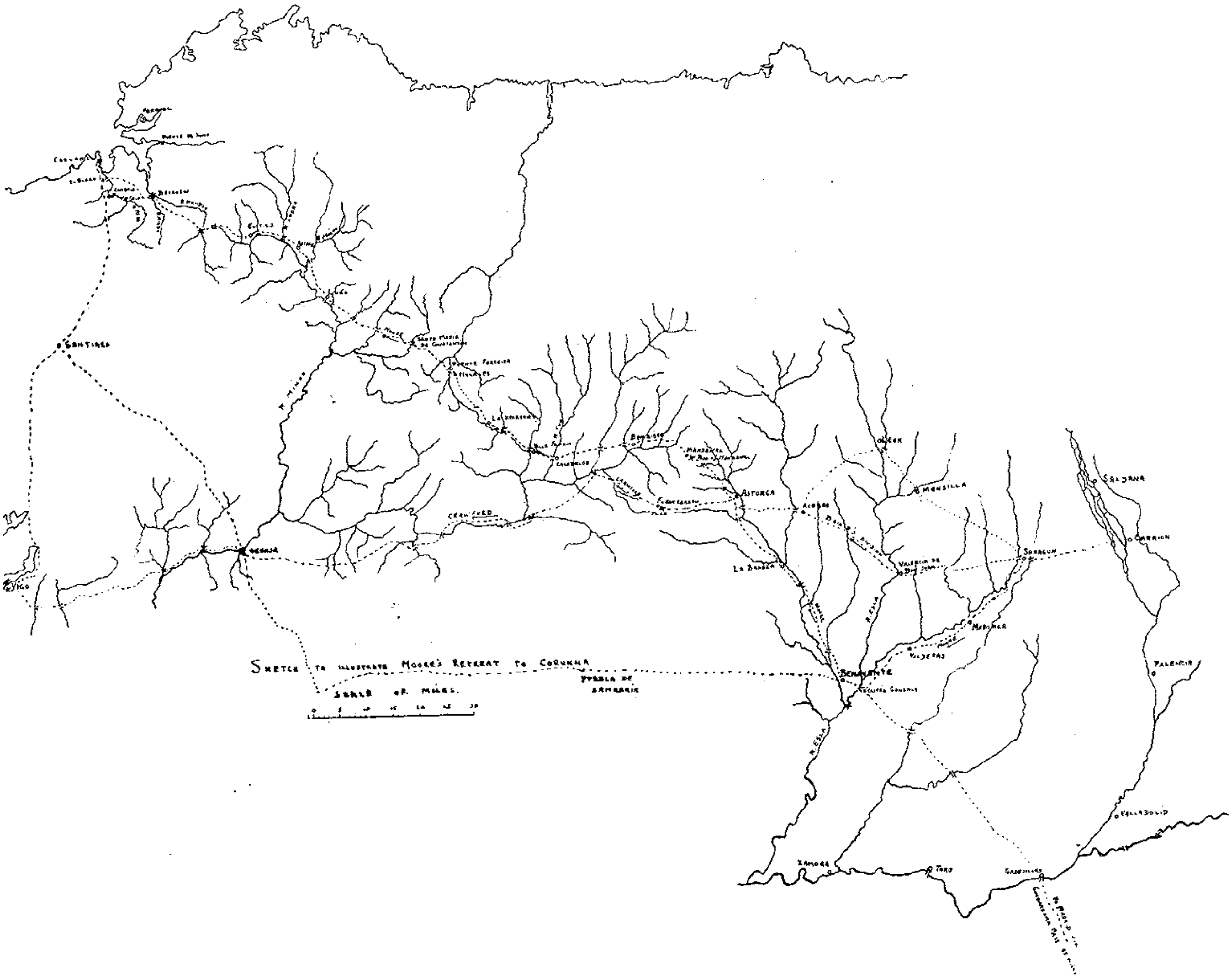
In either case his death stands as a proof that, whatever may have been the defects in the training of the Corps, its spirit at least stood as high as ever.

With the destruction of the two bridges over the Mero the main work of the engineers was over. Doubtless it was an engineer who lighted the train to blow up the great store of 4,000 barrels of powder at Corunna, whose explosion caused a shock which has impressed every writer on the campaign. There was work too to be done in strengthening the defences and erecting batteries at Corunna; but the main work was done, and, it must be admitted, badly done.

Yet out of this evil came good. So impressed was Pasley with the shortcomings of the Corps that he did not rest from urging the need for reform, until in 1812 his importunity was rewarded, and the Royal Engineer Establishment at Chatham came into being.

(10) Schaumann. (11) Fortescue.

ENGINEERS IN THE RETREAT TO CORUNNA.



THE POST-WAR ACTIVITIES OF THE ROYAL ENGINEERS.

(TRANSPORTATION BRANCH.)

BY MAJOR L. C. OWEN, D.S.O., R.E., D.A.D. TRANSPORTATION.

THIS article is intended to supplement the article, under the same general heading, which appeared in the *R. E. Journal* for September, 1924, but in which only a passing reference was made to the Transportation Branch of the Corps.

Following the lines adopted in that article, transportation activities in India are not included.

1. REGULAR PEACE ESTABLISHMENTS (HOME).

In 1912 the R.E. Railway Depot at Longmoor consisted of the 8th, 10th and 53rd Railway Companies, R.E. The 53rd Company was, however, disbanded in 1913, leaving available in 1914 the 8th and 10th Companies only, each with a peace establishment of three officers and 106 other ranks, of whom 30 were recruits at Chatham.

The Railway Depot has now been renamed the Railway Training Centre; and a peace establishment has been authorised for it, consisting of 15 officers and 412 other ranks, exclusive of officers under instruction at Longmoor or on main line railway courses, and of recruits at Chatham.

The Training Centre includes :—

(*a*) Headquarters.

(*b*) 8th (Composite) Railway Company, R.E.

(*c*) 10th (Depot) Railway Company, R.E.

The Headquarters includes the administrative and instructional staff for handling both Regular and Supplementary Reserve Units: the 8th Company, in addition to its own peace establishment includes the peace nucleus for the other regular railway units of the Expeditionary Force: whilst the 10th Company includes all personnel required for running the Military Camp Railways at Longmoor and at Larkhill, both in peace and on mobilization after the despatch of the railway units of the Expeditionary Force.

Up till December, 1923, the Catterick Camp Railway was also run by a detachment from the Railway Training Centre, but this has now been handed over to be worked by the London and North Eastern Railway as the agent of the War Department.

Since April, 1924, the Railway Training Centre has been kept well up to establishment strength, as far as numbers are concerned, which is a great improvement on the state of affairs that existed at the old Railway Depot before the war. At that time, owing to the very reduced numbers actually available, very great difficulty was experienced in carrying out the military and technical training of the companies, and at the same time keeping a minimum service of trains running on the Longmoor Camp Railway.

As regards the trades establishment, the field for railway trades is necessarily so much smaller than that for general corps trades that it has been found necessary during the collective training season to give every non-railway tradesman a general grounding in some railway trade. In addition a series of special courses with the main British Railway Companies have been recommended for selected N.C.O.'s, with a view to providing suitable N.C.O. instructors at the Railway Training Centre. These arrangements have had the effect of considerably improving the "trades position."

As regards the training of officers, two young officers are sent each year from the S.M.E. to the Railway Training Centre, to which they are posted for a period of three years. During this time they do two periods of six months on a civil Railway system, with an intervening period of six months to a year at the Training Centre. Whilst with the civil Railways all officers are instructed in railway maintenance, and in addition either in operating or mechanical work.

2. Regular Peace Establishments (Abroad).

(*a*) There is at present a small establishment of 12 officers and 85 other ranks allowed for the British portions of the Inter-Allied Rhineland Railway Commission and its Sub-Commission at Cologne.

The duties of the Commission and the Sub-Commission are to supervise the German Railways in the occupied territory, and as far as the Cologne Sub-Commission is concerned, in the British zone in particular, so as to ensure that the railways in that zone are maintained to meet any possible Allied requirements, and to prevent as far as possible any militarization by the Germans of the railways in occupied territory in contravention of the Treaty of Versailles. This work entails the close supervision of locomotives, rolling stock and permanent way, and opportunities are thus available for training the British railway personnel on an open line railway.

(*b*) It is hoped to arrange for small parties of officers and N.C.O.'s to be employed on survey or construction work on Colonial Railways, as was done in Nigeria in 1908-1911 on the Baro Kano Railway. At the time of writing tentative arrangements are in hand for two officers and six N.C.O.'s to be employed on the railways in Kenya Colony.

3. Transportation Requirements for War.

In 1914 the only regular transportation units available for the Expeditionary Force consisted of the 8th and 10th Railway Companies, R.E., each of four officers and 250 other ranks. At that time there was definitely no liability to find large numbers of transportation troops, as it had been laid down that the French would carry out all the transportation services required for the B.E.F.

As a result, however, of the experience of the War and the recognition of the vital importance of transportation, accentuated by the development of aircraft, heavy artillery, tanks, mechanical transport, etc., etc., all of which bring increasing demands on the main line of communication transportation services, it has been realised that considerably larger numbers of trained transportation units must be available early for the Expeditionary Force of the future. From the point of view of national economy, it was not desirable to raise all these units on a regular basis, but, as the majority of the personnel required are for construction or maintenance, operating and workshop duties, it was agreed that men enlisted on a militia basis from civil railway employ would be eminently suitable.

It was, therefore, decided to try to raise in peace time, from the employees of the main British Railway Companies, a certain number of transportation units to form part of the Army Supplementary Reserve and to work in war time alongside the regular units for which the 8th Railway Company, R.E. forms the peace time nucleus.

4. Procedure Adopted for Raising Transportation Units of the Supplementary Reserve.

(*a*) It was decided that, in view of the post-war grouping of the British Railways into four main groups, the most suitable way to raise these units would be with the co-operation of the General Managers of these Groups, and under the ægis of the civil railway organisation.

A meeting was, therefore, held at the War Office in May, 1924, between the Quartermaster General and the General Managers, at which the latter promised to give their utmost assistance to the raising by each of the groups of certain definite units. It was proposed that each unit should be composed of officers, N.C.O.'s and men drawn entirely from the employees of any one group, as by this method it was hoped to create an "esprit de corps" in each unit from its formation.

The units which it was desired to raise in the first instance, had already been decided on by the War Office, and, with the concurrence of the General Manager, the allocation of these units to the various groups was laid down on the following general lines :—

(*a*) Platelaying and operating units to the London and North Eastern and Great Western Railways.

(*b*) Docks units to the London and North Eastern Railway.

(*c*) Workshops and railway telegraph units to the London, Midland and Scottish Railway ; and

(*d*) Stores units to the Southern Railway.

It was found impossible to raise a Railway Bridging unit from any one group, but to maintain the " esprit de corps " idea it was agreed that each group should raise one section of this unit, the Great Western Railway, in addition, providing the personnel for the unit headquarters.

(*b*) The General Managers were then asked to nominate officers from their staff to be the first commanding officers of the various units, preference to be given as far as possible to those with previous military experience.

A further meeting was held in September, 1924, between the Assistant Director of Transportation, War Office, and these Commanding Officers to discuss preliminary details with regard to :—

(i) method of selecting officers and other ranks to complete units to establishment ;

(ii) location of headquarters and the general distribution of each unit ;

(iii) arrangements for enlistment, training, etc., etc.

It was decided that, as a first preliminary to the enlistment of other ranks, it was most desirable that uniformity should be obtained as far as possible with regard to the facilities to be given by the various Railway Companies to their employees to enlist, obtain leave for drills and annual camp training, etc. It was, therefore, arranged that a small Committee should be formed, consisting of one officer from each Railway Company, representing the Commanding Officers of the various units being raised by their Company, together with an officer from the Transportation Branch of the War Office, and that this Committee should draw up a draft general circular and forward it to the various General Managers with a view to an agreement being reached on any points at issue, and uniform instructions being issued to all concerned.

The Railway representatives on this Committee were :—

Lieut.-Col. V. M. Barrington Ward, D.S.O., for the L.N.E.R.
Major A. S. Quartermaine, M.C., for the G.W.R.
Major J. V. Denning, M.C., for the L.M.S.R.
Major H. A. Short, M.C., for the S.R.

These officers rendered the greatest assistance both on this Committee and in the subsequent preliminary work of recruiting and organising the units, and the Transportation Branch of the War Office are very much indebted to them for their help, which involved a great deal of voluntary work outside their official duties.

(c) A general circular for issue by the General Managers had been agreed to by the end of the year, the first one actually issued being that of the London and North Eastern Railway on December 20th, 1924.

Unfortunately, owing to a misunderstanding on the part of some of the Trade Union leaders as to the liability of Supplementary Reservists to be called up for military service during a civil disturbance, particularly as "railway strike breakers," the L.N.E.R. circular led to another being issued by the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen, advising their members not to join.

This misunderstanding was subsequently explained, and the circulars of the other three Railway Companies were issued about May 1st, 1925, and the formation of all units was proceeded with as rapidly as possible.

5. Organization and Administration of Supplementary Reserve Units.

The personnel is composed of two categories, B and C, of which Category B have to carry out training in peace time on the same general lines as personnel of the Territorial Army, whilst Category C are recruited in peace time and get an annual "retaining fee" bounty, like Section D of the Regular Army Reserve, but are not liable for any peace time training.

It was decided when the Transportation units were first being raised, to put all the personnel of the Construction units in Category B, but for other units to only include in Category B the officers and senior N.C.O.'s. This was done, as it was considered necessary to give *all* construction personnel technical training under military conditions in such work as rapid platelaying, demolitions, etc., whilst the personnel of other units, such as operating and workshop companies, etc., needed no special technical training, although a nucleus, even if the whole could not be made available, would require military training to enable them to administer, drill, etc., their units.

Each unit has up to the present been linked up, as far as Category B personnel are concerned, for administrative purposes with a County Association of the Territorial Army, through whom, under the Command concerned, all arrangements for the enlistment, clothing, drills, musketry, etc., of personnel are made. Category C personnel are enlisted through the Regular Army Recruiting agencies and are administered by the Officer i/c R.E. Records.

6. TRAINING OF SUPPLEMENTARY RESERVE UNITS.

As stated in the previous paragraph, the military individual training, including drills, musketry, etc., is carried out under Territorial Army arrangements, but the Commandant, Railway Training Centre, at Longmoor, is responsible, under the Transportation Branch of the War Office, for the technical training of personnel.

It had been hoped that all the Railway Recruiting Circulars, referred to in paragraph 4 (*c*) above, would be issued in January, 1925, and that recruiting and the initial organisation of the units could be carried out between then and June. A programme for the technical training of both regular and reserve units at the Railway Training Centre was, therefore, drawn up, under which the reserve units would do their annual camp during the months of June, July and August. Owing to the delay in the issue of the circulars and consequently in recruiting, this programme had to be amended, but it was still found possible, commencing on July 8th with No. 1 (L.N.E.R.) Platelaying Company, to carry out the annual camp training for all construction units and the Category B portion of other units. During this training, the construction units carried out certain technical work, and in addition all units were given instruction in collective training, unit administration and the organisation of the army transportation service. The attached table shows the establishments, Categories B and C, of the various units, the numbers attending annual camp, and the actual strengths of units on September 28th, from which it will be seen that, considering the short time available since it was definitely decided to launch the formation of these units and the difficulties experienced in the initial recruiting, organisation and administration, very considerable and satisfactory progress has been made. For this great credit is due to the Officers Commanding the units and their headquarters personnel, and to the Railway Companies and County Territorial Associations concerned for their co-operation. As a result of this year's annual camp training having been adhered to in spite of the difficulties experienced, it is hoped that all units will be practically up to strength by the end of the financial year, and that full numbers will be able to attend camp next year.

SUPPLEMENTARY RESERVE R.E. (TRANSPORTATION).

Numbers present at ANNUAL TRAINING, 1925, and ACTUAL STRENGTH on 28th September, 1925.

Unit.	Establishment.						Numbers at Annual Training Category B.		Strength on 28th September, 1925.					
	Category B.		Category C.		Total.				Category B.		Category C.		Total.	
	Offrs.	Other ranks.	Offrs.	Other ranks.	Offrs.	Other ranks.	Offrs.	Other ranks.	• Offrs.	Other ranks.	Offrs.	Other ranks.	Offrs.	Other ranks.
No. 1 (L.N.E.) Rly. Platelaying Co. •	6	264	—	—	6	264	6	171	6	197	—	—	6	197
No. 2 (G.W.) Rly. Platelaying Co.	6	264	—	—	6	264	6	96	6	108	—	—	6	108
No. 1 Railway Bridging Company	6	264	—	—	6	264	6	94	6	95	—	—	6	95
No. 1 (L.M.S.) Adv. Rly. Workshop Co.	3	13	—	256	3	269	3	7	3	10	—	111	3	121
No. 2 (L.M.S.) Base Rly. Workshop Co.	4	13	—	254	4	267	3	9	3	12	—	171	3	183
Headquarters Railway Stores Depot.	2	4	—	5	2	9	2	2	2	2	—	2	2	4
No. 1 (Southern) Rly. Stores Co.	5	13	—	239	5	252	2	5	2	5	—	41	2	46
Headquarters Rly. Operating Group	1	2	—	9	1	11	}	}	1	1	—	8	1	9
No. 1 (L.N.E.) Rly. Operating Co.	4	24	—	298	4	318	} 8	42 {	4	22	—	259	4	281
No. 2 (G.W.) Rly. Operating Co.	4	24	—	298	4	318	}	}	3	21	—	120	3	141
Headquarters Docks Group	2	2	—	8	2	10	2	2	2	2	—	6	2	8
No. 1 (L.N.E.R.) Docks Company	11	23	—	107	11	130	11	22	11	22	—	70	11	92
No. 1 (L.M.S.) Railway Telegraphs	6	181	—	—	6	181	2	37	3	42	—	—	3	42
No. 3 (L.N.E.) Railway Operating Co. } Category "C" Units.	—	—	4	318	4	318	—	—	—	—	1	169	1	169
No. 4 (G.W.) Railway Operating Co. } Category "C" Units.	—	—	4	318	4	318	—	—	—	—	1	146	1	146

NOTES ON DUTIES OF ADJUTANTS OF TERRITORIAL ARMY AS REGARDS TRAINING, WITH SPECIAL REFERENCE TO R.E. WORK.

By MAJOR-GEN. G. WALKER, C.B., C.B.E., D.S.O.

1. The duties of an Adjutant of a Territorial Unit are broadly defined in the Regulations for the Territorial Army. The object of these notes is to indicate the methods and the spirit in which those duties should be carried out. The first essential is that the Regular Officer, who is serving as Adjutant of a Territorial Unit, should make himself thoroughly acquainted with the local conditions under which his unit is serving. He must visualise their difficulties and never forget that these citizen soldiers are devoting a great deal of their spare time, and some of their money, gratuitously, to the service of the State. All his work must be carried out with this fact kept clearly in view.

2. It will, therefore, be his business not only to teach the unit its military business but to teach it in such a way as shall not interfere unduly with the civil activities of the Officers, N.C.O's and Men. His instruction must also be organised and carried out in such a way as to impress his pupils with the fact that he has a thorough knowledge of the work himself, and also to engender in them the enthusiasm for the responsibilities which they have undertaken, which is essential to the attainment of any measure of real efficiency. The human side of the picture can never be put aside. A good adjutant must look upon himself as a man whose duty it is to help everyone to learn. He must not merely be a soulless administrator of regulations.

3. As regards detailed methods of instruction apart from routine, it is almost impossible for one officer to try to teach everyone himself. The best way for an Adjufant to proceed is to organise classes.

(*a*) Officers. To be taught by himself.
(*b*) N.C.O's. To be taught, under the Adjutant's supervision, by the Sergeant Instructors and Territorial Officers.

In this way a volume of educated opinion will be formed whereby instruction can be more broadly disseminated. In other words the Adjutant should strive to form a body of qualified instructors, rather than attempt to teach every one himself. These classes should be held quite apart from the ordinary drills and can often be carried on by correspondence; practical work being done at week-end Camps. This work, however, does not relieve the Adjutant of his responsibility for superintending the work of units on parade, and seeing that the Territorial Army Instructors, either Officers or N.C.O's, are working on the right lines.

4. The Officers' classes should be based upon a definite syllabus. The procedure broadly should be as follows :—

All officers, after they have become proficient in Drill and Weapon Training, must first be given a thorough working knowledge of the *Field Service Regulations*, in order that they may understand the principles and methods on and by which troops fight battles. Following this comes the technical education in Field Engineering. In dealing with officers of technical professions in civil life this work will not be difficult and will largely consist of explaining military equipment and methods of improvisation, and an explanation of the application of engineering science to the necessities of an army. Probably the most difficult part will be the instruction in entrenching. The technicalities are few, but the application to military situations, in agreement with the principles of *Field Service Regulations*, is not so simple. A golden rule to follow is that it is the site, not so much as the details of a trench, that matters. This part of the course must be illustrated by actual schemes on the ground and, if possible, it should be done in consultation with artillery and infantry officers. Broadly speaking, the education of the officer of an R.E. unit must consist in

(*a*) Making him a soldier.

(*b*) Making him a *military* engineer.

These are the principles that govern the training of the regular R.E. officer at the S.M.E., and they should be followed in all branches of the Engineer Corps. In fact, an Adjutant of an R.E., T.A. unit should look upon himself as an exponent of S.M.E. methods shaped to suit local conditions. Practically it will be found that this sort of progressive teaching can only be applied to junior officers. The senior officers are fully employed looking after the men. There should, in fact, always be a small school for last joined officers, who are thoroughly instructed before they are asked to instruct the N.C.O's and men of their units. Refresher classes for all officers should also be formed, A suggested syllabus of instruction for these Schools is attached as an appendix.

5. The classes for N.C.O's should deal with the following :—

(*a*) Drill and manœuvre of small units.

(*b*) Weapon Training and Fire Discipline.

(*c*) Technicalities of Field Engineering.

The junior N.C.O's should receive particular attention, and the system should be the same as suggested for officers above, the object of the course being to create good instructors who can pass the instruction on to the men.

6. (*a*) Our training books are now very complete and everyone should be encouraged to read them. Lectures should therefore not partake of the nature from a reading from the book by an instructor, but be a demonstration, pictorially and from experience, of what is written in the books. Nothing is more valuable as illustration than an instructor's personal experience or definite instances from military history.

(*b*) The Adjutant must have a definite programme of lectures and exercises for officers and N.C.O's. This programme should be carried out by lecture, correspondence and in the field—quite apart from the training of the junior ranks in technicalities, which should be carried out in Drill Halls, Week-End Camps and Annual Camps by the T.A. Officers and N.C.O's, under the superintendence of the C.O., Adjutant and permanent staff. It must be emphasised that ocular demonstration by model or diagram is much better than long-winded wordy lectures. We must all clearly understand that we are training units (teams of men) for war, and that we must train the personnel of these teams to each fulfil his particular function in the organisation. We must not muddle up principles and details. Officers and N.C.O's require principles and details, junior ranks details only.

(*c*) In this connection it must be stated that *F.S. Regs., Vol. II*, deals comprehensively with the principles of war, and that all our teaching must be based upon this. The engineer details cannot be dissociated from these principles, as the only office which they perform is to enable the fighting man to make war successfully. In teaching military engineering, everyone should be shown *where* any work is required before he learns what the details are to be.

7. As regards the training in camp.

(*a*) The camp site is usually settled early in the year. As soon as it is settled it is essential that :—

(i) The site should be inspected by the C.O. and Adjutant.

(ii) After this inspection it should be decided what works are to be erected to illustrate the year's work.

(iii) When this has been determined, the Adjutant should make all the necessary arrangements for the supply of the necessary stores to carry out the work properly. It is essential that camp work should all be done with full-sized stores, and not with what may be called semi-model stores.

(*b*) Lectures in camp should be as short as possible and only deal with the works in execution. General lectures should be given before camp.

(*c*) Some units devote time in camp to physical training. The men get plenty of physical work in camp without artificial training of their bodies. P.T. can be done in Drill Halls, and it is axiomatic that the work in camp should only be such as cannot be dealt with at home.

8. In field units it is essential that *all* officers and all the N.C.O's and Drivers of the mounted branch should have adequate instruction in Horsemastership and the care of harness, both in barracks and in the field. It is not sufficient to just let one individual officer or N.C.O. take complete charge of this department.

9. Technicalities are essential for the military engineer, but it is often forgotten that these technicalities are not much use unless everyone clearly understands how they should be applied in the field. To learn this, co-operation with other branches of the service, both in indoor classes and operations in the field, is essential. A military engineer is the servant of the Army, and unless he knows what the Army is likely to want, he is not likely to supply its needs expeditiously, nor be an efficient servant.

10. In organising all classes of Instruction in the Territorial Army, it is well to organise on the basis of a cycle of 4 years, especially for the men. Officers serve longer, and for them this point may not be so important. The time each year is so short that everything cannot be done within that time. The most that can be aimed at is to make the Territorial soldier's education complete by the end of his service. This must not affect the initial classes of instruction alluded to in paras. 3, 4 and 5 above, as they are essential before officers and N.C.O's are really able to take their places in a unit, but it applies to the larger organisation of unit courses such as Field Defences, Bridging, etc.

APPENDIX I.

SUGGESTED SYLLABUS OF INSTRUCTION FOR CLASSES OF JUNIOR OFFICERS R.E.T.A.

F.S.R., Vol. II.

Chap. I, 1, 2, 3, 9; Chap. II, 10, 11; Chap. III; Chap. V; Chap. VI, 33-38 and 40; Chap. VII.

Lectures on the broad principles involved. The object being to make officers read and digest the book itself and ask questions. Too much detail to be avoided, but, wherever possible, concrete cases to be used to illustrate the lectures.

Chap. VIII.

General broad principles, special attention being given to the use of engineers. Lectures on Field Engineering should begin.

Chap. IX.

General broad principles. Siting of trenches on ground and on paper to be done at this time.

Chap. X.

Broad principles only.

Chap. XII.

Broad principles only.

Chap. XIII, 169, 173, 174, 177, 178, 180, 181, 182, 183, 184, 185, 186.

Special attention to Hygiene and Water. Paragraphs of *Manual of Field Engineering* referring to be taught at the same time.

Chap. XIV.

Order writing to be practised not only as regards purely military orders but *also* as regards Engineering Instructions and sketches.

Chap. XV.

Supply of Ammunition and Explosives to R.E. Units.

Appendix No. 1.

To be used when teaching Military Bridging and Trench work.

Generally.

Instruction in Field Engineering should be given alongside the Chapter in *F.S.R.* that bears on the particular part of the subject in hand. The object being to show how the engineer's art works into the methods of making war.

2. The actual technicalities of Engineering must be taught separately however.

Officers should be shown how to use the tables of stresses, weights, etc., given in Appendix V of the *Manual of Field Works*, and in *Military Engineering, Vol. III*, and elsewhere (including *Military Engineering, Vol. I*, when it is published).

Those officers who have no technical engineering qualifications can easily be taught to apply the most commonly used formulae (e.g., that for rectangular beams $r\frac{bd^2}{6}$ and for steel joists rAD) and to work out the bending moment of loaded beams; but care should be taken not to enter into mathematical and statical digressions, and to confine instruction to the use and application of simple formulae and the tables given in these manuals.

3. Appendix No. 1 *F.S.R.* should be referred to throughout as it is essential that the pupils should be thoroughly conversant with the range and power of weapons; in fact these details cannot be referred to too often.

4. It is not sufficient to merely teach and explain the principles of *F.S.R.* and *Field Engineering* in words only. It is essential that the pupils' appreciation of the teaching should be frequently tested by working out short and very simple schemes, so as to enable the instructor to correct any false impressions that have been acquired, before they are too firmly fixed.

Erratum. *R.E.* 7, September, 1925, page 474. The last date of Loos was 8th October.

BATTLE HONOURS OF ROYAL ENGINEER UNITS.

(Continued.)

MOUNT SORREL. 2nd—15th JUNE, 1916.

Unit.	Formation.	E.	Remarks.
177th Tunnelling Co.	2nd Army	E.	
182nd Tunnelling Co.	,,	N.E.	
250th Tunnelling Co.	,,	,,	
1st Canadian Tunnelling Co.	,,	E.	
2nd Canadian Tunnelling Co.	,,	,,	
3rd Canadian Tunnelling Co.	,,	,,	
217th A.T. Co.	,,	N.E.	
213th A.T. Co.	,,	,,	
1st Canadian A.T. Co.	,,	,,	
2nd Canadian A.T. Co.	,,	,,	
3rd Canadian A.T. Co.	,,	,,	
Corps Signals	XIVth Corps	,,	
1st Siege Co. R. Monmouth R.E.	,,	,,	
Corps Signals	Canadian Corps	D.	
83rd Fld. Co.	20th Div.	E.	
84th Fld. Co.	,,	N.E.	
96th Fld. Co.	,,	,,	
20th Div. Sig. Co.	,,	,,	
1st Canadian Fld. Co.	1st Canadian Div.	E.	
2nd Canadian Fld. Co.	,,	,,	
3rd Canadian Fld. Co.	,,	,,	
1st Canadian Div. Sig. Co.	,,	,,	
4th Canadian Fld. Co.	2nd Canadian Div.	,,	
5th Canadian Fld. Co.	,,	,,	
6th Canadian Fld. Co.	,,	,,	
2nd Canadian Div. Sig. Co.	,,	,,	
7th Canadian Fld. Co.	3rd Canadian Div.	,,	
8th Canadian Fld. Co.	,,	,,	
9th Canadian Fld. Co.	,,	,,	
3rd Canadian Div. Sig. Co.	,,	,,	

ALBERT 1916. 1st—13th July.

Unit.	Formation	E.	Remarks.
133 A.T. Co.	4th Army	E.	
134 ,,	,,	,,	No unit diary. Verified by diary of C.R.E. 7th Divn.
135 ,,	,,	,,	
142 ,,	,,	N.E.	
148 ,,	,,	E.	
149 ,,	,,	,,	
214 ,,	,,	,,	
238 ,,	,,	,,	
280 ,,	,,	,,	

ALBERT 1916. 1st—13th JULY.

Unit.	Formation.	E.	Remarks.
281 A.T. Co.	4th Army	E.	
282 ,,	,,	,,	
221 ,,	,,	,,	
232 ,,	,,	D.	No unit diary. Mentioned in diary of C.E. XIII Corps.
236 ,,	,,	E.	No unit diary. Verified by diary of C.E. X Corps.
216 ,,	,,	D.	No unit diary. No mention in other diaries.
1/1st Hants. A.T. Co.	,,	,,	No unit diary. No mention in other diaries.
174 Tunnelling Co.	,,	E.	
179 ,,	,,	,,	
183 ,,	,,	,,	
252 ,,	,,	,,	
178 ,,	5th Army	,,	
4th Pontoon Park	4th Army	,,	
5th ,,	,,	,,	
No. 2 Siege Co. R. Anglesey	,,	,,	
29th Advanced Park Co.	G.H.Q.	N.E.	
No. 1 A.A. Searchlight Section	,,	,,	
No. 2 A.A. Searchlight Section	,,	,,	
1st Bn. Special Brigade	,,	D.	Part of diary missing.
2nd ,,	,,	E.	
5th ,,	,,	,,	
110th Railway Co.	,,	,,	
IIIrd Corps Signal Co.	IIIrd Corps	,,	
VIII ,,	VIII ,,	,,	
X ,,	X ,,	,,	
XIII ,,	XIII ,,	,,	
XV ,,	XV ,,	,,	
23rd Fd. Co.	1st Divn.	,,	
26th ,,	,,	,,	
1/1st Lowland Fd. Co.	,,	,,	
1st Divl. Sig. Co.	,,	,,	
2nd Fd. Co.	8th Divn.	,,	
15th Fd. Co.	,,	,,	
1/1st Home Counties Fd. Co.	,,	,,	
8th Divl. Sig. Co.	,,	,,	
69th Fd. Co.	12th Divn.	,,	
70th Fd. Co.	,,	,,	
87th Fd. Co.	,,	,,	
12th Divl. Sig. Co.	,,	,,	
81st Fd. Co.	19th Divn.	,,	
82nd Fd. Co.	,,	,,	
94th Fd. Co.	,,	,,	
19th Divl. Sig. Co.	,,	,,	
101st Fd. Co.	23rd Divn.	,,	
102nd Fd. Co.	,,	,,	
128th Fd. Co.	,,	,,	
23rd Divl. Sig. Co.	,,	,,	
207th Fd. Co.	34th Divn.	,,	
208th Fd. Co.	,,	,,	
209th Fd. Co.	,,	,,	
34th Divl. Sig. Co.	,,	,,	
9th Fd. Co.	4th Divn.	,,	
1/1st Durham Fd. Co.	,,	,,	
1/1st Renfrew Fd. Co.	,,	,,	
4th Divl. Sig. Co.	,,	,,	

ALBERT 1916. 1st—13th July.

Unit.	Formation.	E.	Remarks.
1/3rd Kent. Fd. Co.	29th Divn.	E.	
1/2nd London Fd. Co.	,,	,,	
1/1st W. Riding Fd. Co.	,,	,,	
29th Divl. Sig. Co. (1/1st London Divl. Sig. Co.).	,,	,,	
210th Fd. Co.	31st Divn.	,,	
211th Fd. Co.	,,	,,	
233rd Fd. Co.	,,	,,	
31st Divl. Sig. Co.	,,	,,	
1/1st S. Midland Fd. Co.	48th Divn.	,,	
2/1st S. Midland Fd. Co.	,,	,,	
1/2nd S. Midland Fd. Co.	,,	,,	
48th Divl. Sig. Co.	,,	,,	
105th Fd. Co.	25th Divn.	,,	
106th Fd. Co.	,,	,,	
130th Fd. Co.	,,	,,	
25th Div. Sig. Co.	,,	,,	
206th Fd. Co.	32nd Divn.	,,	
218th Fd. Co.	,,	,,	
219th Fd. Co.	,,	,,	
32nd Divl. Sig. Co.	,,	,,	
121st Fd. Co.	36th Divn.	,,	
122nd Fd. Co.	,,	,,	
150th Fd. Co.	,,	,,	
36th Divl. Sig. Co.	,,	,,	
57th Fd. Co.	49th Divn.	,,	
1/2nd W. Riding Fd. Co.	,,	,,	
2/1st W. Riding Fd. Co.	,,	,,	
49th Divl. Sig. Co.	,,	,,	
56th Fd. Co.	3rd Divn.	,,	
1/1st Cheshire Fd. Co.	,,	,,	
1/1st E. Riding Fd. Co.	,,	,,	
3rd Divl. Sig. Co.	,,	,,	
63rd Fd. Co.	9th Divn.	,,	
64th Fd. Co.	,,	,,	
90th Fd. Co.	,,	,,	
9th Divl. Sig. Co.	,,	,,	
79th Fd Co.	18th Divn.	,,	
80th Fd. Co.	,,	,,	
92nd Fd. Co.	,,	,,	
18th Divl. Sig. Co.	,,	,,	
200th Fd. Co.	30th Divn.	,,	
201st Fd. Co.	,,	,,	
202nd Fd. Co.	,,	,,	
30th Divl. Sig. Co.	,,	,,	
203rd Fd. Co.	35th Divn.	,,	
204th Fd. Co.	,,	,,	
205th Fd. Co.	,,	,,	
35th Divl. Sig. Co.	,,	,,	
1/1st Edinburgh Fd. Co.	56th Divn.	,,	
2/1st London Fd. Co.	,,	,,	
2/2nd London Fd. Co.	,,	,,	
56th Divl. Sig. Co.	,,	,,	
54th Fd. Co.	7th Divn.	,,	
95th Fd. Co.	,,	,,	
1/3rd Durham Fd. Co.	,,	,,	
7th Divl. Sig. Co.	,,	,,	

ALBERT 1916. 1st—13st JULY.

Unit.	Formation.	E.	Remarks.
77th Fd. Co.	17th Divn.	E.	
78th Fd. Co.	,,	,,	
93rd Fd. Co.	,,	,,	
17th Divl. Sig. Co.	,,	,,	
97th Fd. Co.	21st Divn.	,,	
98th Fd. Co.	,,	,,	
126th Fd. Co.	,,	,,	
21st Divl. Sig. Co.	,,	,,	
11th Fd. Co.	33rd Divn.	N.E.	
212th Fd. Co.	,,	,,	
222nd Fd. Co.	,,	E.	
33rd Divl. Sig. Co.	,,	N.E.	
123rd Fd. Co.	38th Divn.	E.	
124th Fd. Co.	,,	,,	
151st Fd. Co.	,,	,,	
38th Divl. Sig. Co.	,,	,,	
6th Labour Bn.	G.H.Q.	,,	
B. Co. 2nd Labour Bn.	,,	,,	No diary. Verified by diary of C.E. XV Corps.
D. Co. 2nd Labour Bn.	,,	,,	
D. Co. 12th Labour	,,	D.	No diary. Mentioned by C.E. XV Corps. (These Labour Bns. are not mentioned in Orders of battle and any verification is difficult. Very few unit diaries appear to have been kept.)
3rd Fd. Squadron	Cav. Divn.	,,	No unit diary. Definitely mentioned by C.E. XVIII Corps as working in area on 13 . 7 . 16.

BAZENTIN 14th—17th JULY, 1916.

Unit.	Formation.	E.	Remarks.
133 A.T. Co.	4th Army	E.	
134 ,,	,,	,,	
135 ,,	,,	,,	
142 ,,	,,	,,	
148 ,,	,,	,,	
149 ,,	,,	D.	Very brief diary.
214 ,,	,,	E.	
216 ,,	,,	D.	No unit diary. No mention in other diaries.
221 ,,	,,	E.	
232 ,,	,,	D.	No unit diary. C.E. X Corps mentions move out of area 12.7.16.
236 ,,	,,	E.	No diary. Verified by diary of C.E. X Corps.
238 ,,	,,	,,	
280 ,,	,,	N.E.	
281 ,,	,,	E.	
282 ,,	,,	,,	
1/1st Hants A.T. Co.	,,	D.	No unit diary. No mention in other diaries.
132 A.T. Co.	3rd Army	N.E.	
174 Tunnelling Co.	4th Army	E.	
179 ,,	,,	,,	
183 ,,	,,	,,	
252 ,,	,,	N.E.	
178 ,,	5th Army	E.	

BAZENTIN 14th—17th July, 1916.

Unit.	Formation.	E.	Remarks.
4th Pontoon Park	4th Army	E.	
5th ,,	,,	,,	
2nd Siege Co. R. Anglesey	,,	N.E.	
No. 1 Bn. Special Brigade	G.H.Q.	,,	
No. 2 Bn. Special Brigade	,,	D.	
No. 5 Bn. Special Brigade	,,	E.	
110th Railway Co.	,,	,,	
6th Labour Bn.	,,	N.E.	No other division or mention of Labour Bns.
D. Co. 2nd Labour Bn.	,,	D.	(same remark, bracketed)
II A. Corps Signal Co.	II A.C.	N.E.	
III ,,	III ,,	,,	
IV ,,	IV ,,	,,	
X ,,	X ,,	,,	
XIII ,,	XIII ,,	,,	
XV ,,	XV ,,	,,	
2nd Indian Fd. Sqn.	2nd Indian Cav. Divn.	E.	
2nd Indian Sig. Sqn.	,,	,,	
23rd Fd. Co.	1st Divn.	,,	
26th Fd. Co.	,,	,,	
1/1st Lowland Fd. Co.	,,	,,	
1st Divn. Sig. Co.	,,	,,	
101st Fd. Co.	23rd Divn.	N.E.	
102nd Fd. Co.	,,	,,	
128th Fd. Co.	,,	,,	
23rd Divl. Sig. Co.	,,	,,	
207th Fd. Co.	34th Divn.	E.	
208th Fd. Co.	,,	,,	
209th Fd. Co.	,,	,,	
34th Divl. Sig. Co.	,,	,,	
56th Fd. Co.	3rd Divn.	,,	
1/1st Cheshire Fd. Co.	,,	,,	
1/1st E. Riding Fd. Co.	,,	,,	
3rd Divl. Sig. Co.	,,	,,	
63rd Fd. Co.	9th Divn.	,,	
64th Fd. Co.	,,	,,	
90th Fd. Co.	,,	,,	
9th Divl. Sig. Co.	,,	,,	
79th Fd. Co.	18th Divn.	,,	
80th Fd. Co.	,,	,,	
92nd Fd. Co.	,,	,,	
19th Divl. Sig. Co.	,,	,,	
54th Fd. Co.	7th Divn.	,,	
95th Fd. Co.	,,	,,	
1/3rd Durham Fd. Co.	,,	,,	
7th Divl. Sig. Co.	,,	,,	
97th Fd. Co.	21st Divn.	,,	
98th Fd. Co.	,,	,,	
126th Fd. Co.	,,	,,	
21st Divl. Sig. Co.	,,	,,	
11th Fd. Co.	33rd Divn.	,,	
212th Fd. Co.	,,	,,	
222nd Fd. Co.	,,	,,	
33rd Divl. Sig. Co.	,,	,,	
105th Fd. Co.	25th Divn.	,,	
106th Fd. Co.	,,	,,	
130th Fd. Co.	,,	,,	
25th Divl. Sig. Co.	,,	,,	
206th Fd. Co.	32nd Divn.	,,	

BAZENTIN 14th—17th July, 1916.

Unit.	Formation.	E.	Remarks.
218th Fd. Co.	32nd Divn.	E.	
219th Fd. Co.	,,	,,	
32nd Divl. Sig. Co.	,,	,,	
1/1st South Midland Fd. Co.	48th Divn.	N.E.	
1/2nd South Midland Fd. Co.	,,	E.	
2/1st South Midland Fd. Co.	,,	,,	
48th Divl. Sig. Co.	,,	,,	
57th Fd. Co.	49th Divn.	,,	
1/2nd W. Riding Fd. Co.	,,	,,	
2/1st W. Riding Fd. Co.	,,	N.E.	
49th Divl Sig. Co.	,,	E.	
203rd Fd. Co.	35th Divn.	N.E.	
204th Fd. Co.	,,	E.	
205th Fd. Co.	,,	,,	
35th Divl. Sig. Co.	,,	N.E.	

DELVILLE WOOD. 15th July—3rd September, 1916.

Unit.	Formation	E.	Remarks.
5th Fd. Co.	2nd Divn.	E.	
226th Fd. Co.	,,	,,	
1/1st E. Anglian Fd. Co.	,,	,,	
2nd Divl. Sig. Co.	,,	N.E.	
56th F.D. Co.	3rd Divn.	E.	
1/1st Cheshire Fd. Co.	,,	D.	
1/1st E. Riding Fd. Co.	,,	D.	Diary for July missing.
3rd Divl. Sig. Co.	,,	N.E.	
63rd Fd. Co.	9th Divn.	E.	
64th Fd. Co.	,,	,,	
90th Fd. Co.	,,	,,	
9th Divl. Sig. Co.	,,	N.E.	
All R.E. Units of 18th Divn.	18th Divn.	,,	
103rd Fd. Co.	24th Divn.	E.	
104th Fd. Co.	,,	,,	
129th Fd. Co.	,,	,,	
24th Divl. Sig. Co.	,,	N.E.	
83rd Fd. Co.	20th Divn.	N.E.	
84th Fd. Co.	,,	D.	
96th Fd. Co.	,,	N.E.	
20th Divl. Sig. Co.	,,	E.	
54th Fd. Co.	7th Divn.	D.	
95th Fd. Co.	,,	,,	
1/3rd Durham Fd. Co.	,,	E.	
7th Divl. Sig. Co.	,,	N.E.	
1st New Zealand Fd. Co.	N.Z. Divn.	E.	
2nd New Zealand Fd. Co.	,,	,,	
3rd New Zealand Fd. Co.	,,	D.	
179 Tunnelling Co.	4th Army	E.	
2nd Indian Fd. Sqdn.	2nd Indian Cav. Divn.	,,	
59th Fd. Co.	5th Divn.	,,	
1/2nd Home Counties Fd. Co.	,,	D.	
1/2nd Durham Fd. Co.	,,	E.	
5th Divl. Sig. Co.	,,	N.E.	

POZIERES. 23rd July—3rd September, 1916.

Unit.	Formation.	E.	Remarks.
133 A.T. Co.	4th Army	N.E.	
134 ,,	,,	D.	No unit diary. No mention in C.E.'s diary.
135 ,,	,,	E.	
142 ,,	,,	N.E.	
148 ,,	,,	E.	
149 ,,	,,	D.	Very brief diary.
214 ,,	,,	E.	
216 ,,	,,	D.	No unit diary. No mention in C.E's. diary.
217 ,,	,,	N.E.	
221 ,,	,,	E.	
232 ,,	,,	D.	No unit diary. No mention in C.E's. diary.
236 ,,	,,	E.	No unit diary. Verified by diary of C.E. II Corps.
238 ,,	,,	N.E.	
280 ,,	,,	E.	
281 ,,	,,	,,	
282 ,,	,,	,,	
1/1st Wilts. A.T. Co.	,,	N.E.	
1/3rd Cornwall A.T. Co.	,,	E.	No unit diary. Verified by diary of C.E. IV Corps.
1st Canadian A.T. Co.	,,	,,	
1/1st Hants A.T. Co.	,,	N.E.	
174 Tunnelling Co.	,,	,,	
178 ,,	,,	E.	
179 ,,	,,	,,	
181 ,,	,,	,,	
183 ,,	,,	N.E.	
252 ,,	,,	,,	
No. 2 Siege Co. R. Anglesey	,,	,,	
No. 1 Siege Co. R. Monmouth	,,	E.	
No. 4 Pontoon Park	,,	,,	
No. 5 Pontoon Park	,,	,,	
No. 2 Labour Bn.	,,	D.	Detachments of these units were in Area.
No. 6 Labour Bn.	,,	,,	
III Corps Sig. Co.	III Corps	E.	
II ,,	II Corps	,,	
1st Anzac Corps Sig. Co.	1st Anzac Corps	,,	
No. 2 Bn. Special Brigade	G.H.Q.	,,	
No. 5 Bn. Special Brigade	,,	,,	
3rd Fd. Squadron	3rd Cav. Divn.	,,	
2nd Indian Fd. Squadron	2nd Indian Cav. Divn.	,,	
23rd Fd. Co.	1st Divn.	,,	
26th Fd. Co.	,,	,,	
1/1st Lowland Fd. Co.	,,	,,	
1st Divl. Sig. Co.	,,	,,	
73rd Fd. Co.	15th Divn.	,,	
74th Fd. Co.	,,	,,	
91st Fd. Co.	,,	,,	
15th Divl. Sig. Co.	,,	,,	
81st Fd. Co.	19th Divn.	,,	
82nd Fd. Co.	,,	,,	
94th Fd. Co.	,,	,,	
19th Divl. Sig. Co.	,,	,,	
101st Fd. Co.	23rd Divn.	,,	
102nd Fd. Co.	,,	,,	
128th Fd. Co.	,,	,,	

POZIERES. 23rd JULY—3rd SEPTEMBER, 1916.

Unit.	Formation.	E.	Remarks.
23rd Divl. Sig. Co.	23rd Divn.	E.	
207th Fd. Co.	34th Divn.	,,	
208th Fd. Co.	,,	,,	
209th Fd. Co.	,,	,,	
34th Divl. Sig. Co.	,,	,,	
69th Fd. Co.	12th Divn.	,,	
70th Fd. Co.	,,	,,	
87th Fd. Co.	,,	,,	
12th Divl. Sig. Co.	,,	,,	
105th Fd. Co.	25th Divn.	,,	
106th Fd. Co.	,,	,,	
130th Fd. Co.	,,	,,	
25th Divl. Sig. Co.	,,	,,	
1/1st S. Midland Fd. Co.	48th Divn.	,,	
1/2nd S. Midland Fd. Co.	,,	,,	
2/1st S. Midland Fd. Co.	,,	,,	
48th Divl. Sig. Co.	,,	,,	
57th Fd. Co.	49th Divn.	,,	
1/2nd West Riding Fd. Co.	,,	,,	
2/1st West Riding Fd. Co.	,,	,,	
49th Divl. Sig. Co.	,,	,,	
1st Australian Fd. Co.	1st Aus. Divn.	,,	
2nd Australian Fd. Co.	,,	,,	
3rd Australian Fd. Co.	,,	,,	
1st Aus. Divl. Sig. Co.	,,	,,	
5th Aus. Fd. Co.	2nd Aus. Divn.	,,	
6th Aus. Fd. Co.	,,	,,	
7th Aus. Fd. Co.	,,	,,	
2nd Aus. Divl. Sig. Co.	,,	,,	
4th Aus. Fd. Co.	4th Aus. Divn.	,,	
12th Aus. Fd. Co.	,,	,,	
13th Aus. Fd. Co.	,,	,,	
4th Aus. Divl. Sig. Co.	,,	,,	
7th Divl. Sig. Co.	7th Divn.	,,	
54th Fd. Co.	,,	,,	
95th Fd. Co.	,,	,,	
1/3rd Durham Fd. Co.	,,	,,	
1st Canadian Fd. Co.	1st Can. Divn.	,,	
2nd Canadian Fd. Co.	,,	,,	
3rd Canadian Fd. Co.	,,	,,	
1st Can. Divl. Sig. Co.	,,	N.E.	
59th Fd. Co.	5th Divn.	,,	
1/2nd Home Counties Fd. Co.	,,	E.	
1/2nd Durham Fd. Co.	,,	,,	
5th Divl. Sig. Co.	,,	,,	
1/3rd London Fd. Co.	47th Divn.	N.E.	
2/3rd London Fd. Co.	,,	E.	
1/4th London Fd. Co.	,,	,,	
47th Divl. Sig. Co.	,,	N.E.	
7th Fd. Co.	50th Divn.	E.	
1/1st Northumbrian Fd. Co.	,,	,,	
2/2nd Northumbrian Fld. Co.	,,	D.	
50th Div. Sig. Co.	,,	N.E.	

GUILLEMONT. 3rd—6th September, 1916.

Unit.	Formation.	E.	Remarks.
280 A.T. Co.	4th Army	E.	No other A.T. Cos. of 4th Army can be identified in Area.
178 Tunnelling Co.	,,	D.	No other Tunnelling Cos. of 4th Army can be identified in Area.
183 ,,	,,	E.	
1st Fd. Squadron	1st Cav. Div.	N.E.	
2nd Indian Fld. Squadron	2nd Ind. Cav. Div.	E.	
No. 2 Bn. Special Bde. R.E.	G.H.Q.	,,	No other Bn. of special Bde. can be identified in Area.
59th Fd. Co.	5th Div.	,,	
1/2nd Home Counties Fd. Co.	,,	,,	
1/2nd Durham Fd. Co.	,,	,,	
5th Div. Sig. Co.	,,	,,	
155th Fd. Co.	16th Div.	,,	
156th Fd. Co.	,,	,,	
157th Fd. Co.	,,	,,	
16th Div. Sig. Co.	,,	,,	
83rd Fd. Co.	20th Div.	,,	
84th Fd. Co.	,,	,,	
96th Fd. Co.	,,	,,	
20th Div. Sig. Co.	,,	,,	
54th Fd. Co.	7th Div.	,,	
95th Fd. Co.	,,	,,	
1/3rd Durham Fd. Co.	,,	,,	
7th Div. Sig. Co.	,,	,,	
103rd Fd. Co.	24th Div.	,,	
104th Fd. Co.	,,	,,	
129th Fd. Co.	,,	,,	
24th Div. Sig. Co.	,,	N.E.	
1/1st W. Lancs. Fd. Co.	5th Div.	E.	
2/1st W. Lancs. Fd. Co.	,,	,,	
2/2nd W. Lancs. Fd. Co.	,,	N.E.	
55th Div. Sig. Co.	,,	D.	
1/1st Edinburgh Fd. Co.	56th Div.	N.E.	
2/1st London Fd. Co.	,,	E.	
2/2nd London Fd. Co.	,,	N.E.	
56th Div. Sig. Co.	,,	N.E.	
1st New Zealand Fd. Co.	N.Z. Div.	E.	
2nd New Zealand Fd. Co.	,,	,,	
3rd New Zealand Fd. Co.	,,	,,	
N.Z. Div. Sig. Co.	,,	N.E.	
228th Fd. Co.	41st Div.	E.	
233rd Fd. Co.	,,	,,	
237th Fd. Co.	,,	,,	
41st Div. Sig. Co.	,,	N.E.	

GINCHY. 9th SEPTEMBER, 1916.

Unit.	Formation.	E.	Remarks.
280 A.T. Co.	4th Army	E.	No other A.T. Co's. of 4th Army can be identified in Area.
178 Tunnelling Co.	,,	D.	No other Tunnelling Co. of 4th Army can be identified in Area.
183 ,,	,,	E.	
1st Field Squadron	1st Cav. Divn.	,,	
2nd Indian Field Squadron	2nd Ind. Cav. Divn.	,,	
No. 2 Bn. Special Brigade	G.H.Q.	N.E.	No other Bn. of Special Bde. can be located in area.
155th Fd. Co.	16th Divn.	E.	
156th Fd. Co.	,,	,,	
157th Fd. Co.	,,	,,	
16th Divl. Sig. Co.	,,	,,	
1/1st Edinburgh Fd. Co.	56th Divn.	,,	
2/1st London Fd. Co.	,,	N.E.	
2/2nd London Fd. Co.	,,	E.	
56th Divl. Sig. Co.	,,	,,	
1/1st W. Lancs. Fd. Co.	55th Divn.	N.E.	
2/1st W. Lancs. Fd. Co.	,,	E.	
2/2nd W. Lancs. Fd. Co.	,,	N.E.	
55th Divl. Sig. Co.	,,	D.	
54th Fd. Co.	7th Divn.	E.	
95th Fd. Co.	,,	,,	
1/3rd Durham Fd. Co.	,,	,,	
7th Divl. Sig. Co.	,,	N.E.	
103rd Fd. Co.	24th Divn.	E.	
104th Fd. Co.	,,	,,	
129th Fd. Co.	,,	,,	
24th Divl. Sig. Co.	,,	N.E.	
1st New Zealand Fd. Co.	N.Z. Divn.	E.	
2nd New Zealand Fd. Co.	,,	,,	
3rd New Zealand Fd. Co.	,,	,,	
N.Z. Divl. Sig. Co.	,,	N.E.	
228th Fd. Co.	41st Divn.	E.	
233rd Fd. Co.	,,	,,	
237th Fd. Co.	,,	,,	
41st Divl. Sig. Co.	,,	N.E.	

FLERS-COURCELETTE. 15TH—22ND SEPTEMBER, 1916.

Unit.	Formation.	E.	Remarks.
133rd A.T. Co.	4th Army	E.	Verified from diary of C.E. XVth Corps.
134th ,,	,,	,,	
142nd ,,	,,	D.	No unit diary.
149th ,,	,,	,,	
214th ,,	,,	N.E.	
216th ,,	,,	D.	No unit diary.
217th ,,	,,	E.	
221st ,,	,,	D.	No unit diary.
232nd ,,	,,	,,	
238th ,,	,,	N.E.	
280th ,,	,,	E.	
281st ,,	,,	,,	
282nd ,,	,,	N.E.	

FLERS-COURCELETTE. 15th—22nd SEPTEMBER, 1916.

Unit.	Formation.	E.	Remarks.
1/3rd Cornwall A.T. Co.	4th Army	D.	No unit diary.
1/1st Wilts. A.T. Co.	,,	E.	
178 Tunnelling Co.	,,	,,	
179 ,,	,,	,,	
183 ,,	,,	,,	
4th Pontoon Park	,,	,,	
5th ,,	,,	N.E.	
No. 2 Labour Bn.	,,	E.	
135th A.T. Co.	Res. Army	,,	
148th A.T. Co.	,,	,,	
236th A.T. Co.	,,	D.	No unit diary.
1/1st Hants. A.T. Co.	,,	N.E.	
No. 2 Siege Co. R. Anglesey R.E.	,,	,,	
No. 1 Siege Co. R. Monmouth R.E.	,,	E.	
7th Canadian A.T. Co.	,,	N.E.	
174 Training Co.	,,	,,	
252 ,,	,,	,,	
No. 6 Labour Bn.	,,	,,	
IInd Corps. Sig. Co.	IInd Corps	E.	
IIIrd Corps Sig. Co.	IIIrd Corps	,,	
XIVth Corps. Sig. Co.	XIVth Corps	,,	No unit diary. Presumptive evidence.
XVth Corps Sig. Co.	XVth Corps	,,	
Can. A.C. Sig. Co.	Can. Corps	,,	
No. 1 Special Co. Special Brigade	G.H.Q.	,,	
110th Railway Co.	,,	D.	
119th ,,	,,	E.	
23rd Fd. Co.	1st Div.	,,	
26th Fd. Co.	,,	,,	
1/1st Lowland Fd. Co.	,,	,,	
1st Div. Sig. Co.	,,	,,	
73rd Fd. Co.	15th Div.	,,	
74th Fd. Co.	,,	,,	
91st Fd. Co.	,,	,,	
15th Div. Sig. Co.	,,	,,	
101st Fd. Co.	23rd Div.	,,	
102nd Fd. Co.	,,	,,	
128th Fd. Co.	,,	,,	
23rd Div. Sig. Co.	,,	,,	
1/3rd London Fd. Co.	47th Div.	,,	
1/4th ,,	,,	,,	
2/3rd ,,	,,	,,	
47th Div. Sig. Co.	,,	,,	
7th Fd. Co.	50th Div.	,,	
1/1st Northumbrian Fd. Co.	,,	,,	
1/2nd Northumbrian Fd. Co.	,,	,,	
50th Div. Sig. Co.	,,	,,	
55th Fd. Co.	Guards Div.	,,	
75th Fd. Co.	,,	,,	
76th Fd. Co.	,,	,,	
Guards Div. Sig. Co.	,,	,,	
59th Fd. Co.	5th Div.	,,	
1/2nd Durham Fd. Co.	,,	,,	
1/2nd Home Counties Fd. Co.	,,	,,	
5th Div. Sig. Co.	,,	,,	
12th Fd. Co.	6th Div.	,,	
1/1st London Fd. Co.	,,	,,	

FLERS-COURCELETTE. 15th—22nd SEPTEMBER, 1916.

Unit.	Formation.	E.	Remarks.
2/2nd West Riding Fd. Co.	6th Div.	E.	
6th Div. Sig. Co.	,,	,,	
83rd Fd. Co.	20th Div.	,,	
84th Fd. Co.	,,	,,	
96th Fd. Co.	,,	,,	
20th Div. Sig. Co.	,,	,,	
1/1st Edinburgh Fd. Co.	56th Div.	,,	
2/1st London Fd. Co.	,,	,,	
2/2nd ,,	,,	,,	
56th Div. Sig. Co.	,,	,,	
61st Fd. Co.	14th Div.	,,	
62nd Fd. Co.	,,	,,	
89th Fd. Co.	,,	,,	
14th Div. Sig. Co.	,,	,,	
97th Fd. Co.	21st Div.	,,	
98th Fd. Co.	,,	,,	
126th Fd. Co.	,,	,,	
21st Div. Sig. Co.	,,	,,	
228th Fd. Co.	41st Div.	,,	
223rd Fd. Co.	,,	,,	
237th Fd. Co.	,,	,,	
41st Div. Sig. Co.	,,	,,	
1/1st West Lancs. Fd. Co.	55th Div.	,,	
2/1st West Lancs. Fd. Co.	,,	,,	
2/2nd West Lancs. Fd. Co.	,,	,,	
55th Div. Sig. Co.	,,	,,	
1st New Zealand Fd. Co.	N.Z. Div.	,,	
2nd New Zealand Fd. Co.	,,	,,	
3rd New Zealand Fd. Co.	,,	,,	
N.Z. Div Sig. Co.	,,	,,	
67th Fd. Co.	11th Div.	,,	
68th Fd. Co.	,,	,,	
86th Fd. Co.	,,	,,	
11th Div. Sig. Co.	,,	,,	
57th Fd. Co.	49th Div.	,,	
1/2nd West Riding Fd. Co.	,,	,,	
2/1st West Riding Fd. Co.	,,	,,	
49th Div. Sig. Co.	,,	,,	
1st Can. Fd. Co.	1st Can. Div.	D.	
2nd ,,	,,	E.	
3rd ,,	,,	D.	
1st Can. Div. Sig. Co.	,,	E.	
4th Can. Fd. Co.	2nd Can. Div.	,,	
5th ,,	,,	,,	
6th ,,	,,	,,	
2nd Can. Div. Sig. Co.	,,	,,	
7th Can. Fd. Co.	3rd Can. Div.	,,	
8th ,,	,,	N.E.	
9th ,,	,,	,,	
3rd Can. Div. Sig. Co.	,,	E.	
1st Field Squadron	1st Cav. Div.	,,	
1st Signal Squadron	,,	,,	
1st Ind. Fd. Squadron	1st Ind. Cav. Div.	,,	
2nd ,,	2nd Ind Cav. Div.	,,	
2nd Ind. Sig. Squad.	,,	,,	

To be Continued.

MODERN PRACTICE IN E. AND M. ENGINEERING.

I. EARTHING THE NEUTRAL POINT IN H.T. 3-PHASE A.C. SYSTEMS.

By LIEUT. W. M. N. MORECOMBE, B.SC. (Eng.) R.E. (Co. Bn.).

THE practice of earthing the neutral point in H.T., A.C. systems is now well established in this country, and it is understood that the forthcoming revised issue of the " E.C. Regulations for Securing the Safety of the Public " will contain a clause making N.P. earthing compulsory.

The matter is dealt with in the *Military Manual of Electrical Engineering*, pp. 76 to 79, but the object of the present article is to explain the considerations involved a little more fully, particularly with regard to H.T. systems,

I. ELEMENTARY CONSIDERATIONS.

(a) Neutral Point Insulated.

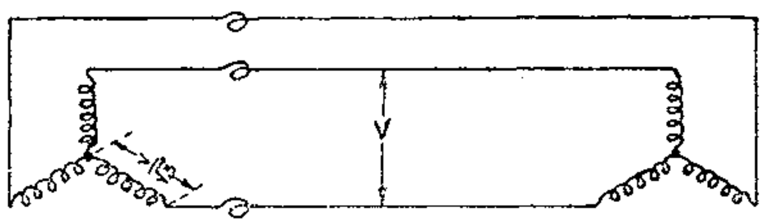


FIG. 1.

Consider first a star-connected alternator feeding a three-wire H.T. line at pressure V. (Fig. 1). The insulation of each line has normally to withstand a pressure $\frac{V.}{\sqrt{3}}$

It might be thought at first sight that it has to withstand a pressure $\frac{V}{2}$ only, but, assuming a pure sine E.M.F. wave and perfect line insulation, the N.P. is maintained at earth (*i.e.*, zero) potential by the star-connected condensers formed by the line capacity.

Unfortunately, a pure sine wave is never actually attained (although closely approached by modern alternators) and triple harmonic E.M.F.s (and multiples thereof), being co-phasal with regard to the three-line wires, are effective between the N.P. and earth, although they do not appear in the voltage between line and N.P.

So, in practice, an insulated N.P. will generally be above earth potential, due to the triple harmonic E.M.F.s, and the pressure between each line and earth will be somewhat greater than $\frac{V}{\sqrt{3}}$

Now, since perfect line insulation is never attained, especially with overhead lines, the zero point of the system may be anywhere on the generator windings, depending upon the relative values of the individual insulation resistances of the three lines. Consequently the *potential of the N.P. is not stable.* In the limit, if an earth fault of low resistance occurs on one line conductor, the zero point of the system is shifted to that conductor, and the P.D. to earth of the other two conductors is raised from $\frac{V}{\sqrt{3}}$ to V.

Therefore the *insulation must be designed for a working voltage of V volts.*

Now, with regard to isolation of faults, if simple over-load protection is installed, an earth fault on one line only will not cause an interruption of supply. An earth must develop on a second line, thus producing a short circuit sufficiently low in resistance to operate the O.L. trips, which will require at least 150 to 200 per cent. of full load current to function, depending on the setting. This is most objectionable, as will be emphasised later.

(*b*) *Neutral Point Earthed at Generating Station.*

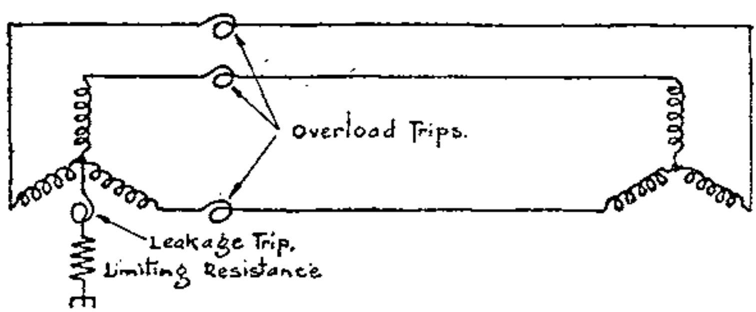


FIG. 2.

If the N.P. of the alternator is earthed, its potential is definitely zero, and the P.D. between each line conductor and earth is now limited to $\frac{V}{\sqrt{3}}$ (or a little higher, due to harmonics).

There could, therefore, be some saving in line insulation with this arrangement, but in actual practice, except in the case of very high pressures, machinery and lines are designed for full line pressure V, and advantage taken of the larger factor of safety.

An earth on one line will now cause an interruption of supply by operating the O.L. trip in that line. But this arrangement is still open to the objection that large currents may have to be broken, and to overcome this difficulty it is usual to insert a resistance in the earth connection to limit the maximum possible leakage current to that necessary to operate the O.L. trips (see Fig. 2).

If, however, a trip coil is inserted in the neutral connection to earth, it will not be affected by normal overload currents, and may, therefore, be designed to trip with a relatively small leakage current, and the circuit can be isolated with smaller shock to the system.

(c) *Connection with Earth at more than one Point.*

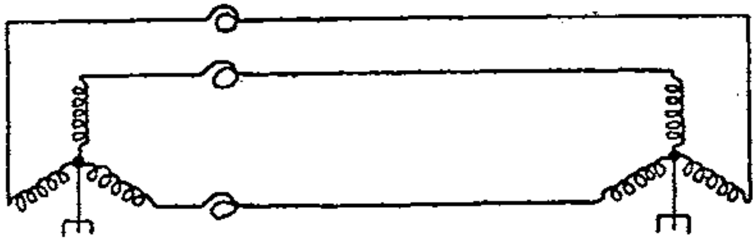


FIG. 3.

In the two cases considered above, when the insulation of all the lines is perfect, the only earth currents are those due to capacity, and these will be comparatively small in amount. But if connection with earth is made at two points, say, at the N.P. of alternator and also at the N.P. of a motor at the receiving end of a line (Fig. 3), a definite conducting path is provided through the earth.

With sine E.M.F. waves the two neutral points will be at the same potential unless the load is unbalanced, but, as mentioned above, the triple harmonic E.M.F.s are co-phasal with regard to the three line conductors, and, therefore, a single phase triple harmonic current will circulate through the three line conductors in parallel and back from one earth connection to the other. As far as the power system itself is concerned these effects are seldom of sufficient magnitude to cause inconvenience, but the arrangement produces a maximum of inductive effect on telephone circuits and is very undesirable.

II. THE EFFECTS OF EARTHING THE N.P. ON THE GENERAL WORKING OF THE POWER SYSTEM CAN NOW BE CONVENIENTLY CONSIDERED UNDER THREE HEADS, VIZ :—

(1) Safety from shock and fire.

(2) Continuity of supply.

(3) Telephone Interference.

(1) *Safety from Shock and Fire.*

It is sometimes argued that there is less danger from shock to anyone coming in contact with one conductor of a H.T. system if the N.P. is insulated.

This may be true (theoretically) in very small systems with only, say, two or three miles of line, but it is absolutely foolish to rely on this possibility.

In general, as explained above, the effect of capacity is to keep the N.P. at earth potential, and a person making contact between one conductor and earth through his body receives practically the same shock as if the N.P. of the system were permanently earthed. (The considerations affecting L.T. systems are quite different. Earthing the N.P. secures economy in copper without increasing danger from shock).

In the case of overhead lines it is obviously essential to cut off the line if a conductor falls to the ground, and the E.C. Regulations for O.H. lines make it compulsory to instal apparatus to render a line conductor "dead" if it falls. *This Regulation implies working with N.P. earthed* to enable leakage protection to be installed.

With regard to fire, since in systems of moderate size, the capacity current flowing through an earth fault and the heat generated thereby may be considerable when the N.P. is insulated, risk of fire is introduced, and if the leak is through combustible material, as in machines and cables, it will probably develop into a short-circuit between phases. Moreover, in gassy atmospheres, *e.g.*, mines, risk of explosion is also incurred.

(2) *Continuity of Supply.*

The only advantage derived from running with the N.P. insulated is the possibility of maintaining the supply with an earth fault on one line. This advantage applies really to overhead lines only in which earth faults are not so liable to develop into short circuits as in cables. However, the fault will probably lead ultimately to the conductor burning through and falling to the ground. Therefore, although the possibility should be borne in mind *in war on grounds of expediency*, it is no justification for not conforming with the usual practice in normal times.

It must not be forgotten that the question of the safety of the system itself is closely bound up with that of continuity of supply. The less the damage done to the system through a fault, the less the cost of repair and the shorter the duration of interruption of supply. It is, therefore, far preferable to clear faults in the incipient stage rather than to wait for short-circuit conditions and the consequent greater shock to the system which this means. When a short-circuit occurs, the excessive current which has to be broken is very severe on the switch, owing to the large E.M.F. induced; the arc at the break is very persistent, and results in serious burning of the switch contacts, and in extreme cases the induced E.M.F. is so great that the switch is unable to break the arc at all, and an explosion results. Moreover, very large mechanical forces operate between conductors. Many cases have occurred in which oil switches have been destroyed, busbars displaced, and their supporting insulators broken. These effects naturally become more pronounced as the size of the system increases, and it may safely be asserted that on systems of moderate size, with overload protection only, it is practically impossible to clear short circuit faults satisfactorily.

In the case of overhead lines, with insulated N.P., an earth fault on one conductor is in parallel with the capacity of that line to earth, and in series with the capacity to earth of the other two lines. The connection with earth is frequently intermittent, or in the form of an arc, which, being shunted by a capacity, is unstable, and the continued extinction and reformation of the arc sets up high voltage surges in the system which are very severe on the insulation, and sometimes flash over insulators in other parts of the system with destructive effects.

All this trouble is avoided by simply earthing the N.P. through a suitable resistance.

(3) *Telephone Interference.*

Theoretically, unbalanced loads and unbalanced leakage and capacity between conductors and earth will produce a certain amount of inductive effect on telephone circuits, and this is so whether the N.P. is insulated or not. Overhead lines are naturally more troublesome than cables in this respect. But the chief cause of disturbances in telephone systems is leakage.

It has been pointed out above that, with the N.P. at the generating station earthed and perfect insulation of the lines, the only earth currents are those due to capacity, the most important being the triple harmonic currents. But as soon as an earth fault develops on a conductor these earth currents increase very much in value, and may affect telephone circuits in the vicinity. The inductive effect due to slight leakage is naturally rather more than it would be with insulated N.P., and from this point of view the insulated neutral point might be considered preferable.

Experience shows, however, that if sensitive leakage protection is installed, the line is invariably cleared before the interference becomes annoying. Moreover, the *E.C. Regulations require immediate steps to be taken to improve the insulation if the leakage current exceeds one-thousandth part of the maximum load current.*

But, if the N.P. is earthed on another part of the system (as in Fig. 3), the effect of the triple harmonic currents is generally sufficient to interrupt telephone communication for many miles around. For this reason *earthing at more than one point is forbidden by E.C. Regulations*, except in special cases, and then only with the concurrence of the Postmaster General.

However, the necessity for multiple earthing only arises in the case of inter-connectors between two separate power stations, and this matter will be touched on briefly.

The connections are usually made through step-up transformers as in Fig. 4.

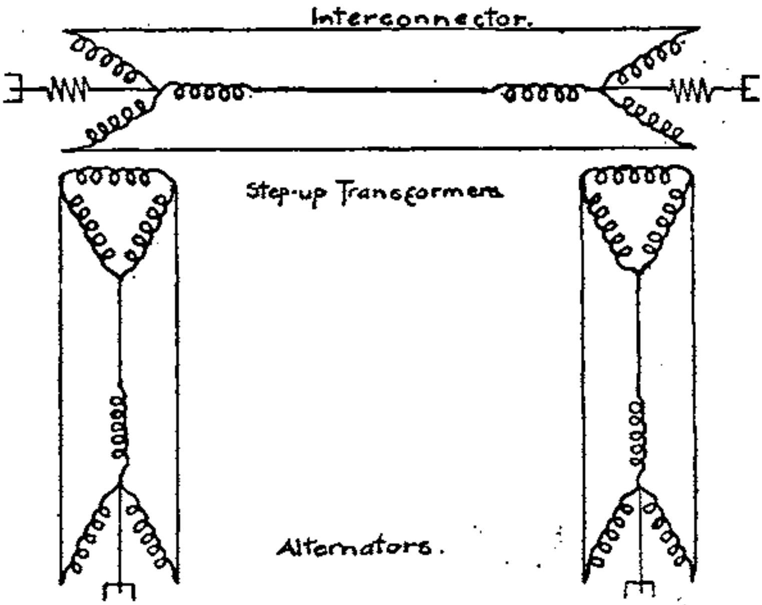


FIG. 4.

It will be noted that the alternator circuits are not electrically connected, and their neutral points are earthed direct, without any resistance.

Earthing the alternator N.P. in this case is not essential to the operation of leakage devices, but it prevents damage to the machine windings from excessive pressures which, under certain conditions, may be induced electrostatically from the higher to the lower pressure windings of the step-up transformer.

The N.P.s of both step-up transformer secondaries are earthed through limiting resistances, but the delta connected primaries ensure the absence of triple harmonic E.M.F.s in the secondaries. This arrangement ensures that the interconnector will at no time be left without an earth connection.

Multiple earthing on the above lines is sometimes approved by the E.C. and the P.M.G.

It should be noted in this connection that the telephone receiver is most sensitive to disturbances of a frequency of 800-900 cycles per second, therefore harmonics in the power system are much more troublesome than the fundamental.

The above remarks deal principally with "noise" in the telephones making speech difficult or impossible.

It has also been proved conclusively that the telephone system is much less liable to have excessive pressures induced therein when faults occur in the power system, if the N.P. of the latter is earthed. This is, of course, due to the faulty power lines being cut off in the incipient stage.

The advantages of earthing the N.P. in H.T. systems may now be summarised as follows :—

(1) *Leakage Protection* can be installed, thus discriminating between overloads and earth faults, and enabling the latter to be cleared with a minimum of damage to the system.
(2) An overload line can be disconnected promptly if a conductor falls.
(3) Excessive pressure rises due to "arcing" earths are avoided.
(4) The factor of safety of the insulation is increased in the ration of $\sqrt{3}$ to 1.
(5) The system is not so susceptible to damage from atmospheric effects.

III. Earthing Arrangements.

It remains now to explain how the earthing is carried out. *Star Connected Systems*, being the more common, will be dealt with first.

The case of a Single Alternator is simple (see Fig. 5).

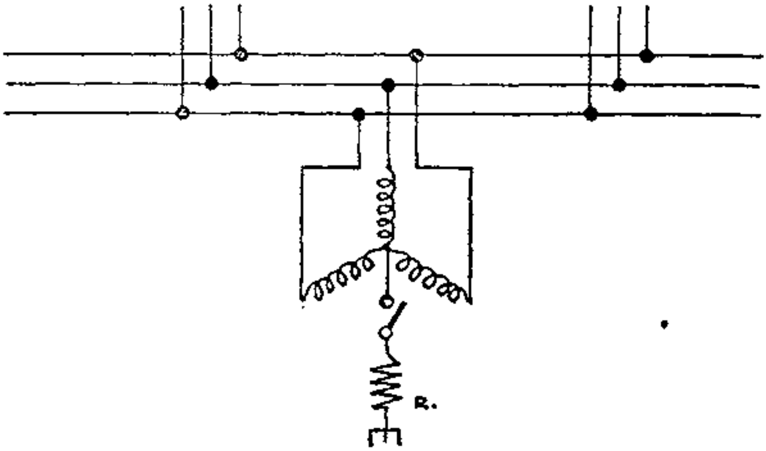


Fig. 5.

The N.P. is earthed through a non-inductive resistance R, and, if there is only one feeder, a trip coil can be inserted in the neutral connection, as shown in Fig. 2, but in the general case where there are a number of feeders, this arrangement will not do, as an earth fault on any one feeder will cut off the supply from the busbars by opening the generator main switch. The practical method is to instal a leakage trip on each feeder, making use of three current transformers and the current balance principle; see Vol. II, *Military Electrical Engineering*, p. 60 and Plate 26. This ensures that the faulty feeder only shall be disconnected.

When, as is more usual, several alternators are working in parallel, the matter is a little more complicated.

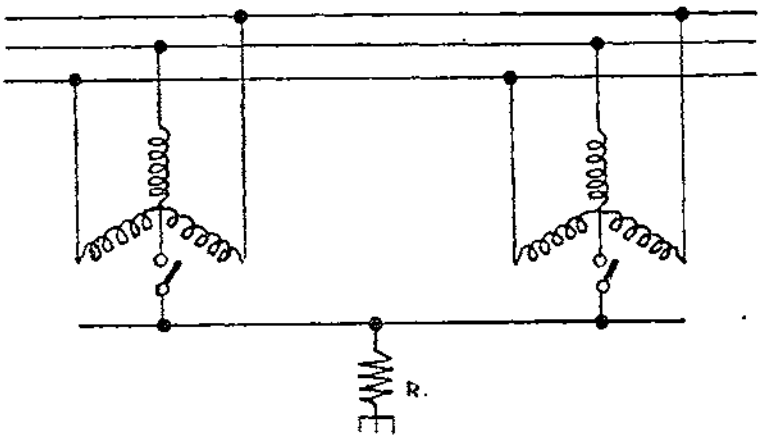


FIG. 6.

If the neutral points of the two machines are connected together solidly, as in Fig. 6, a complete path is provided for triple harmonic currents to circulate in the windings. In modern machines of similar design there is little to fear from this, but if the machines are of different make, the probability is that their triple harmonic E.M.F.'s are of different values, and the result will be an appreciable circulating current. But since the current divides between the three-phase windings in parallel, the heating effect of quite large currents is negligible. (A circulating current equal to 50 per cent. of load current does not increase the heating by more than 3 per cent.)

If, however, these circulating currents are found to be objectionable in their effects on measuring instruments and protective gear, they may be reduced in value by inserting a separate earthing resistance in each neutral connection to the earth bar (see Fig. 7).

In extreme cases it may be necessary to run with one generator only earthed at a time.

It is necessary to insert a switch (a disconnecting link will do) in each neutral connection to enable the machine to be completely isolated when necessary for overhaul.

Now, with regard to the value of the resistance it is impossible to generalise. The value should be such that the fault current to earth is sufficient to operate the leakage protective device on the heaviest feeder.

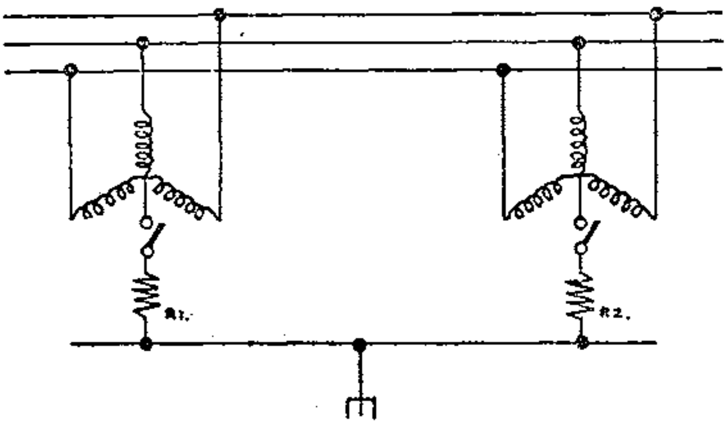


FIG. 7.

The E.C. Regulations lay down that if one of the conductors of an overhead wire makes contact with earth, the resulting leakage current must not be less than twice the value necessary to operate the leakage devices.

If leakage relays are used, a resistance limiting the fault current to 20 per cent. of the full load current of the feeder is quite suitable, since relays can be made very sensitive. But if simple leakage trips are installed without relays, the resistance must be much smaller in value.

When the arrangement in Fig. 6 is adopted it is usual to make R sufficient to limit the fault current to the full load current of the largest alternator. And when Fig 7 is used, the resistance in each neutral connection is made of such a value that the fault current through it cannot exceed the full load current of the machine to which it is connected. In the latter case the total fault current may exceed the full load current of one machine when several are working in parallel, and from this point of view it may be an advantage to run with the N.P. of one machine only earthed at a time. It is to be noted, however, in this connection, that all the oil switches in a generating station, whether on machines or feeders, are invariably of the same size, capable of dealing individually with the full capacity of the station.

The resistances must have sufficient heat capacity, and be installed in a fireproof chamber, to provide for possible delay in the working of the trip coil. It is usual to design them to carry a full load current for 30 seconds with a rise in temperature not exceeding 300° C. Insulation must be provided for full phase pressure.

The *Metal Grid* type of resistance having a positive temperature coefficient, the fault current tends to fall away rapidly if unduly prolonged. For this reason some engineers prefer to use a resistance of carbon which has a negative temperature coefficient.

Fig. 8 shows how the fault current varies with the time of its duration.

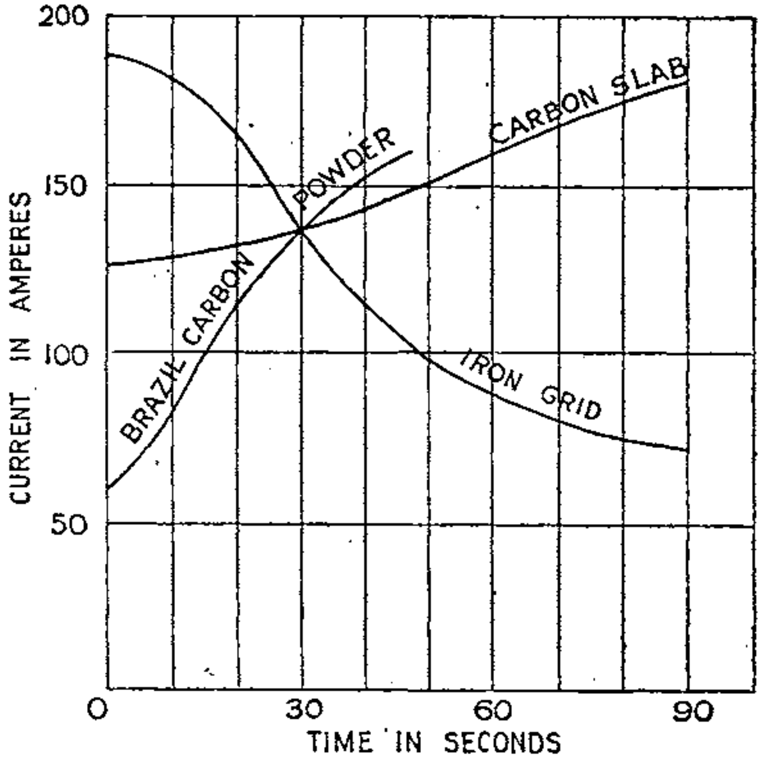


Fig. 8.—Variation of Fault Current with Time.

The "*Brazil*" type of carbon resistance consists of a number of fireclay troughs with carbon terminals at each end, the space between these terminals being filled with a special carbon powder. This form suffers from the disadvantage that excessive currents unduly prolonged tend to alter the value of the resistance permanently. Moisture also has an adverse effect.

The *Carbon Slab* type of resistance, it is claimed, entirely overcomes these disadvantages. This type consists of a number of solid carbon slabs fitted with terminals at each end, and protected against moisture by a coating of vitreous glaze. The slabs are perforated to accommodate porcelain insulators which rest upon one another, the whole being mounted on strong dome-shaped insulating supports (see Plate 2). The insulators also carry grooved channel pieces for the reception of the busbars necessary for grouping the various slabs in series or parallel, according to requirements.

The construction is simple and robust.

Compared with the metal grid type, the carbon resistance appears to have the following advantages :—

(1) *Negative temperature coefficient.* This ensures that the fault current starts at its lowest value and gradually increases until circuit breaker opens.

(2) *It can be left in circuit much longer without damage.*

(3) *Smaller space occupied.*

(4) *Somewhat cheaper.*

(5) Simpler to carry out re-grouping of the units and to add more units when modification is found necessary.

The metal grid type is used most extensively at the present time, the reason being that engineers have been acquainted with this type of resistance construction for many years, but the carbon slab type will, doubtless, be used a good deal when its advantages are fully appreciated.

Plate 1 illustrates a metal grid resistance designed to carry an initial current of 160-170 amps on a 6,600 volt system. It has resistance of about 23 ohms total, and is suitable for use with a 1875 K.V.A. Alternator.

The approximate cost of the complete apparatus, as illustrated, in X.P.M. cubicle, and fitted with a disconnecting link, is £70. Its overall dimensions are 9-ft. high, 5-ft. wide, 2-ft. deep.

Plate 2 illustrates a carbon slab resistance to carry 150 amps on a 6,600 volt system. It has a resistance of 25 ohms and is, therefore, suitable for a 1875 K.V.A. machine. The space occupied by the resistance itself is 2-ft. 6-in. high × 2-ft. 6-in. wide × 2-ft. 6-in. deep. The overall dimensions of the X.P.M. cubicle with disconnecting link would probably be about 5-ft. high, 3-ft. wide, 3-ft. deep.

The cost of the *resistance alone*, as illustrated, is about £40. (It is made up of a 50 amp. unit in parallel with a 100 amp. unit).

The following examples of metal grid resistances actually installed may also be noted :—

(1) 3,300 *Volt* 1250 *K.V.A. Alternator.*

Resistance 14.9 ohms. Overall dimensions as above (including disconnecting link), 7-ft. 6-in. × 3-ft. × 1-ft. 6-in.

(2) 6,400 *Volt* 16,667 *K.V.A. Alternator.*

Resistance 2.5 ohms. Overall dimensions as above, 7-ft. × 5-ft. × 3-ft.

Delta Connected Systems.

In a Delta-connected system, an artificial neutral point can be obtained in the following manner :—

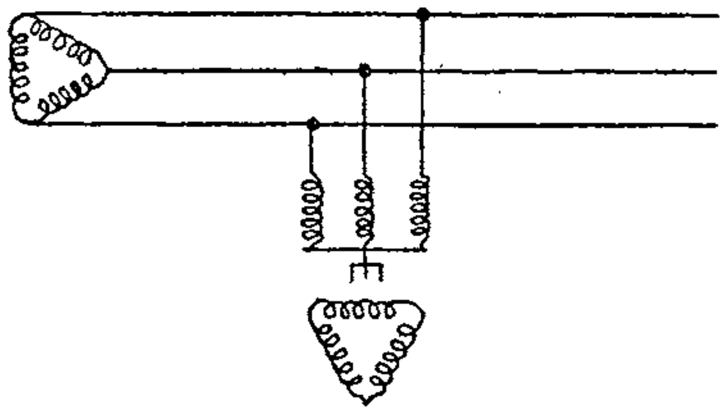
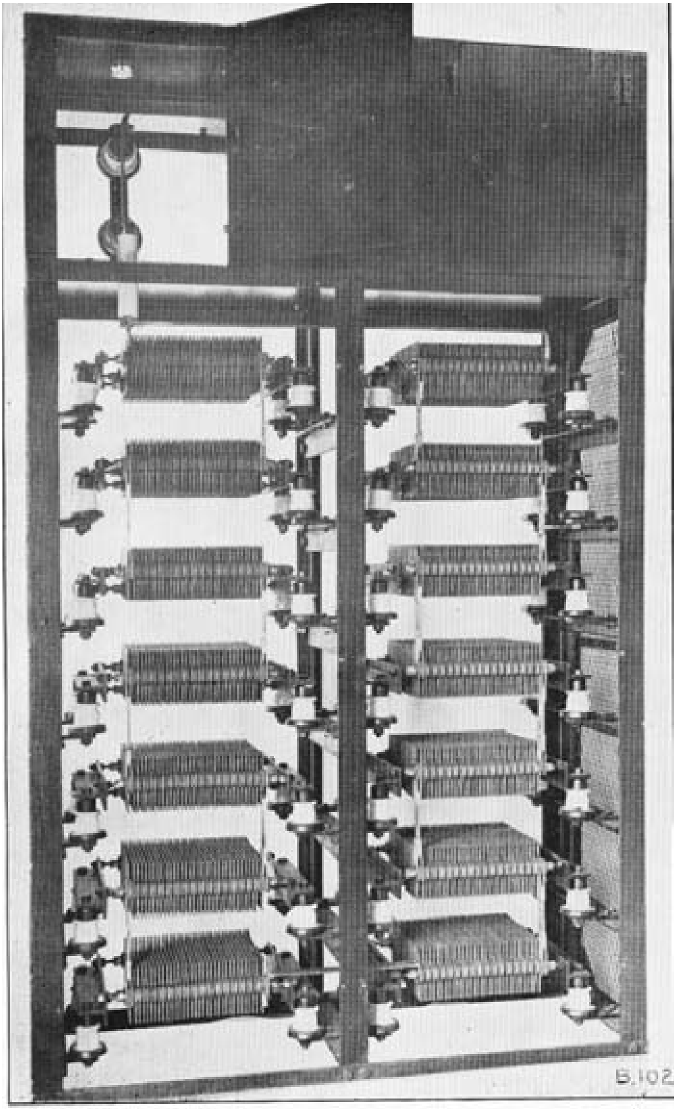


FIG. 9.

If an ordinary type of *Star-connected 3-phase power transformer* is connected to the busbars, the star point provides a suitable neutral point for earthing purposes. Although not essential, it will be an improvement if the secondary winding is mesh-connected and left isolated on open circuit (see Fig. 9). When faults occur, the currents circulating in the mesh cause the fault current to divide approximately equally between the three primary phase windings and reduce the effective impedance of the apparatus. The result is that for a given fault current a smaller transformer can be used than would be necessary if the secondary winding were absent.

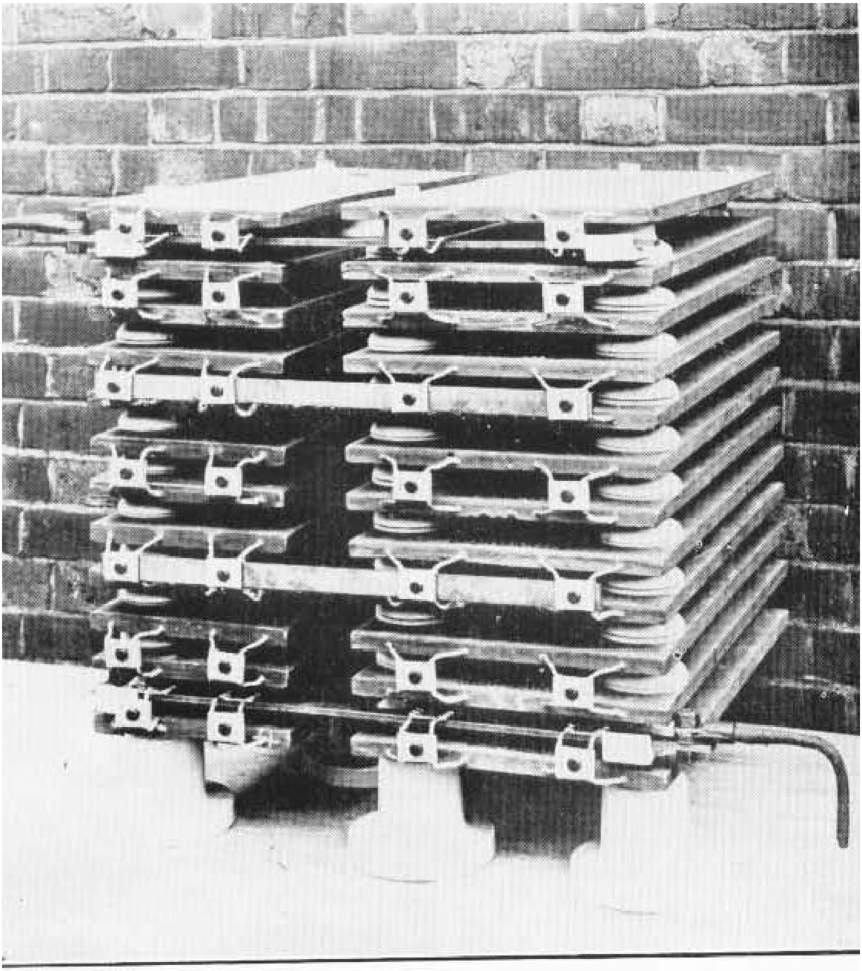
Three separate single-phase transformers may be used instead of a three-phase transformer, but in this case the mesh connection of the secondaries is absolutely essential, since the three phases are not interlinked magnetically. Without the secondary, if a dead earth occurs on one line, the primary winding of the transformer connected to that line will be short-circuited and cease to function. Therefore, although the pressures across the primaries of the other two transformers increase from V to $\sqrt{3}$.V, the resulting current through the earth connection will be only a relatively small magnetising current. In a 3-phase transformer a pressure is maintained in the short-circuited winding by the interlinking of the magnetic circuits.

With regard to the size of this earthing transformer, a suitable continuous rating would be of the order of 2 to 3 per cent. of the maximum normal load on the largest feeder. For a 250 K.V.A. feeder, a 5 K.V.A. transformer would be quite big enough. At a line pressure of 6,000 volts, the maximum feeder current would



Neutral Point Earthing Resistance. Metal grid type. 6,600 Volts., 170 Amps.
Overall dimensions, 9'x5'x2'. (Ferguson, Pailin, Ltd., Manchester)

PLATE 1.



Neutral Point Earthing Resistance. Carbon slab type. 6,600 Volts., 150 Amps. Overall dimensions, 2'6"x 2'6" x 2'6". (Everett, Edgcumbe & Co., Ltd., London)

PLATE 2.

be 25 ampères, full load transformer current 0.5 amps., and the transformer would pass a fault current of 4-5 ampères for 30 seconds comfortably. This should be amply sufficient to operate a leakage relay.

When working normally, on a sound system, the earthing transformer would take a no-load current of about 0.15 ampère per phase, and the iron losses would be about 120 watts.

The above indicates the line of action which might be taken if a suitable earthing transformer is available, but if it is intended to purchase suitable apparatus, it will be found cheaper to obtain what is known as an "*Inter-connected Star Earthing Compensator.*"

This apparatus is built like an ordinary transformer, but has only one inter-connected star winding (see Fig. 10).

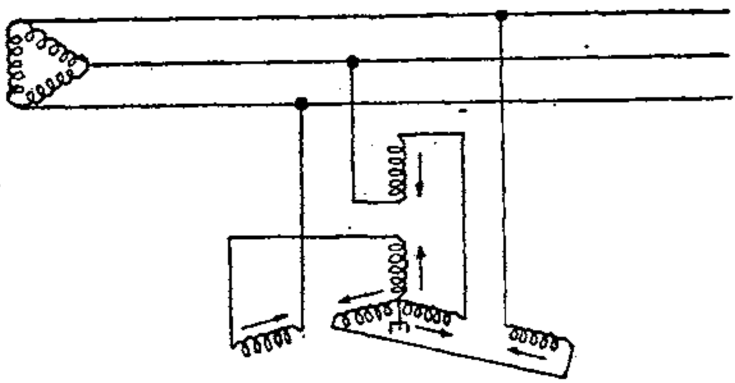


FIG. 10.

The fault current divides equally between the three phases, and as the magneto-motive forces cancel out on each limb, the windings act as if they were non-inductive as far as the fault current is concerned.

The apparatus can be designed with sufficient reactance to limit the fault current to a safe value, but for large sizes it is generally cheaper to use non-inductive limiting resistances. When there are no faults on a system the transformer takes simply a magnetising current similar to the Star-Delta type of earthing transformer referred to above, or to any other transformer with the secondary on open circuit.

The above described method of obtaining an artificial neutral point is, of course, quite suitable for star-connected systems as well; the only objection being the waste of power due to the iron losses.

THE LIFE AND WORK OF COLONEL CLARKE.

BY COLONEL SIR CHARLES CLOSE, K.B.E., C.B., C.M.G., F.R.S.

DURING the meeting of the British Association at Southampton in August, 1925, the President of the Association, Professor Horace Lamb, F.R.S., unveiled a tablet on No. 21, Carlton Crescent, to commemorate the fact that Colonel Clarke had lived in the house for twenty years. The tablet bears the inscription, "In this house from 1861 to 1881 lived Colonel A. R. Clarke, C.B., F.R.S., R.E., who determined the Figure of the Earth." *The Times* of August 28th had an article on Clarke's work with the title "An English Pioneer," and this article gave a brief account of his scientific labours. After Clarke's death an excellent two-page notice of his career was written, for the *Proceedings of the Royal Society*, by the late Colonel E. H. Hills, F.R.S.; but this account is not generally accessible to officers of the Corps, and it is thought that it might be of interest to record in the *R.E. Journal* a somewhat fuller notice of the life and work of a brother officer who was so distinguished in that branch of science to which he devoted his active life.

On the extreme northerly coast of Scotland, in Sutherland, not far from Cape Wrath, there will be found marked on the maps an inlet of the sea named Loch Eriboll, and it was in this neighbourhood, near the south-east end of the Loch, that there lived the old Scottish family of Clarke. Colonel Clarke's father, David Ross Clarke, of Eriboll, had gone out to Jamaica as a merchant, and, in 1827, married Eliza Hall, the daughter of Charles Hall. Their son, the subject of this memoir, was born at Reading on the 16th December, 1828. It appears that he must have returned with his parents to Jamaica at a tender age, for he used to tell his children stories of Jamaica, of which he could recall many memories. On leaving Jamaica the family returned to Eriboll and spent many years there, until they finally migrated to London for good, where, after several moves, they settled down in 35, Devonshire Place, W.; David Ross Clarke died there in 1861.

Of his youthful days in Scotland the Revd. A. Mackay-Clarke, his eldest son, writes: "I do not know what schooling he had in those young days, but remember his telling me of a 'dominie' putting him under his desk and kicking him from time to time, also how 'taws' were used. Anyway he learned Latin and Mathematics."

Alexander Ross Clarke, the future geodesist, when he was seventeen, suddenly formed the desire to join the Army, and went up for the entrance examination for the Royal Military Academy, after only about three weeks' preparation. The time available for preparation for this examination was insufficient; he passed in, but was last on the list. Once at Woolwich, however, his natural ability asserted itself; he rapidly rose in his batch and passed out first, being commissioned as a second lieutenant in the Royal Engineers on the 1st October, 1847. There has survived of his work at this period a little green pocket book, containing text-book examples of conics and Cartesian geometry; it is a model of neatness. On leaving Woolwich he went, in the usual course, to Chatham. The order, from 84, Pall Mall, runs thus: "You are granted leave of absence to the 1st November, on which day you will join the Field Instruction at Chatham, and report yourself to the Director of that Establishment, previously appearing at this office in Regimentals . . . . E. Matson, Asst. Adjt. General." A note is attached to the order that, "Every officer of Engineers is to provide himself with a proper case of drawing instruments, a telescope, box of colours and hair pencils, fifty-feet tape, a small sextant, and a pair of eighteen-inch parallel rulers."

He seems early to have made up his mind that the Ordnance Survey would provide scope for his mathematical abilities, for he approached Colonel William Reid, C.R.E. at Woolwich, a veteran of the Peninsula, who had himself served for some years on the Survey under Colby. Reid wrote to Colonel Hall, then Director of the Survey, and Hall replied in the following terms: Southampton, 4th January, 1850. "My Dear Reid, My funds for the year ending the 31st March next do not admit of my increasing the present number of officers on the Survey. From the 1st April next we are to have a separate vote of £2,000 per annum for the preparation and publication of the Trigonometrical Survey, and I will bear your recommendation in mind regarding Lt. Alex^r. Ross Clarke and speak to Matson about him."

Hall was as good as his word, and Clarke was posted to the Ordnance Survey, at Southampton, in April, 1850. But in 1851 he was ordered to Canada, and remained there until 1854, when he returned to the Survey. He remained on the Survey at Southampton for 27 years, i.e., until 1881, when he retired. All his geodetic work was done at Southampton. The "separate vote of £2,000" was perhaps the best spent money in the history of the Survey.

Clarke, then, was posted to the Survey in 1854, and no doubt was immediately put on to the work of discussing the Great Triangulation. In 1856 he was placed in charge of the Trigonometrical and Levelling Departments. The last observations of the triangulation had been taken in 1853, but the work was practically complete in 1851. Anyway, when Clarke re-joined at Southampton in 1854, the field work was finished, and the time had come for the immensely laborious task of reduction. Now, at that time, there were no accepted methods in Great Britain of dealing with such a mass of observations. Clarke was able to study the methods in use in France and Germany, and perhaps in India, but the problem was not quite the same as in those countries; for one thing, the triangulation of the United Kingdom had been carried out in the form of a network covering the Islands completely, whilst abroad the system in general use was that of meridional and longitudinal chains. No reduction of a general or systematic kind had been attempted before Clarke's arrival. He accomplished the task with extraordinary thoroughness and rapidity, for the results were published in 1858 in a monumental quarto volume of some 800 pages, known as *The Account of the Principal Triangulation.*

Clarke, for the first time in this country, applied the principle of "least squares" to the computations in the most thorough manner. This principle, which is now of universal application in such computations, is due chiefly to Gauss, and consists in rendering the sum of the squares of the errors (or residuals) a minimum. It is noteworthy that in 1837, Airy, whose Figure of the Earth was shortly after that date adopted by the Survey, rejected this principle in his calculations for that determination. Clarke followed Bessel's *Gradmessung in Ostpreussen* closely. The network of triangles covering the British Isles was broken up into 21 figures, and the most complicated figure involved the solution of 64 equations of condition. The total number of equations of condition, for the whole reduction, was 920. Clarke's remarkable *Account of the Principal Triangulation* is not only a record of the computations, but it is, in itself, an exposition of the principles of, and a treatise on, geodesy. It contains the calculations for several Figures of the Earth, based on somewhat differing assumptions. The 1858 general figure is much used in British topographical surveys. The book contains much original matter.

In 1860, Struve, the astronomer, moved the Russian Government to invite the co-operation of the Governments of England, France, Germany and Belgium in the measurement of a longitudinal arc between Valentia Island, off the south-west of Ireland, in about longitude 10°30′ W, and Orsk in south-eastern Russia, in longitude about 58°30′ E; the arc covering about 69 degrees of longitude. As preliminaries for this undertaking it was necessary, first, to compare the various national standards of length, and secondly, to re-observe and render more precise the junction of the British with the continental triangulations. The comparison of the standards was entrusted to Clarke, who carried out the work in a building which was specially designed and constructed for the purpose at Southampton. The comparison included not only the standards of those countries mentioned above, but also the 10-foot bars for India and Australia. Tucked away in the volume which describes the comparisons will be found another discussion of the Figure of the Earth; the volume was published in 1866, and this figure is known as the 1866 Figure. This 1866 Figure has a considerable world importance. Every country is faced with the necessity of adopting some standard spheroid of reference. Thus in the British Isles it is Airy's Figure that was adopted; in India, Everest's, and so on. In the case of the United States, Clarke's 1866 Figure was chosen; and Canada and Mexico have, very wisely, followed suit. So that now, for the whole of the North American continent, the 1866 Figure is used.

In 1861 Clarke took part in the observations for the new connection of the triangulations mentioned above. The results were computed by him and published in 1863. In 1861 also he reduced and published the results of the spirit levelling in Great Britain. The reductions, by Clarke, were admirable; but the field-work left a good deal to be desired. It is now superseded by the geodetic levelling of 1912-21, so far as concerns England and Wales. In 1878 he again discussed the Figure of the Earth; this time on the assumption that the earth was not a figure of revolution, but was an ellipsoid with three unequal axes. With an assumption of this kind, which gives an extra figure of freedom, it is, of course, possible to obtain smaller residuals; but the hypothesis is by no means proved thereby, and we may look upon the computation as the amusement of a mathematician.

In 1880 he wrote his celebrated book on "Geodesy," which was published by the Clarendon Press. It remains the best English book on the subject, and may properly be described as a classic. In this book, also, he worked out a Figure of the Earth from new data, additional arcs having become available. The 1880 Figure also has its international importance. It is used by the French *Service Géographique de l'Armée* in all their recent work, and was used by the late Sir David Gill for the triangulation of South Africa. There never was a geodesist who so persistently tackled the problem as Clarke did between 1854 and 1880. It may be of interest to put down his principal results. In the Table which follows, a stands for the semi-axis major of the ellipse of revolution, and c stands for the compression, or $(a-b)/b$ where b is the semi-axis minor. The lengths of a are given in international metres.

Date.	Authority.	Semi-axis major or a in metres.	Compression or c.
1858	*Principal Triangulation.*—British data only.	6,378,257	$\frac{1}{269.15}$
1858	Do. Do., only making allowance for topographical deflection.	6,378,497	$\frac{1}{280}$
1858	*Principal Triangulation,* from all available data.	6,378,293	$\frac{1}{294.26}$
1866	*Comparison of Standards of Length.*	6,378,206	$\frac{1}{294.98}$
1880	Clarke's *Geodesy.*	6,378,249	$\frac{1}{293.46}$

The Figure used by the Ordnance Survey since 1837 is Airy's. In this Figure $a=6,377,542$, and $c=\frac{1}{299.33}$

In 1901, Helmert, the celebrated German geodesist, worked out, from gravity measurements, a Figure which gave; $c\ \frac{1}{298.3}$ The late Mr. Hayford, the American geodesist, in 1911, found these values derived from American measurements: $a=6,378,388$; $c=\frac{1}{296.96}$ Finally, in 1924, the Geodetic Section of the newly formed International Union of Geodesy and Geophysics recommended the use of Hayford's last Figure, namely $a=6,378,388$; $c=\frac{1}{297}$. Where the international metre may be taken as equal to 3.28084275 feet.

It was a very fortunate thing for the Ordnance Survey that Clarke came when he did and stayed so long. The older men of science had disappeared; Colby had left a few years before and was succeeded by an officer of no scientific ability. Drummond was dead and Portlock had gone in 1843, and there was no officer left who was capable of undertaking the difficult and laborious task of reducing the triangulation. It is only right to say that, during the greater part of Clarke's time on the Survey, that department was commanded by an officer—Sir Henry James—who, though no mathematician himself, did thoroughly appreciate the necessity for a sound mathematical foundation for the Survey, and in every way supported Clarke officially in his great labours. Though, it might be suggested by some that Sir Henry James himself absorbed some of the credit which was due to Clarke. But, on the whole, James as Director and Clarke as geodesist worked well together.

What was the effect on the normal work of the Survey of all Clarke's work? Well, the effect was largely indirect in stimulating and sustaining a high standard of precision. There was, of course, a direct effect also, which was chiefly this: the whole triangulation was welded into a perfectly consistent whole, so that geographical positions and linear distances could be used with the certainty that, whatever the extension of a piece of work, no discrepancies could occur. The day was over for rule-of-thumb adjustments. Exactness and certainty took the place of the tentative and experimental methods of the past.

He was elected a Fellow of the Royal Society in 1862, but in later years the expenses of a large family obliged him to cut down his subscription list and he resigned from the Society. But in 1888 the Royal Society did him the great honour of re-electing him as a Fellow, without the necessity of his paying any subscription. In 1887 the President and Council of that Society had awarded him a Royal Medal for his "Comparison of Standards of Length and Determination of the Figure of the Earth." In 1868 he was elected a corresponding member of the Russian Imperial Academy of Sciences. In 1871 he was elected an honorary member of the Cambridge Philosophical Society, in the goodly company of Huxley, Spottiswoode, Argelander and Helmholtz.

Much of his work was done in No. 21 Carlton Crescent, Southampton. Surrounded by a family of young children, he had the faculty of detaching his mind from his surroundings to such an extent that they could play in the room in which he was working without interrupting the current of his thoughts; though he made the stipulation that they should not address him directly.

Clarke might reasonably have expected to have succeeded to the next vacancy as Director of the Survey and to have served till he was retired for age. But, in 1881, when he was not quite 53, an official of a familiar type woke up to the fact that Clarke had been at a home station for 27 years, and he was ordered abroad, to a tropical station, as C.R.E. Clarke was a man of somewhat hasty temper, and, on receipt of this order, he at once sent in his papers. His retirement was approved and he was gazetted out. Immediately a storm of indignation arose in the scientific world and representations from influential quarters were made to the War Office. Of no avail! His retirement had been approved and must stand. A lesson must be taught those who cherished the illusion that any officer was indispensable.

But Clarke *was* indispensable. He was the one man fitted for the post that he had occupied with so much distinction for so many years. His successor in this post was a well-known officer, of charming personality, universally popular, but alas! without mathematical ability. From that time for a long period, the history of the Ordnance Survey is, from a scientific point of view, but a melancholy recital of mediocrity. But officialdom in those days was of opinion that it was necessary to enforce the great principle that one officer was as good as another. Clarke's retirement was a veritable disaster for the Survey, and his departure lowered the whole tone and scientific status of the department for many a long year.

After his retirement he was appointed one of the British delegates to the Geodetic Congress which was held in Rome in October, 1883, the Astronomer Royal being the other delegate. But after that year he seems to have given up most of his scientific work. He appears to have published nothing more except some articles in the *Encyclopædia Britannica*, although he lived for more than thirty years after his retirement. In 1884 he was nominated as one of the British members of the International Geodetic Association, but it does not appear that he took any active part in the affairs of that body. The writer of this account had occasion to ask Clarke a question with reference to some geodetic matter, a few years before his death. It was evident from his reply that, in his old age, he had lost all interest in the subject.

After retirement Clarke settled at Redhill. There is an account of a visit paid to Clarke by the Russian geodesist Witkowsky. It is too long to quote in full, but the following extracts may give some idea of the manner of Clarke's life in retirement. Witkowsky writes: "My object in going to Redhill was not to enjoy nature, but to visit the well-known English geodesist, Alexandre Clarke. Arrived at Redhill, I walked confidently from the station along the main street, and though unaware of Clarke's address, thought that his house would be pointed out to me by any of the passers by. I was mistaken, the same as in Hamburg whilst searching for Repsolde, and came to the conclusion that no one could be a Prophet in his own country. Clarke's name seemed unknown to the residents of Redhill."

However, he found the house and was told that Clarke and his daughters had gone to church; he was asked to come in and shortly afterwards Clarke arrived; "Soon a ring announced the Master's return and in a few seconds I was in the embrace of my respected elder, he received me as a relative. From future conversations I came to the conclusion that even in England great men are not always appreciated by their worth." This must have been in the year 1898, for the writer goes on to say that "notwithstanding his 70 years Clarke continues to work, and is chiefly interested in scientific questions appertaining his speciality . . The translation of his works into the Russian language has afforded him great pleasure. Besides science, like many other learned English, Clarke takes a deep interest in religious subjects." The Russian geodesist had dinner with the family and after dinner "My sense of hearing was soothed by the Psalms sung and music played by them (Clarke's daughters) on the pianoforte. In every respect I was made to feel perfectly at home. My host not being able to continue his astronomical studies for want of an observatory, turned his attention to microscopical objects, and says that in them, there is as great grandeur as in anything else in the universal space. Here he comes into contact with some interesting mathematical problems. For lighting the microscopical apparatus he has a small kerosene lamp with a bluish glass; such a glass absorbs the heat-rays and keeps both the microscope and apparatus cool. Whilst inspecting the library Clarke enquired if I knew how many paints were required to paint a large map, so that each country should be of different colours, and that the same colours not clash. It appears that four paints would be quite sufficient, and a proof of this rule is a difficult problem. . . .

Our farewell was very touching, all the Family escorted me to the station and waved their handkerchiefs until a turn in the railway hid them from my sight. So I left peaceful Redhill, the residence of the respected Geodesist famed through England (? Europe) but not sufficiently appreciated in his own country."

The chief contributions of Clarke to the literature of geodesy are: *The Account of the Great Triangulation* 1858; *The Accounts of the Levelling of England, Wales and Scotland*, 1861; *The Extension of the Triangulation into France and Belgium*, 1863; *The Comparison of Standards of Length*, 1886; *Geodesy*, 1880; articles on mathematical geography and on geodesy and the Figure of the Earth in the *Encyclopædia Britannica*; there are some 16 papers on geodetic subjects mentioned in the Royal Society's *Catalogue of Scientific Papers*.

In 1853 he married Frances, daughter of the late Major-General Dixon, R.E.; she died in 1888 leaving eight children, five daughters and three sons. The writer of this account is indebted to the eldest son, the Rev. A. Mackay-Clarke, for much of the information therein contained.

Clarke died at Reigate, on the 11th February, 1914, aged 85, leaving behind him the reputation of having been one of the most distinguished geodesists that this country has produced, and the most eminent man of science who has ever served on the Ordnance Survey.

PROFESSIONAL NOTES.

(Communicated by the Field Works and Bridging School, S.M.E.)

THE DEMOLITION OF RAILWAYS.

THE deliberate demolition of railways will include not only the destruction of bridges and culverts, but also that of the permanent way. In flat countries the latter may be the only possibility. In the Palestine campaign a great deal of valuable experience was gained in this type of demolition, from raids carried out on the Hedjaz Railway. An article on this subject appeared in the January 1919 issue of the *R.E. Journal.* With careful organization it is possible for both the demolition party and the enemy repair gang to attain a high rate of progress and such operations may well resolve themselves into a race between these two parties.

It was proved in Palestine that an ordinary clean cut in a rail was of little value. The ends are easily tapped together and a new length inserted as soon as a sufficiently wide gap has been made. A twisted or bent rail is a much more difficult matter and must usually be returned to the mills for re-rolling.

Two methods of producing this result are already known. One is to overturn the entire track; this requires a large party of men. The other applies only to steel sleepers and consists in placing a small mined charge of 2 lbs. of guncotton under the centre of a mid-rail sleeper. This has the effect of humping the sleeper and twisting the rails outwards.

Both are therefore subject to limitations and it was felt that if the ordinary guncotton charge could be so placed or adjusted as to produce a bend or twist instead of a clean cut, valuable information would have been obtained. Experiments have recently been carried out at Chatham on these lines.

A 60 foot length of single track with wooden sleepers, chairs, etc., as for a permanent line was laid for the purpose. Two types of 80 lb. rail were used, flat bottomed and bull-headed. Both behaved in much the same way. In every case a joint was attacked, fish plates and bolts being left in position, when placing the charge. It was found:—

(1). That 2 slabs packed with clay and placed centrally on a joint will usually blow a jagged fracture 2 feet long, leaving no trace of fish plates or bolts. It makes little difference whether the charge is placed underneath or on the side. In the latter case, clay was packed out to the level of the bolt heads, to provide a good seating. Slight distortion of the rails may occur but is not to be relied on.

(2). That 2 slabs placed centrally on the bolt heads but without clay packing will usually blow a jagged fracture 1 foot long. The fish plates and bolts will be distorted but not entirely removed. The rails are unlikely to be distorted.

(3). That 1 slab on a joint (even when tamped) is insufficient to produce any effect with certainty.

It thus appears that guncotton is too shattering an explosive to produce a bend with any certainty, but that the most effective method is to use 2 slabs tied on the side against the bolt heads without any clay packing. The distorted fish plates and bolts take some time to remove.

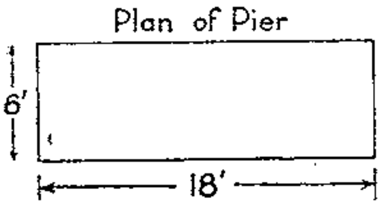
The charges should be staggered, alternate joints being selected on each rail.

DEMOLITION OF MASONRY PIERS BY MEANS OF MINED CHARGES.

This is a method of demolition which has perhaps not received the attention which it deserves.

The economy in explosives to be effected by the use of mined charges, instead of cutting charges, is very great and can readily be seen from a comparison of the respective formulæ in the following example :—

CUTTING CHARGE.



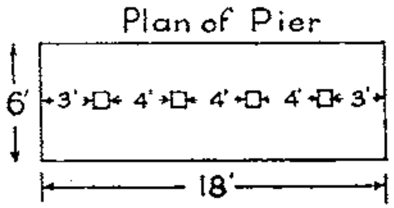
Using a row of Guncotton Slabs placed along one face of the pier.

$C = 2/3\ BT^2$

$= 2/3 \times 18 \times 36$

$= 432$ lbs Guncotton.

MINED CHARGE.



$C = \frac{L^3}{6}$

$= \frac{3 \times 3 \times 3}{6}$

$= 4\frac{1}{2}$ lbs. of ammonal for each charge.

Distance apart of charges

$= 4/3\ L = 4$-ft.

Hence number of charges is 4, and total amount of Ammonal—

$= 18$-lbs. Ammonal.

There has hitherto been little or no data on which to base an estimate of the time required to prepare the boreholes, and it may be that many officers consider the operation much more lengthy than it actually is.

Experiments have recently been carried out at Chatham with a Miners Class in order to obtain some statistics of work of this nature.

The results are set out in the table below.

It will be seen that the preparation of the chambers is not necessarily a lengthy operation, and that this method of demolition may well be included under the heading of " hasty demolition " where the thickness of the pier is not excessive.

Time Required to place Borehole Charges in Masonry Piers and Quantity of Explosives Required.

Based on experiments carried out at Chatham with a Miners Class. Masonry selected was the brick lining to the Ravelin Ditch ; good class work in good state of repair.

Maximum length of bore-hole that could be driven was 3 feet, the limiting thickness of the wall. Times for longer boreholes are estimates only. In practice it is generally found that few piers are solid masonry throughout, the interior being usually rubble and fairly easy to work.

Thickness of Pier.	Spacing of Charges measured along face of Pier.	Weight of Ammonal for each Charge.	Suitable size of Borehole.	Length of Borehole required.	Estimated time taken by 3 men to make borehole and lay and tamp charge.	Remarks.
		lbs.			hrs.	Suitable Tools.
3′	2′	½	2″ diam.	1′ 8″	1	
4′	2′ 8″	1½	3″ ,,	2′ 2″	1½	Bars, jumping and boring.
5′	3 4″	3	4″×4″	2′ 8″	2	Chisels, brick.
6′	4′ 0″	5	5″×5″	3′ 3″	2½	Scrapers, Miners'.
7′	4′ 8″	7	6″×6″	3′ 9″	3	Hammers, Miners', Sledge.
8′	5′ 4″	11	7″×7″	4′ 4″	4	
9′	6′ 0″	16	8″×8″	4′ 10″	5	
10′	6′ 8″	21	9″×9″	5′ 5″	6	Ditto, ditto, Boring.

Note.—If men are working from slung staging, increase time by 25%

Approaches for Pontoon Bridges.

The introduction of the new pontoon equipment brings into prominence the question of approaches. The standard bridge is now the "medium" bridge designed for 5½ ton axle loads. This includes the 3 ton lorry and other mechanically propelled vehicles, which comprise the modern Divisional transport, also 6" howitzers and 60pr. guns.

Mechanical transport will normally be confined to roads and when it is found impossible to site a pontoon bridge giving direct access to metalled roads on both banks, auxiliary approaches will be necessary.

The site of a demolished bridge must normally be left clear for the construction of a stock-span bridge.

It follows, therefore, that the provision of a temporary crossing will generally include not only the construction of a pontoon bridge but also of a considerable length of approach on either side. The latter may well be the deciding factor in estimating the time required to complete the work.

It is thought that the following example of a typical case may be of some value to those officers who have not yet had an opportunity of handling the new equipment. The solution is entirely theoretical, the estimates being based to some extent on experience gained during instructional training at the S.M.E.

The estimate for the slab road will obviously depend very much on the amount of levelling to be done.

Problem.

It is required to construct a temporary crossing over the stream shown in the sketch. The crossing to consist of a medium pontoon bridge connected by slab road to the metalled roads on either side.

Data.

(1) The work to be carried out as quickly as possible.

(2) There is at present no access to E. bank.

(3) There will be one steel trestle at each end of the bridge.

(4) Banks are 3 feet above water level.

(5) The current is 3 knots.

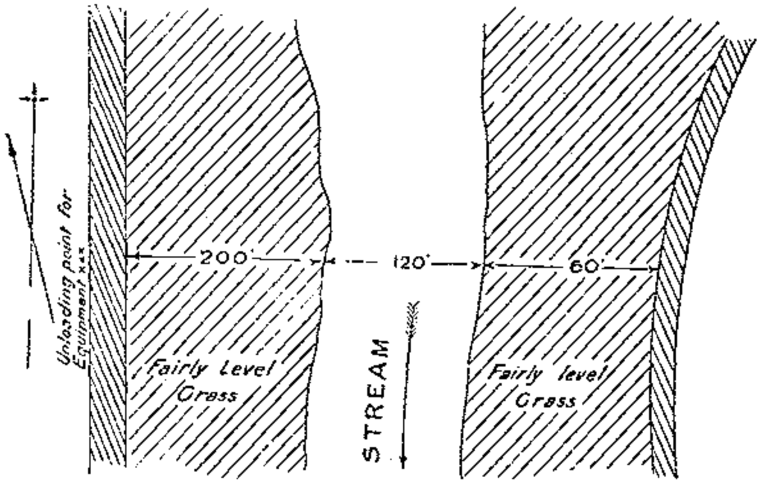
(6) No interference is to be expected from the enemy.

SUGGESTED SOLUTION.

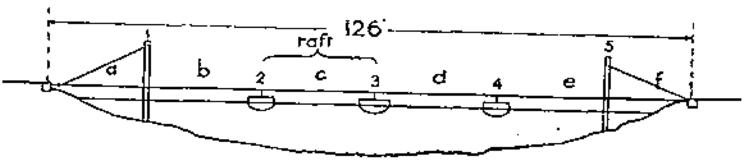
Unloading Stores. Carrying party for a pontoon = 24 men.

Take this as a unit party. Not more than 4 of these parties can work simultaneously without undue congestion.

∴ Unloading party = 100 men (including N.C.O's.).



The Bridge.



Number of Party Loads.

2	Steel trestles—2 saddles	1
6	Pontoons	6
42	R.S.J's. and 6 Stiffening Transoms ..	10
176	9" x 3" Chesses	15
12	Ribands	1
6	Heavy anchors and cables	1
6	Buoys and Buoylines	
14	Shore baulks, spars	2
5	Saddles, lashings, cross-bracing, etc..	
		36=9 trips per party

Average time for trip and return, including unloading and launching in the case of Pontoons, say, 5 minutes.

∴ Total time for unloading is 45 minutes.

CONSTRUCTION OF BRIDGE.

(*a*) *Trestles.*

The only justification for using trestles would be where the water was not deep enough to float a pontoon. (Tidal river need not be considered.) Hence the quickest method of erecting, will be to wade in and carry out.

Trestle No. 5 must be ferried over in pieces and assembled on East bank. Keep one pontoon for this as long as possible and for ferrying over men to start levelling for slab road on East bank.

Organisation.

Serial No.	Time.	Party.	Task.	Remarks.
1	Z + 45 min. to Z + 1 hr. 20 min.	1 N.C.O. & 12 men.	Erect Trestle 1, complete Shore Bay and Span *a*.	
2	Z + 45 min. to Z + 1 hr. 30 min.	1 N.C.O. & 12 men.	Ferry over Trestle 5 in parts on Pontoon No. 4. Assemble and erect. Insert 2 outer joists in span *f*.	
3	Z + 45 min. to Z + 1 hr. 30 min.	2 N.C.O.'s & 26 men.	Construct Raft *c*. Come into bridge. Complete spans *c* and *b*.	
4	Z + 1 hr. 30 min. to Z + 2 hrs.	Serial No. 1, 2 and 3.	Insert Pontoon No. 4 and complete entire bridge.	

Thus, to construct bridge, total party is 4 N.C.O's. and 50 men.

It appears then, that a suitable organization will be to divide the unloading party into two halves as soon as the pontoon equipment is unloaded. One half becomes the bridge construction party, the other half carries on unloading the slabs for the road.

In addition, a further party of 4 N.C.O's. and 50 men could be employed from Zero hour on levelling the foundations of the road, 3 N.C.O's. and 35 men on the West bank, 1 N.C.O and 15 men on the East bank, the latter party being ferried over on Pontoon No. 4 as soon as this is launched.

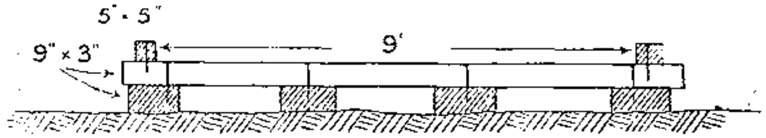
Slab Road.

Assuming that the ground is reasonably firm, drains can be left till later.

It is proposed merely to level off minor irregularities and to lay the runners direct on the grass. 6″ nails are used instead of spikes, to save auger holes.

Forty-five minutes elapse before the pontoon wagons are unloaded and clear of the site, to enable the lorries to bring up slabs.

Adopting this type



Total slabs required = 454.
weighing 15 tons.
= 5 Lorries.

Unloading.

Fifty of the 100 men who unloaded the pontoon equipment will carry on unloading the slabs; the other 50 constituting the Bridge Construction Party.

Ten men per lorry should unload and stack in field alongside work in 20 minutes.

West Approach.

Serial No.	Time.	Party.	Task.	Remarks.
1	Z to Z + 1 hr.	3 N.C.O.'s & 35 men.	Level foundations.	
2	Z + 1 hr. to Z + 2 hrs.	7 N.C.O.'s & 85 men.	Lay runners and complete road.	Serial No. 1 reinforced by slab unloading party on completion of unloading.

East Approach.

Serial No.	Time.	Party.	Task.	Remarks.
1	Z to Z + 2 hrs.	1 N.C.O. & 15 men.	Level foundations.	
2	Z + 2 hrs to Z + 2 hrs 30 min.	12 N.C.O.'s & 150 men.	Lay runners and complete road.	Bridge and west approach completed at Z + 2 hrs. All three parties available from this hour.

Summary.

One hundred and fifty men, with a proportion of officers and N.C O's. should complete the work in about $2\frac{1}{2}$ hours.

A suitable organization would be as follows.

Three parties. A, B and C, each consisting of

1 Officer
4 N.C.O's.
50 men.

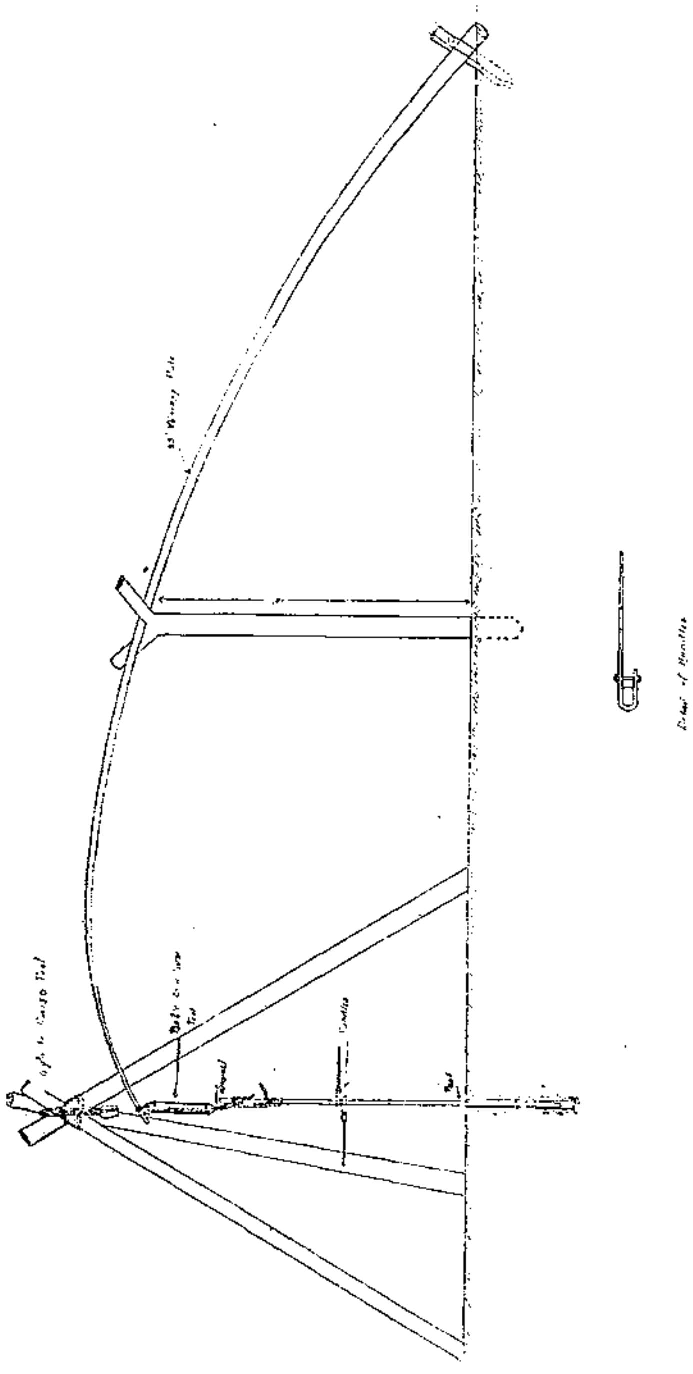
Time.	Party.	Task.	Remarks.
Z to Z+45 min.	A B C	Unload Pontoon Wagons. Do. do. do. Level approaches. 35 on west bank—15 on east bank.*	*Must wait a few mins. until a pontoon is available.
Z+45 min. to Z+2 hrs.	A B C	Construct bridge. Unload slabs. Lay runners and slabs on west approach. Continue levelling approaches.	Bridge and west approach completed Z+2 hrs.
Z+2 hrs. to Z+ 2½ hrs.	A B C	Carry and lay runners and slabs on east approach.	East approach completed Z+2½ hours.

CAST-IRON HOUSES.

The following information was published in *The Times* of 1st October, 1925, about the cast-iron houses which are being manufactured by Messrs. Newton, Chambers and Co., of Sheffield:—

Some 11 tons of pig iron are used for each house. Blocks are moulded in the foundry, where there is a unique lay-out of moulding machinery. The cast-iron plates are joined together in the walls by bolts through the flanges, between which there is a wood-packing strip used for securing the internal linings. The outer walls are faced with a special cement roughcast. The houses with their red tiles and porches, seen against the background of the Yorkshire woods, are attractive in appearance. The opinions of the men employed in the works and collieries were ascertained before the houses were built, in order that they might be designed to meet the wishes of possible tenants. All consulted asked for a bath room to be installed upstairs. They asked, too, for good cupboards and picture rails in the downstair rooms. The kitchen has a range containing a roaster, a plate warmer, a hot closet, and a copper back boiler. The rooms are 9ft. high and therefore have more space than the majority of council houses.

The houses contain a living room, measuring 17ft. 10½in. by 11ft. 11in., a kitchen, 11ft. 3½in. by 9ft. 3in., a larder, 7ft. 11in. by 6ft. 3in., a coal place, 6ft. 3in. by 2ft. 8in., and on the first floor three bedrooms and a bath room. They are being delivered and erected within a radius of 50 miles, complete with internal fittings, fireplaces, bath, w.c., wash basin and hot water system, at £425. The increased cost quoted for erecting such a house at Brighton recently was £10. Arrangements have been made to supply these houses complete, to erect them and finish them for occupation without touching local supplies of skilled building labour. All the houses are built under building trade conditions. The price, of course, excludes the provision of foundations and drains.



SIMPLE BORING PLANT

SIMPLE BORING PLANT.

This apparatus is in common use in certain parts of Queensland where shallow wells are employed for watering stock. It is simple of operation, can be improvised in any ordinary circumstances, and as the bulk of the material can be cut from standing timber it is cheap and easy of transport.

It has been used with success to depths up to fifty feet or more, depending on the strata, and test bores can be sunk at the rate of from ten to fifteen feet per hour.

Its operation is as follows: Two men operating on the handles maintain a vertical oscillating movement of the tool, the whippy pole doing the bulk of the work. The tool can be turned in the bore by the men walking round as it is striking. The length of tool is adjusted by the tackle between the pole and the top of the tool, a gyn being provided to remove the tool as required. Fresh lengths are screwed on as the bore descends.

E. G. B. SCRIVEN, *Lieut.*
Staff Corps.

THE ROTOSCOPE.

Mr. A. J. Ashdown, of the Westinghouse Morse Chain Co., Ltd., Letchworth, Herts, has devised a new form of stroboscope for observing rhythmically moving or rotating objects having speeds ranging from the lowest to the highest met with in practical engineering.

The instrument is named the Rotoscope, and is so light and portable that it may be held in one hand when in use. A full description of the instrument is given in *The Engineer* of the 11th September, 1925, with illustrations and a general description of the principle on which all stroboscopes function.

The new Rotoscope allows binocular vision, and thus prevents strain on one eye, and as it is operated by clockwork, may be used in any position without preliminary setting up.

The shutter has a large range of speeds, from 500 to 20,000 per minute, giving a glimpse frequently up to 40,000 per minute, and a glimpse period as low as one thirty-three thousandth part of a second.

By means of this instrument the separate bars of a commutator may be clearly seen when passing any given point at the rate of 300 per second; a study can be made of the motion of the wings of a dragon fly, or the speed of rotation of a high speed turbine may be determined.

Engaging gear wheels of an engine may be studied or the slipping of belts in high-speed pulley drive. The instrument should add to the knowledge of the mechanical engineer.

MEMOIRS.

SIR MONTAGU OMMANNEY, G.C.M.G., K.C.B., I.S.O.

SIR MONTAGU FREDERICK OMMANNEY, who died at Cuckfield on the 19th August, at the age of 83, received his first commission in the corps of Royal Engineers in January, 1864, and retired as a captain in 1878. He was born on April 4th, 1842, the son of Francis Ommanney, of York House, Worcester Park, and educated at Cheltenham and the R.M.A., Woolwich. From 1866 to 1870 he was employed on special duty at the War Office and Admiralty, and was one of the original members of the Council of the R.E. Institute, and, as we had reason to be reminded at the recent celebration of the Jubilee of our Institution, designed the Institute building at Chatham. In 1871 he became an instructor at the R.M.A. In 1874 he received his first appointment in the Colonial Office as private secretary to Lord Carnarvon. In 1877, on account of his previous experience as an engineer, he was given the new appointment of third Crown Agent for the Colonies, and, in 1900, was appointed, by Mr. Joseph Chamberlain, to the office of Permanent Under-Secretary of State for the Colonies, which he held until his retirement in 1907. He was a Vice-President of the Royal Colonial Institute and King of Arms of the Order of St. Michael and St. George. Of his work in the Colonial Office he will be chiefly remembered for his development of railways in the tropical colonies and dependencies. The following letter from Captain Frederic Shelford, M.Inst.C.E., formerly consulting Engineer for the Sierra Leone, Gold Coast, Nigeria, and other Government Railways, published in *The Times* of 1st September last, is a worthy tribute to his memory :—

The late Sir Montagu Ommanney had to deal with many problems when Permanent Under Secretary of State for the Colonies, the nature of which cannot be revealed, but his energy and business capacity left more outward and visible signs which may be more openly referred to. It was particularly due to his foresight that some of the Crown Colonies emerged from impoverished and neglected territories to prosperous dependencies with large revenues and sufficient assets to enable them to raise loans upon their own security alone. Sir Montagu's foresight, backed in particular by Mr. Joseph Chamberlain, led to the construction of the so-called Uganda Railway, which reached Victoria Nyanza in

Sir MONTAGU F OMMANNEY GCMG KCB ISO

1902. Sir Montagu served on the Committee of Management during the construction of this line. For many years it failed to pay its expenses on account of the paucity of traffic, but is now almost "snowed under" by the volume of traffic which the railway itself has created.

Another remarkable case is the Gold Coast. In 1899 I walked from Sekondi, on the Coast, to Kumasi through the tropical forest and back to Accra, and reported in favour of the construction of a railway from Sekondi to Kumasi, and later a railway from Accra to Kumasi. Owing to the business ability of Mr. Chamberlain and Sir Montagu Ommanney, the first of these railways was constructed. The usual conventions were brushed aside. The fact that the Colony could not raise a loan was not allowed to stand in the way. The interest on the cost of construction was guaranteed by those interested in the Colony, and the railway was built. In 1901 the revenue of the Gold Coast was about £400,000 per annum. In 1924 it was nearer to £4,000,000. The enormous development in the cocoa and other industries was entirely due to the construction of the first Gold Coast Government Railway in the first place, and then to the ability of the local Government and the enterprise of the natives in making use of the new means of transport.

The Colony of Sierra Leone also increased in importance by being the first to construct a railway, though its advance is not so exceptional, but when one considers Nigeria, the case of the Gold Coast is repeated on even a larger scale. It was in 1897 that railway construction was begun in this Colony in a tentative and cautious manner, but so immediate was the success achieved that length after length was added until Nigeria is likely to be covered with a network of railways before long. In most cases harbour works were undertaken at the same time. These railways, and there were others, were all remarkable for two features which required the courage of men like Mr. Chamberlain and Sir Montagu Ommanney to carry them through. First, they were built in spite of the fact that the Colonies had no money to pay for them, and in the faith that they would in due course pay. Secondly, they were built as "pioneer" railways, as more or less surface lines, avoiding deep cuttings and great engineering works, such as tunnels. This policy, which required great pluck and foresight, has resulted in these Colonies leaping into prosperity, but has had the natural result that those who came later have been compelled to improve the pioneer railways by reducing gradients and curves and making them nearer to the ideal railway, which should be level and straight. The original construction may have been reprobated for bad construction, but if these African railways had first been proposed as first-class main lines they could never have been constructed at all. In such cases as these, railways must be "planted" and be allowed to grow, as they have done, into good railways. Sir Montagu Ommanney had the foresight to believe in this policy and the pluck to carry it out.

Lord Sydenham writes:—"He was a first-rate public servant, and his training as an engineer gave him the practical turn of mind which administrators frequently lack."

CAPTAIN MATTHEW HENRY PHINEAS RIALL SANKEY, C.B., C.B.E.

M. H. P. R. Sankey came of an Irish family, the home being Bawnmore in the County of Cork. He was the son of the late General W. Sankey, C.B., and was born at Nenagh, County Tipperary, on the 9th November, 1853. He was consequently in his 72nd year when his sudden and lamented death took place at Ealing, on 3rd of October last. Sankey was educated privately at Woolwich and in Switzerland and entered the Royal Military Academy at the head of his batch in 1871. He had a most distinguished career at the "Shop." He passed out at the top of his batch and was the Responsible Under Officer of his term, thus winning both the Pollock Medal and the Sword of Honour. He received his Commission in the Royal Engineers on 29th April, 1873. Sankey's career at the S.M.E. was as distinguished as that at the "Shop." His extraordinary ability being at once recognised by all with whom he came in contact. My father, who was a subaltern at Chatham in those days, used to say in jest, that Sankey was the only man he ever met who appeared to be able to keep his private accounts by means of the Calculus. Sankey was not only a mathematician of the very highest order but also a very good linguist. Another of his early accomplishments, which I can personally remember, was that he played the violin.

Towards the end of his S.M.E. Course, Sankey was selected to assist in the conduct of the famous trials of continuous railway brakes, which were carried out by the Royal Commission on Railway Accidents in 1876, at Thurgarton, between Newark and Nottingham.

On leaving Chatham he was employed in the I.G.F's office for a time on architectural design and then went to Gibraltar for a tour of foreign service. While at Gibraltar he was appointed Instructor in Fortification, at the Royal Military College, Kingston, Canada. It was in Canada, where he arrived in 1879, as assistant to my father, that I first met him to know him. My father I know had the highest possible opinion of him both personally and professionally, but it was the personal side which attracted me. His energy and cheeriness were extraordinary. His joy in living was infectious; rowing, skating and similar sports seemed to come just the same as electrical measurements. I shall never forget one incident. Sankey had engineered a submarine mine, to be exploded electrically for the benefit of the spectators at the Public Day at the end of one of the College terms. The mine consisted of a length of cast iron water main filled with gun cotton and plugged at the ends. It was a very successful show and I well remember putting off in a boat, after the explosion, to gather the dead fish. To lay the mine, a big boat had been rigged with some tackle at the mast head, and the day after the show this had to be dismantled. The boat was moored beside

CAPTAIN M H P R SANKEY CB CBE RE

the wharf at the back of the old (Frigate) barrack block of the College. My father, Sankey and a French Canadian gunner proceeded to take down the gear. I was an interested spectator in the boat. In spite of mild protests from my father, Sankey proceeded to climb the mast and the boat immediately turned turtle! Sankey went to the bottom with the mast and gear, my father disappeared under the boat, I and the gunner crawled up on to the keel as she turned over. Never shall I forget the scene. My father's face, scarlet with indignation, emerging from under the gunwale, Sankey suddenly emerging from the waves and the French Canadian kneeling astride the keel and praying, in an unknown tongue, to all the Saints in the Calendar to save him. When he saw we were all safe, Sankey at once started in a light-hearted way to dive from the wharf to try and recover some of the lost gear. I tell this story as the incident made a great impression on me. His behaviour was typical of the man; nothing could depress him. While at Kingston, Sankey wrote a book on Electrical Measurements for the benefit of the Cadets. and collaborated with my father in writing a book of notes on Fortification. I think amongst other things he drew all the pictures. I have a copy of these notes still and they seem to me to be about the best of their kind that I have ever come across, in that they enunciated, with the most unmistakable clearness, that the art of fortification was invented to help soldiers to fight battles and that such was its only object. One of the axioms laid down was that a work must be properly sited, that it should be of such dimensions that men could fire out of it, and that it should be bullet proof. I doubt if the whole art can be more succinctly described.

Sankey returned to England in 1882 and was posted to the Ordnance Survey at Southampton, as some one with electrical knowledge was required to perfect the system of the electrical deposition of copper, in connection with the reproduction of map sheets. This was done at that time by current supplied by Smee Cells. This was costly and it was desired to use a dynamo. Sankey succeeded in solving the problem and in course of his search for a high speed engine for the purpose, he came in contact with the Willans engine of the day and introduced it. This engine was not of the central valve type which became celebrated later. Another improvement in map reproduction which Sankey introduced, was the substitution of power for hand printing presses. This enabled the printing to be done on dry paper and obviated the necessity for the damp paper, used under the old system, and its consequent shrinkage and loss of scale.

In 1889 Sankey retired from the Service as a Captain and joined the firm of Willans and Robinson, engine builders, of Thames Ditton. As a result of his experience and investigations with this firm he wrote a paper on the *Thermal Efficiency of Steam Engines,* and another on the *Strength of Shafts Subject to Small Forces Rythmically Applied*, for which latter the Institution of Civil Engineers awarded him the George Stephenson Medal and Prize in 1905.

In 1904, Sankey resigned his directorship of Willans and Robinson and commenced practice as a Consulting Engineer, in which he was very successful. He later became Director and Consulting Engineer of Marconi's Wireless Telegraph Co., Ltd., and Marconi International Marine Communications Co., Ltd., which he held to the end of his life.

He became a member of the Institution of Mechanical Engineers in 1894, was a member of the Council, 1910-19, elected Vice-President in 1919 and President in 1920 and 21, two years in succession. He was a most active member of the Institution, both as a member of many scientific Committees and also as a contributor to contemporary literature, in connection with all kinds of machines and materials.

In 1895 he was elected a member of the Institution of Civil Engineers and took a very prominent part in the preparation of the original Standard Codes for the conduct of engine and boiler trials, and played a similar rôle in connection with the revised version, promulgated this year. For some years before his death he had served on the Council of the Institution and had been chosen as Vice-President for the coming Session. Had he lived, therefore, he would normally have become President of this great professional Institution also. Sankey had become a member of the Institution of Electrical Engineers in 1885, but never served in any office. In addition to the above, he was a member of the Iron and Steel Institute, the Institution of Naval Architects, the Institution of Gas Engineers, the American Society of Mechanical Engineers, and was for several years a member of the Governing Board of the National Physical Laboratory.

When the Great War came Sankey volunteered his services to the Director of Fortifications and Works at the War Office. His services were accepted and he was appointed a staff captain in the D.F.W's office. His work was invaluable, although he was left in the anomalous position of never being given promotion above the rank of Captain, with which he had retired. After all, as most of us know, it is not the rank but the man that matters and, if there ever was a man, it was Sankey. His employment was entirely honorary and he never received any emoluments for his work.

As Engineering Adviser to the D.F.W., he was an invaluable link with the Civil branches of the profession. During 1915, when War Office methods as regards Camp Construction were under criticism, the President of the Institution of Civil Engineers was asked to form a Committee to examine the work, and Sankey was the representative of the D.F.W. who was responsible for all the arrangements. Subsequently this Committee was called upon to advise upon all kinds of large works, such as the Loch Doon Aerodrome, Coast Defences, etc. In their reports this Committee frequently acknowledged their indebtedness to Sankey for his able assistance. Sankey also went overseas to Flanders in 1915, and devised a scheme for the drainage of water-logged trenches. This scheme was carried out by the 197th (Land Drainage) Coy., R.E. and resulted in a very great improvement in the condition of the works.

In 1918 he went out with Sir Maurice Fitzmaurice to report upon the possibility of inundating certain portions of the front. For the above services he received the C.B. (Civil). After the War he was a member of the Valuation Committee, which worked for years assessing the values of various munition factories, etc. For this service he received the C.B.E.

Sankey was married in 1876 to Elizabeth Mary, eldest daughter of General E. L. Pym, Royal Marines, and there were five children, two sons and three daughters. The younger son died in infancy, the elder is Lt.-Colonel C. E. P. Sankey, D.S.O., R.E. (*retired*), who is now the resident engineer in charge of the preservation of St. Paul's Cathedral.

The above is a brief, and I fear a very inadequate, summary of the story of Sankey's life in our Corps and as an Engineer in civil life. I should like, however, to say a word about the man, apart from his achievements, for it is the character of a man that matters to those who are left behind.

He was a perfectly straightforward, simple, God-serving Englishman; a gentleman to the tips of his fingers. He was thorough in his work, which he loved, and in the doing of which no trouble was too great, no detail too small. Many will testify to his kindness of heart. I have been privileged to read some letters of appreciation addressed to the Secretary of the Institution of Mechanical Engineers and they all are written in the same strain. They all emphasise Sankey's personal charm and unfailing solicitude for those who wanted help, besides deploring the great loss which the profession has sustained by his untimely death.

It was his cheerfulness, however, that always attracted me; no trouble seemed to depress him, and he had experience of trouble. He seemed to radiate cheerfulness and charm to all around him. In him was personified the saying that "the impossible is possible to smiling men."

G.W.

COLONEL HORATIO DOVE.

COLONEL DOVE was the eldest son of the Rev. J. T. Dove, who for over 44 years was Vicar of Cowbit, in the Fens of Lincolnshire. This is recorded to emphasize a fact too little recognised. The Vicarage and the Manse have contributed one of its best elements to the fighting forces of the Empire. Sometimes it has risen to high distinction, more often it has just done its duty in a plain matter-of-fact way, but with a keen intelligence, a sturdy loyalty, and a hatred of the limelight, which have made it (even more than "the non-commissioned man") the backbone of the Army. And for the Senior Service it has done the same, as in this family. Colonel Dove's next brother went down somewhere in mid-Atlantic as First Lieutenant of the ill-fated training ship H.M.S. Atalanta, and he himself was a fine example of the type. Born on 30th June, 1849, and bred in a Curate's home in St. Marylebone, he knew nothing but simplicity in life, and as a day boy at Merchant Taylors, and afterwards at the R.M.A. in the '60's, his life was not exactly an easy one.

An excellent mathematician he passed out fourth of his batch, which included Sir Reginald Hart, V.C., and received his first commission in the Royal Engineers in January, 1869. After passing through Chatham in the ordinary course, he went out to India. He was there 10 years. During that time Dove saw active service in the Jowaki-Afridi Campaign of '77-8 and in the Afghan war '79-'80, and received for each the medal and clasp. He was also for several years working on the commission for the delimitation of the N.W. Frontier, much of the report being in his handwriting. On returning to England as Captain he was stationed at Preston, where in 1883 he married Annie, second daughter of Edmund Birley, Esq., of Clifton Hall. From Preston in 1885 he was ordered to Port Said and shortly after to Hong Kong, where he placed all the big guns round the harbour; from thence he went to Ceylon, and about '88 returned home and was C.R.E. at Edinburgh. Finally he accepted the post of C.R.E. Jersey on account of his wife's health. There she died, and there a few years later he married Mabel, daughter of Captain Gibson of the Indian Army.

On retirement Col. Dove resided at Leamington, where in May, 1915, he raised the local Fortress Company R.E. For 1916-17 he was recruiting officer at Budbrooke, walking to and fro daily to the further side of Warwick, and afterwards he did much duty as Special Constable in Leamington.

Though in his youth a good gymnast, of the old type, Col. Dove made no mark in athletics. Always a student he possessed a fund of learning which he would never air. Hating publicity he would not even talk of his experiences, and self-denying to a fault he would never spare himself; but where a task came his way he did it with complete thoroughness, fearing God, honouring the King.

His only child, a daughter, is wife of J. C. C. Coxhead, Esq., H.M. Vice-Consul at Elizabethville, Belgian Congo.

J.H.D.

COLONEL C. H. H. NUGENT, C.I.E.

Colonel Charles Hugh Hodges Nugent, who died at Naini Tal on 2nd December, 1924, was the son of Colonel Sir Charles Nugent, K.C.B., late Royal Engineers, and was born at Bermuda on 11th December, 1868. He obtained his first Commission in the Royal Engineers in 1888, and gained the Fowke medal at the S.M.E. After a course of training at the Elswick works of Armstrong, Mitchell and Co., he was employed in charge of machinery at Portsmouth, 1893-94, Ceylon 1894-95, Hong Kong 1896-99 and in the Thames District 1899-1905. During this last-named period he was Inspector of Iron Structures and Chief Mechanical Engineer to the War Office and was responsible for much of the equipment of the Imperial Military Railways in South Africa. As an original member of the War Office Committee on Mechanical Transport he had a wide experience in matters connected with self-propelled vehicles, heavy and light, and he took especial interest in the problems presented by the use of heavy oils for purposes of transport. From 1911 to 1919 he was Inspector of Machinery at Army Headquarters, India, at Simla, and during the War his activities included the formation and organization of mechanical transport and armoured car units in India, Mesopotamia, Aden and West Africa. He received the C.I.E. in 1916. His War Service included motor transport reconnaissance in Seistan and visits to several of the theatres of operations, and he also took part in the Afghan War of 1919. At the time of his death he was Chief Engineer Eastern Command, Naini Tal. Colonel Nugent married Jessie, daughter of the late Major-General Wray, C.B., Royal Artillery.

BOOKS.

OFFICIAL HISTORY OF THE CANADIAN FORCES IN THE GREAT WAR, 1914-19.

VOL. I—THE MEDICAL SERVICES.

By Sir Andrew Macphail. Professor of History of Medicine, McGill University.

Published by authority of the Minister of National Defence.

This is a most delightful, interesting and instructive book without a single dull line in it. In the course of 400 pages it gives a connected history of the raising and activities of the Canadian Medical Service in all its branches, in a style and with a method adapted to the general, as well as the professional reader. Sir Andrew Macphail, when selected to write the book, was given access to all relevant official documents, but the inferences drawn and the opinions expressed are those of the Author himself. Sir Andrew was, therefore, in much happier and freer circumstances than are official historians in this country and the reader profits thereby. An order was happily issued on mobilization to the Canadian Medical Service (quite contrary to regulation) recommending officers to keep private diaries, and these have been at the disposal of the Author. Many extracts from them, often of a high literary standard, enliven the narrative. The account in Chapter VII of the march from the Salient to the Somme is consolidated from various of the diaries, and the result is a delightful and vivid description which must especially appeal to every reader.

The growth of the Canadian Medical Service from its inception is described, and it is interesting to find that in the pre-war years Sir Alfred Keogh, when D.G. A.M.S., developed a plan for unity of method in the Medical Services of this Country, the Dominions and India. The plan was followed in Canada and elsewhere with the happiest results: from the very beginning the various Medical Services of the Empire talked, as it were, the same language, and worked together with the utmost cordiality and mutual help.

The Canadian Medical Schools and Hospitals had long been renowned, and every effort was made to construct a Medical Service that would be the best in the Army. It certainly was second to none, and the writer remembers the thrill he had when visiting, in 1917, No. 3 General Hospital, the especial product of the McGill University.

The work of the Canadian Medical Services is admirably told in general terms, and the functions of the various organizations described in a way that gives the reader never a tedious moment, whilst all is made so clear that understanding is never at fault.

There is a special interest in Chapters XI to XVI, which deal fully with the effort made by Sir Sam Hughes to segregate the Canadian Forces in general and the Medical Services in particular: these efforts failed, accompanied by the downfall of the Minister. In the attempt to keep the Canadians to themselves reckless statements were made, casting a slur both on the Canadian and British Services, which were wholly without foundation, but which required a special Board of Officers to clear up. Segregation was in itself impossible from a practical point of view, and "the facts would have risen to the surface without the injection of sentiment." The Sentiment arose of itself and carried the day: viz., that "the bonds of Empire would be strengthened by the intermingling in hospitals of men from all forces of the army, as they had intermingled, comrades on the field." The comradeship and cordial interworking of the British and Canadian Medical Services were pronounced from start to finish, and every English reader of this book must feel gratified at the tributes paid throughout to the help extended at every juncture and in every service by England to Canada.

H. M. LAWSON,
Lieut.-General.

MILITARY ENGINEERING (Vol. II) DEFENCES, 1925.

This is a booklet of 99 pages with 27 Plates, divided into *Land Defences* and *Coast Defences*.

The *Land Defence* section opens with a short review of the past up to 1914, devotes brief paragraphs to Liège, Namur, Antwerp, Maubeuge and Verdun (1916), and after a reference to trench warfare which lasted so long, not only on the Western front, but in Eastern theatres also, draws general conclusions as to Permanent Land Fortification today.

Emphasis is laid, properly, on (*a*) mobile heavy artillery; (*b*) trench systems and wire; (*c*) defence in depth. Material preparations during peace in the case of important strategic areas and positions are limited to such items as maintenance of open fields of fire, communications (physical and signal), storage, shell-proof dug-outs for H.Q. of formations and troops, O.P's., landing grounds and protection of air-defence-organisation, anti-tank obstacles and mines. The last item perhaps is more of a aspiration than a realisation at the present time: in fact, later on (page 45) it is stated with much truth, "Various types are at present under consideration."

In the description of concrete shell-proof dug-outs there is an important omission from the "principles of construction," viz.:—the necessity for substantial reinforced concrete *floors*. The plates shew correctly this important feature, but the letter-press omits it.

Land Defence closes with a chapter on organisation and execution of work, in which good use has been made of the experience of March-July, 1918, in France.

Coast Defence opens with a few definitions and general methods of enemy attack. A short historical review is given from Gibraltar (1782) to Port Arthur (1904), which is followed by brief accounts of C.D. attacks, &c., during the Great War, viz.:—W. Hartlepool (1914), The Dardanelles, Blocking Raids on Ostend and Zeebrugge, German Defences on the Belgian Coast, Capture of Tsing-tau and motor boat raids at Pola (1917) and Kronstadt (1919).

The general conclusions which are drawn are based necessarily on much less data than in the case of Land Defences but the conclusion that a purely naval attack of a properly defended port is a hopeless proposition, will not be disputed until our unfortunate experiences in the Dardanelles (Nov. 1914-March, 1915) become blurred with time; when doubtless a few enthusiasts will revive once more this ancient and disastrous heresy. On the other hand it is laid down that while C.D. cannot prevent the naval bombardment of an area, the risk of serious results from a naval "area" bombardment is negligible, a conclusion which no one who saw the results of our constant coastal bombardments of the Belgian coast during the war will be inclined to dispute.

Development in Air Attack is said to be countered by development in Air Defences, and so far has progressed little beyond "area" bombardment. The question of the enemy use of gas is dealt with perforce in a "nebulous" way.

In discussing the general organisation of Defence Works the various responsibilities of the Navy, Army and Air Force are defined; the responsibility of the R.A.F. including close reconnaissance and co-operation with the R.A. It is difficult to believe that this allocation of responsibilities, so fraught with danger, will stand the test of time or that the last word has been said on the question of respective responsibilities.

Artillery armament is divided into "fixed and mobile" and the use of railway and transportable mountings is not contemplated for C.D. Great mechanical difficulties undoubtedly exist in connection with accuracy of fire, traversing, and stability, before guns on railway or transportable mountings can be used with efficiency in C.D., but the benefits which would accrue from a solution of these problems would be so great that it is a pity that experimental design to this end should be barred.

The question of siting batteries, the details of their requirements and Defence Electric Lights are dismissed in a few paragraphs, and the difficult problems of Defence against Aircraft and Signal communications are practically not dealt with, as little more than mention is made of these subjects; presumably future volumes of the *Manual of A.A. Defence* will deal fully with these points.

The book generally is significant not from what it says, but from what it does not say, and it is presumably a transitory publication intended to remind the Army that the whole subject has not been altogether lost sight of.

Efficient Land and Coast Defence (especially in the case of Great Britain) involves more than ever questions of time and space, and the closest co-operation between the Army and the Air Force, and in some measure the Navy also, for the earliest intelligence of hostile air-craft may often be obtained from sea-craft at a distance from our shores; efficient co-operation between different services is always a difficulty and is attained but rarely, judging from past history.

On shore the problems of co-operation between R.A., R.E., R.C. of S., and R.A.F. are complex and require in each case much forethought and careful organisation. In fact sound organisation and signal communications must be the framework of any successful defence and the basis on which training is built up.

Naval attack upon our coasts has become of minor importance, while the problems of attack by hostile air-craft have become a pressing urgency.

It is upon these problems that light is needed, and the laying down of a doctrine which will command the assent of informed opinion, and ensure (as far as is humanly possible) success in the day of trial.

H.B.

LA GUERRE EN ACTION. LE 22 AÔUT, 1914, AU IV. CORPS D'ARMEE, VIRTON.

By COMMANDANT A. GRASSET. (Paris: Berger-Levrault.) Price 10 francs.

This is the third of Commandant Grasset's most valuable and instructive studies of the opening fighting in August, 1914. The two earlier ones were concerned with the combats at Neufchâteau and Ethe. The actions he has described are quite different to those fought by the B.E.F. on the defensive at Mons and Le Cateau, or in pursuit at the Marne; for in each of them both French and Germans were advancing, ignorant of each other's presence. The tactical lessons are, therefore, of greatest interest, and the problems presented are well worth considering by those who have promotion examinations and manœuvres before them. There is much to be learnt from the mistakes and misadventures. At Neufchâteau two forces struck each other literally at right angles; at Ethe, a French advanced guard was caught in a village, which by its situation compelled the force to make a turn at right angles to its general line of advance. In Virton a German and a French division settled down for the night within striking distance, unknown to each other. The Germans, starting first, at mid-night, discovered the French, drew back a little and dug in; they easily dealt with the cavalry sent forward to get information in the morning mist, and then attacked.

Unfortunately, from our special point of view, there is not a word about the engineers, except that in one of the two advanced guards there was a small party; the French infantry of 1914 seem to have been capable of doing for themselves what battle engineering they required in the way of bridging and removing obstacles. One battalion, which, finding strong opposition, slipped into a churchyard and defended its walls, held its ground without difficulty and had hardly any losses; but elsewhere the infantry, thanks to "doctrine," showed a distinct disinclination to entrench, and suffered accordingly.

Commandant Grasset tells his story most vividly, and provides a large number of situation maps, so the course of the fighting is very easy to follow. As he gives the information at the disposal of the divisional and corps commanders, there is ample material to work out how the C.R.E. of a British division in like circumstances might have advised his general, and how the field companies might have been employed in aid of the infantry, while as pure military history the book is in the very first class.

J.E.E.

LUDENDORFF SUR LE FRONT RUSSE, 1914-1915.

By GENERAL CAMON. (Berger Levrault. 1925). Price 6.75 fr.

This is the second book produced by General Camon this year. It consists of articles which have already appeared in the *Revue Militaire Générale*. The book is based mainly on the published accounts of Hindenburg, Ludendorff, and Falkenhayn, and includes many quotations from their works substantiating the author's ideas. No official documents on the period, either German or Russian, are yet available.

The author explains in his preface the object of his study of Ludendorff's methods. It is briefly this. Ludendorff appears to have conceived all his manœuvres with a view to bringing about the " manœuvre napoléonienne," i.e., " la manœuvre sur les derrières de l'adversaire " ; whereas for actual battle he showed a preference for the " schèma de Cannes." The study of Ludendorff's methods is not merely of historical interest ; the author considers that the German leader is still young enough to take part in the future war of revenge that he imagines Germany to be already preparing. In addition, all budding German strategists are now busily engaged in studying his methods and battles.

General Camon somewhat naively adds that he had invented these " schèmas " before the war, basing his nomenclature on Napoleon's own expressions. To the fact that the *École de Guerre* refused to have anything to do with his ideas in pre-war days, he largely attributes France's lack of success in the late war !

The constant repetition of the phrases " la manœuvre napoléonienne " and " le schèma de Cannes," gives the reader the idea that these are the only methods of conducting war. How simple it would all be if this were so !

To supplement his two main ideas the author has invented a series of " catch-words " ; e.g., " Masse de démonstration," " Masse de choc " or " de rupture," " Masse de manœuvre," etc. These or similar expressions appear again and again in describing various battles, and give the reader that same uncomfortable feeling that is produced by reading the jargon found in the works of certain modern English military writers. Owing to the annoying effect of the author's phraseology the book requires a considerable effort to read.

The book, however, is well worth the effort, throwing as it does a most interesting light on Ludendorff's strategy and methods. The sub-title " Manœuvres et Batailles " gives the clue to the arrangement of the book. It is divided into two parts ; the first a description of various manœuvres, including Lodz (Nov., 1914), Bialystok (Feb., 1915), and Vilna (Sept., 1915) ; the second a brief description of four battles from Tannenburg to Augustowo. In the case of Lodz the preliminary operations described in Part I., are followed by an account of the battle in Part II.

The author's main conclusion is that whereas in his preliminary operations Ludendorff always endeavoured to bring off his results by the manœuvre napoléonienne," when it came to a pitched battle he preferred the "schèma de Cannes." The modern conception of the former, he says, is the wide turning movement by a powerful and mobile force launched against the enemy communications at a considerable distance in his rear, followed up by a strong frontal or flank attack against the enemy, already threatened with lack of supplies, etc., by the movement against his L. of C.

In July, 1915, Ludendorff proposed a movement on Vilna on these lines, similar to the operations of Napoleon himself at the same place 100 years previously. Falkenhayn, however, refused to take the risks involved. In September, 1915, Falkenhayn, having been recalled to the Western front, Ludendorff undertook the operation. Unfortunately for him, he had fewer troops available than in July, and by September the Russian right wing had been withdrawn considerably. The result was that the German forces were insufficient to achieve a dramatic success, and the Russians escaped with the loss of a large area of country.

The second part of the book deals with the conception of Cannae as applied by Ludendorff. General Camon first shows in a few short but interesting descriptions, how the idea of envelopment on both flanks, as demonstrated by Hannibal at Cannae, was modified with success by Frederick II. at Leuthen and later by Napoleon ("la manœuvre napoléonienne"). He then shows how and why Moltke went back to the enveloping idea, quoting his use of three main armies both in 1866 and in 1870. The same idea was taught by Schlieffen during the 15 years he was Chief of the Great General Staff. Finally, we have an account of how Ludendorff applied the idea in two definite battles, namely, Tannenburg and Augustowo, and of how, at Insterburg, he reverted to the Napoleonic idea.

That Ludendorff applied Napoleon's ideas, but did not always follow his methods, was shown at the battle of Lodz. There, the direction of the actual battle was left by Ludendorff in Mackensen's hands, this being in accordance with established German custom. Mackensen himself lived much too far from the scene of action to exercise any real control. In criticising this action of Ludendorff, General Camon quotes Napoleon, writing from Vilna, July 6th, 1812, giving certain instructions to Murat, the Emperor concluded: *Mais mon intention n'est point qu'on engage une aussi grande affaire sans ma présence.*

In summing up, General Camon points out that, under modern conditions and with equally well trained armies, the larger the forces engaged, the less chance there is of successful encirclement. He reminds us that had the Russian leadership and equipment been less unequal to that of the Germans, the results of these two battles would have been very different. He concludes with a plea for the study of "le schèma napoléonien," the excellence of which he says is "incontestable."

The volume contains a number of indifferent sketches, for the majority of which a reading glass is essential.

G.E.G.

LE 8e CORPS EN LORRAINE, AOUT-OCTOBRE, 1914.

By GENERAL DE CASTELLI. (Berger-Levrault.) 12 fr.

GENERAL De Castelli was in command of the 8th French Corps during the first two months of the Great War, and his book deals with a period of strenuous fighting, which probably deserves more study than it receives on this side of the English Channel. The period divides itself into four fairly distinct phases as far as the 8th Corps was concerned, namely:—

1. The disastrous advance into German Lorraine of August, 1914, culminating in the defeat of the French at Saarburg.

2. The defence of the "Trouée de Charmes" between Toul and Epinal.

3. The period of the German advance south of Verdun which resulted in the formation of the St. Mihiel salient.

4. The fighting in the Forêt d'Apremont, east of St. Mihiel, which ended in the establishment of trench warfare early in October.

The 8th Corps played a prominent part in these operations, especially as it was situated on the outbreak of war on the extreme left of the First Army, and became involved to a considerable extent in the operations of the Second Army. During the German attacks which penetrated to St. Mihiel, however, the Corps was withdrawn from the line (on September 19th) under orders from G.Q.G. and spent several days in moving backwards and forwards without ever coming into action as a complete Corps. It was not till the end of the month that the Corps Commander found all his troops again under his orders, in the Forêt d'Apremont sector. It is to this withdrawal, which was carried out as one of the divisions of the Corps was engaged in a successful counter-attack, that General de Castelli attributes the German success on this part of the front.

In spite of the importance of the operations described, the book suffers from two great drawbacks, at any rate to the English reader. One is that there are no maps or sketches, merely a reference to some dozen 1/80,000 or 1/200,000 French maps being given. As the operations are described in considerable detail, to read the book without the maps is to lose the greater part of its value, while they are not easy to obtain. The second drawback is that, although the book is ostensibly written to draw attention to the importance of the success of the French armies in preventing a German break-through on this part of the Western Front, it consists largely of a vindication of the actions and opinions of the author, who was relieved of his command on October 10th as being "too worn out by the strain of operations to be able to continue to carry out his duties as a commander." General de Castelli claims that the real reason was continued differences of opinion with the First Army Commander, and especially his opposition to the policy of carrying out a long series of attacks against strong positions, which merely resulted in unnecessary loss of life. One naturally calls to mind General de Lanrezac's "Plan de Campagne Française," but General de Castelli is unable to quote extracts from orders and documents, with the exception of war diaries, which are only narratives of events. This places him at a disadvantage, compared to General de Lanrezac; in addition, his method of writing in the third person is unattractive. There is no doubt that the stubborn resistance of the French on the eastern portion of the battle front, in which the 8th Corps took a leading part, contributed largely to the success of the manœuvre of the Marne; and it is understandable that General de Castelli does not wish the part played by his Corps to be forgotten. The description, however, of the friction between corps and army headquarters is not very pleasant reading; in one place the author even speaks of the "reign of terror" which held sway throughout the First Army!

In conclusion, the general impression given by the book is that it is well worth reading by any one who wishes to understand and appreciate the somewhat involved, but none the less important, fighting which took place in Lorraine during the early months of the Great War; but such study is of little value unless the requisite maps are obtainable. On the other hand, although many of the author's criticisms of the Higher Command are evidently well-founded, the spirit of controversy pervading the entire book is liable to detract from its merits as a detailed description of operations.

H.A.J.P.

COURS DE CRYPTOGRAPHIE.

By Colonel M. Givierge. (Berger-Levrault.) 20 fr.

This book is written not for experts, but for enquirers, although any one who reads and masters it will need only experience to make him an expert, so clearly are the various problems set out.

We had hoped that the book might contain some sensational revelations of important messages decoded during the Great War, but the author contents himself with mention of only two examples, and one of these was probably not a deciphering from first principles, but a commercial transaction. He states that Ludendorff had the Russian cipher at Tannenburg, and as the Russians used W/T entirely between armies, he was always well informed of the Russian plans. The other example is German W/T messages at the Marne, which were deciphered by the French—but only some weeks after the battle! The latter example is probably a useful warning to budding "decipherers."

The author divides ciphers into three main systems :—

1. Substitution systems.
2. Transposition systèms.
3. Dictionaries or codes.

Of these, substitution ciphers probably offer the easiest lines of attack, along the lines of frequencies of recurrence of single letters, pairs, and even groups of letters. Tables of such frequencies, in many languages, are obtainable.

Transposition systems, *i.e.*, systems in which a "salad" is made of the letters or words of the text, according to some pre-arranged system, must again be attacked by examination of frequencies, this time of pairs of letters, with the primary object of discovering the "tableau" in which the text is written for enciphering. As this may be of any number of letters either way, across or down, and either complete (*i.e.*, gaps filled with dummies) or incomplete, it is obvious that the problem is no easy one. In fact, given only short messages to work on, the anagram method of simple trial and error may be the only possible way.

Whatever method is adopted, the author strongly recommends the student "to try something, and not sit for whole days looking at the problem!" However, to give him his dues, he suggests many methods of trial.

In the chapter on dictionaries and codes a description of the various commercial codes in use is given, but the author emphasises that in war a specially prepared book-code will probably be used, and here the decipherer alone is powerless. Other branches of the intelligence system must help, *i.e.*, steal the book.

The author concludes with an interesting chapter on ciphering machines. The fact that the War Office are inviting inventions of such machines through the Daily Press reminds one of the prominence that ciphering and deciphering are likely to have in war in these days of universal wireless. Any prospective inventor of a ciphering machine would do well to read this book, if only to discover what is wanted, and what to avoid.

W.E.B.

THE THEORY OF MEASUREMENTS.

By LUCIUS TUTTLE, B.A.(Yale), M.D. (John Hopkins), formerly Associate in Physics, Jefferson Medical College, Philadelphia, and JOHN SATTERLY, M.A. (Cambridge), D.Sc., London, A.R.Sc. (London), F.P.S.L., F.R.C.S., Professor of Physics, University of Toronto. (Longmans Green & Co.) Price 12/6.

Recognising that absolute accuracy of observation is unattainable, the authors have sought to give full and clear information as to the scientific recording of measurements and observations, their classification, reduction, etc., so as to secure a maximum of accuracy with a minimum of labour. Quite a third of the treatise is very elementary, dealing with weights and measures, abridged arithmetic, angles, circular measure, Vernier scales, logarithms, significant figures, small magnitudes, graphical representation, etc., but a considerable part of the elementary portion is well worthy of attention, there is many a useful tip, and a grasp of the admirable chapters on significant figures will save the student much needless arithmetical labour in the future. The more advanced part of the treatise deals, *inter alia*, with the following subjects:—interpolation, extrapolation, relative errors, uncertain figures, superfluous accuracy, possible and probable errors. Harmony and disagreement of observations, classification of errors, deviation and dispersion, the weighting of observations, the rejection of doubtful observations, indirect observations, the method of least squares, the slide rule, the representation of statistics.

A fair idea of the scope of the work will be given if I quote a couple of examples. (1) If (t) seconds is the record time of a trotting race of (m) miles, find the relation between (m) and (t) from the following data:—

(t)	119,	257,	416,	598,	etc.
(m)	1,	2,	3,	4,	etc.

(2) The magnet of a magnetometer was set in vibration and the time

of passage through the centre was taken with a half-seconds chronometer; the time of passage through the centre was taken, with the following results; here follows a very elaborate table. Find the time of vibration.

In this case, of course, every observation would have to be "weighted."

The arrangement might possibly have been improved, for example, the subject of errors has been dealt with in three different chapters.

The term "observations" instead of "measurements" in the title would give English students a better idea of the scope of the work.

The treatise is full of useful information ably and clearly expounded, and should appeal to everyone responsible for observational work and to actuaries.

The examples are numerous and well chosen.

J. M. WADE, *Lt.-Col.*, B.Sc., London.

BATS, MOSQUITOES AND DOLLARS.

By DR. CHARLES A. R. CAMPBELL, M.D. (The Stratford Company, Boston, Massachusetts.) Price $3.

No apology is needed to readers of this Journal for calling their attention to a book dealing with the extermination of mosquitoes. The Corps has borne its share in the war for many years now and the results upon the health of our garrisons in tropical stations have been surprising. In this book Dr. Campbell, of St. Antonio, Texas, tells the tale of his research and experiments by which he has discovered that bats, the chief enemies of night-flying mosquitoes, can be cultivated like bees in hives or "roosts" and located in the neighbourhood of mosquito swamps. The experiments lasted over many years, but ended in complete success. The installation of a bat-roost will eliminate the danger of infection from mosquitoes in the most malarious area, and incidentally from the droppings of the bats, mainly consisting of the undigested fragments of mosquito bodies, is obtained a most valuable guano which commands a high price as a manure. The story is full of interest and well told. The first roost was a costly failure. Dr. Campbell "suspended his professional career, closed his office, and left family and friends for the mountainous wilds of his beloved State (Texas) with a firm resolution not to return without a complete knowledge and solution of the great problem." He found it, and his new roost "built according to the new plans, scented with a quantity of an especially prepared guano which carries a sexual odor," has been a brilliant success. All honour is due to this indefatigable explorer for his invaluable discovery. He mentions other roosts which have now been erected in America and one in Italy, and gives the cost of a bat roost at between 500 and 700 dollars. The plan and the special guano are no doubt secrets.

The enemy of the day-flying mosquito is the dragon fly. Dr. Campbell has much to tell us about dragon flies, but he leaves the solution of the problem of their cultivation to others. One experiment of his is instructive. He found that the oiling of a pool in which both mosquitoes and dragon flies were breeding was successful in driving away the dragon flies, but not the mosquitoes. After about eight days the mosquitoes had returned and soon rendered the neighbourhood uninhabitable.

F.E.G.S.

MOTOR MANUALS. VOL. III.: THE MECHANISM OF THE CAR.

By ARTHUR W. JUDGE. (Chapman and Hall.) Price 4s.

THE two previous volumes of this series have already been reviewed. The subject matter in Vol. III. is presented to the reader in the same manner as the preceding volumes, namely, the basic principles of various mechanisms, etc., embodied in motor cars are first discussed and explained in as non-technical language as possible, and these principles are afterwards illustrated by actual examples taken from the latest automobile practice.

The first two volumes of this series dealt with the engine and carburettor. Volume III. deals with the chassis, frame and suspension systems, front axle and steering, clutch, gear-box, propeller shaft, back axle and brakes. There is a chapter on alternative transmission systems, in which friction, hydraulic, and two forms of electric transmission are described, together with Constantinesco and De Lavaud variable transmission systems.

There are chapters on brakes, traction, and braking principles. The former has a good deal of space devoted to the description of the four-wheel brake. The latter has some interesting formulæ on power, adhesion of wheels and braking, engine revolutions, car speed, etc. Two types of steam car, one electric car, and one semi-tracked vehicle are discussed.

This is a most useful volume. It is well illustrated, the descriptions are clear, and the subject matter carefully chosen.

G.C.G.

SINGAPORE AND NAVAL GEOGRAPHY.

By VAUGHAN CORNISH, D.Sc., F.R.G.S. (Paper covered pamphlet, 16-in. by 16in., published by Sifton Praed.) Price 5s.

IN this reprint of a paper read at a meeting of the Royal Colonial Institute in June, 1925, Dr. Vaughan Cornish gives a short review of the naval and strategical considerations which demand the construction of a fully equipped Naval dockyard at Singapore. The paper takes a wide view of the problem, and is illustrated by an excellent series of maps designed to convey a truer impression of the ocean communications of the world than is obtainable from the usual atlases. The question of the Singapore base is a vital one in the problem of Imperial Defence, and Dr. Cornish has stated the main issues very clearly.

R.H.D.

IMPERIAL MILITARY GEOGRAPHY.

By Capt. D. H. COLE, M.B.E., F.R.G.S., *A.E.C.* Third edition. (Sifton Praed.) Price 10/-

This valuable book, first published in January, 1924, has already been through two editions and a reprint. In this, the third edition, the author has seized the opportunity to include much new material and revise the existing information. A chapter has been added on Climates of the

Empire, and special stress is laid on matters concerning Imperial Defence. A new section dealing with the "Heart of the Empire" has been added, and extra paragraphs dealing with the fighting races of Africa, and the States of modern Arabia inserted. The chapter on Cables and Wireless has been revised and brought up to date. Seven new diagrams and eight maps, including sketch maps of the British Isles, Canada, and the Indian Railway systems, are provided.

The new edition is thus a great improvement on an already very valuable work, and the price remains the same.

R.P.P.-W.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

(*June*, 1925.)—*Is Germany moving towards a Militia Army?* By C. When the question is asked "How is it that our late enemy has succeeded in breaking through the meshes of the net by which the framers of the Treaty of Versailles thought to cripple her army?" the answer frequently received is, "By adopting the militia system." Taking as the definition of a militia system that given by M. Jaurés in *L'Armée Nouvelle*, the writer shows that in no single instance are the conditions fulfilled in the German organisation, which is a carefully devised instrument for maintaining the system and traditions of the old army, with such improvements as the experiences of the late war have shown to be necessary. An article worthy of perusal.

French and German Fortifications. The conclusion of Col. Normand's article. After studying the part played by the various fortresses during the late war, and most of them contributed a greater or less degree of assistance to their own side, Col. Normand proceeds to sum up his conclusions. His arguments in favour of well-devised schemes of permanent fortification are well marshalled, and he brings out their superiority to field defences, whilst the value of the latter as adjuncts to the former and in the open field are not lost sight of. An interesting and instructive article.

An Encounter Battle, Virton. The continuation of Commandant Grasset's article, describing the capture of Meix, N.W. of Virton, by the French, and their preparations for an attack on Robelmont, which had unfortunately to be abandoned owing to an alarm, later proved to be false, that a German force was threatening their left. The artillery, however, had retired and could not re-occupy their position in the dusk. Between this and Virton the French also achieved a success, capturing the German first line trenches, the elaborate nature of which caused great surprise. The assault was not ordered by any high authority, and appears to have been a spontaneous effort on the part of the three battered and almost exhausted regiments there in line, showing the extent to which they were impregnated with the doctrine of the attack. The article is accompanied by a sketch of the position at 18.00 hours, and by a copy of the Belgian 1/40,000 map showing the general position at midnight on 22/23 August. The Corps Commander's orders for 23rd, issued at 23.30 on 22nd, are given in full. At that hour he had received no orders from Army H.Q. (*To be continued*).

The British Empire in 1924. The conclusion of Commandant Texier's article—Part II. The imperial policy of the Labour Cabinet. After a summary account of the development of the British Empire, and of the recent relations between the Mother Country and the Dependencies and India, the writer studies the effect on these relations of the advent to office of a Labour Government. His account is fairly impartial, and if some of his deductions from history may be open to challenge, he has evidently been reading H. G. Wells' version, a quotation from which is made. His conclusion is that the measures of "disimperialization," of which the Macdonald Cabinet may be accused, have been compensated by the firm decisions taken in all circumstances in which the vital interests of the Empire were concerned. Singapore and Imperial Preference are evidently not considered vital, for he proceeds to say that nothing of the power and unity of the Empire has been lost by the advent to power (*sic*) of pacifist and anti-imperial sentiments.

The Battle of the Marne. Was it commenced a Day too soon? By Robert Duché. In an article in the *Temps* of 22nd December, 1922, General Mallaterre argues that circumstances imposed the 6th September, 1914, for joining battle, and that if the French VIth Army had waited till next day it would have been opposed not only by the German 4th Reserve Corps, but by the 2nd and 4th Active Corps, which von Kluck caused to withdraw to the north during the 6th, not to parry the unexpected attack of the VIth Army, but to conform to imperative orders from the Great General Staff. In this article are studied the events immediately preceding the battle so that a correct conclusion may be derived. In Chapter I the orders and messages received by von Kluck and his orders issued thereon from 4th to 6th September are examined at some length, and the conclusion arrived at is that von Kluck was so far obsessed by his determination to be the general who would turn the Allied left that neither orders from G.H.Q. nor reports from neighbouring formations of a powerful French concentration on his right, could induce him definitely to dispose his army as a flank guard. It was only after his 4th Reserve Corps had been attacked on the afternoon of the 5th that he ordered the 2nd and 4th Corps to retire at all, and only after he had heard that the 4th Reserve Corps had been forced to retreat that he directed the other two Corps to proceed north of the Marne on 6th. The article is illustrated by a diagram. (*To be continued*).

The Decline of the German Effectives. The German offensives on the Aisne (27th May) and Oise (9th June, 1918) are dealt with this month. (*To be continued*).

Foreign Military News. Switzerland. The new Army Organization Act came into operation on 1st July. The principal changes are the replacement in all battalions of the fourth company by a machine-gun company, and the formation of a new regiment of mountain infantry from three already existing battalions. In the cavalry, guides are suppressed and the 4th Brigade disappears. In the artillery, 25 tractor batteries of fortress guns are to be formed, and in aviation, all the squadrons are grouped into 30 companies.

Japan. Under the pressure of public opinion, effectives (officers and men) are being seriously reduced, and now number 195,000 only, a reduction of one-third from the strength in 1922. The reduction of four divisions would entail the elimination of 2,000 officers, but only 1,000 will be retired, owing to the creation of new air, tank, and A.A. units, and to the organization of preparatory military instruction.

(*July*, 1925.)—*The Battle of the Marne.* M. Robert Duché's article is concluded, continuing the narration of events on 7th September. The conclusions then drawn are (i) that it was only General Gallieni's attack on the German 4th Reserve Corps on 5th that induced von Kluck to take the half measures he did to strengthen his right flank guard, and (ii) that if this attack had not been made on 5th, the plan of the French G.H.Q. would have had time to mature. The 2nd and 4th German Corps on 5th and 6th would have advanced further to the south where they would have been inextricably gripped by the general frontal attack of the Allies. General Gallieni, reinforced by troops from the east and depôts, could then easily have brushed aside the weaker German force and advanced against the rear and communications of the German armies with decisive results. Besides, Gallieni's army had been placed with certain reservations under the orders of the C. in C. and should not have been seriously engaged without previous reference to him.

Concerning a German Opinion. Chap. V of this article is continued, and answers separately each of the von Taysen's criticisms of the French infantry. 1st—*The dogma of superiority of fire does not necessarily imply the subjection of the infantry to the other arms.* The fact that the formation commander arranges that, for as long a period as possible, infantry should have the support of guns, tanks, and aircraft where and when required, implies no subjection of the infantry except to himself. The French *Infantry Regulations* are, however, misleading in stating that only exceptionally will infantry have to fight without the assistance of the other arms; the possibility of their having to do so is ever present, and this faulty teaching requires rectification. At the same time infantry should be sufficiently powerfully armed to be able to act alone, and this will only be when they have their own accompanying artillery, and when the directly supporting artillery is more definitely placed under their orders. These remarks apply more especially to war of position, but are equally applicable to encounter battles where two forces meet face to face. The encounter battle where one wing of the enemy is to be surrounded or a gap in his lines exploited, is different. Here the element of surprise is all-important and discounts the rule regarding superiority of fire. The writers would like to see the principles of such a combat given a place of honour in the regulations, but it must be acknowledged that von Taysen is correct in saying that the present text is dumb in this respect. 2nd point.—*The dogma ought not to lead infantry to forget the value of manœuvres and the hand to hand conflict.* Once the enemy's position is entered, movement can only be carried out if the attack can develop superiority of fire. The regulations are therefore right in laying stress on the latter, but it would be an improvement if they also emphasized the value of the former. 3rd point.—*The dogma should not allure infantry into excessive care to avoid casualties.* The regulations certainly state that victory cannot be won without sacrifice of life, but perhaps err in referring to "a few losses which it is fantastic to hope entirely to avoid." If the soldier is not taught to realize that losses may at times be severe he may have a rude awakening after hostilities have been commenced and may lose his nerve. The effect of the regulations should be to galvanize his energies and promote in him a spirit of self-sacrifice. 4th point.—*The dogma should not result in excessive inflation of the so-called material arms at the expense of the infantry.* Whatever irresponsible individuals may say, it is unthinkable that the military authorities would ever increase the auxiliary at the expense of the acknowledged principal arm. (*To be continued*).

The Tank as an Economical Weapon. By Lt.-Col. Velpry. The writer deduces from the performances of the tanks in the late war that improved tanks will economise cost, material, time and loss of life in future wars. For an effectual artillery preparation, an expenditure of 1,500 to 3,000 tons of projectiles per kilometre of front is required, costing 12 to 24 millions of francs. About 20 tanks, costing 4 millions for light, or 7 millions for the heavy type, would produce the same or better effect, but, whereas the shells will have disappeared for ever, 90% of the light, or 60% of the heavy tanks would emerge unscathed and be available for a fresh advance more quickly than the guns could change position. Less material and less factory labour would be required for the tanks, less transport to bring them to site, the loss of life during the enemy's counter-preparation would be avoided, and advance through the position under cover of tanks is less costly than when artillery alone is employed. But the existing tank is too vulnerable to machine and anti-tank gun fire. A really heavy tank is required, protected by 25 c.m. of armour and carrying 3 or 4 guns, which could only be effectively engaged by a 25 c.m. gun moved on caterpillar tracks by motor power, but which, carrying no light armament for its own defence would fall an easy prey to its opponent. The financial effort demanded to produce such tanks would be well expended in view of the decreasing French birthrate and growing paucity of recruits.

A Second Lesson of the American War of Secession. Lt.-Col. Daille in this article proposes to show that Grant's operations, after he became C. in C. of the Federal armies in March, 1864, afford a striking example of the methods which nations enjoying a superiority of force employ to defeat their adversaries. He commences with a statement of the general political and military situation of the Union early in 1864, and of the steps taken by Grant to reorganize and discipline his forces. He then traces the operations in Virginia up to the battle of the Wilderness, and illustrates his article by a sketch. (*To be continued*).

The Decline of the German Effectives in 1918. Lt.-Col. Paquet's article is continued and deals with the German offensive in Champagne on 15th July. (*To be continued*).

A German Controversy. Commandant Martin makes a further contribution to this subject with the review of an article in *Wessen und Wehr,* by General Kraft von Dellmensingen, defending Crown Prince Rupert of

Bavaria from accusations brought against him by General Wetzel. The last named accuses the Prince of having prematurely undertaken his offensive in Lorraine on 20th August, 1914, instead of continuing his retirement with the view of drawing the French into a pocket, as planned by the German G.Q.G. so that it could be overwhelmed by von Schlieffen's favourite "Battle of Cannae" manœuvre. General von Dellmensingen quotes documents hitherto unpublished, particularly part of the German G.Q.G. instructions for the strategic deployment for the preliminary operations, and attempts to prove that Prince Rupert neither disobeyed his orders nor acted prematurely.

Under *Foreign Military News* is mentioned a new German monthly magazine "Kriegskunst in Wort und Bild" (first issue October, 1924), which appeals to the junior ranks of the Reichswehr and members of associations interested in military education. Each number contains an article inculcating patriotism, such as the life of some well-known military leader, a study in the employment of small bodies of troops of the various arms, comprising (*a*) theory, and accompanied by tables, sketches and photographs, and (*b*) a tactical problem, the solution of which appears in the next issue, an article on foreign politics or history of frankly anti-French tendency, and lastly a picture calculated to warn the soldier against wine, women and cards, spies, cowardice, etc.

Books and Reviews. Les origines immédiates de la guerre (*28th June —4th August*, 1914). Pierre Renouvin (Costes). Written by a historian highly qualified for dealing with such a subject, a professor of the Sorbonne, this book claims to be entirely free from bias of any description—a claim which the reader will readily endorse.

BULLETIN BELGE DES SCIENCES MILITAIRE.

(1925, Nos. 7 and 8).—The story of the operations of the Belgian Army during the Great War, 1914-1918, is continued in the numbers of the *Bulletin* under notice; further events occurring on October 7 are recorded therein. A relative calm prevailed during the night of October 6-7 on the left bank of the Scheldt opposite Schoonaerde, where the Belgian 4th Division was entrenched with a view to preventing the passage of the river by the enemy; the units of this Division took advantage of the apparent inactivity of the Germans to repair and strengthen their defences, which had been knocked about a good deal on the previous day by the hostile artillery. In the meantime, the Germans had succeeded in collecting boats and other bridging material at De Distel (2,000 yards below stream from Schoonaerde). An autumn mist hung over the valley; the conditions for passing troops across the stream being favourable, the Germans quickly seized their opportunity. At daybreak of October 7 some of the units of the 37th Landwehr Brigade began to cross the river in boats; a raft was meanwhile constructed, and as soon as it was ready a flying bridge was established at De Distel, and utilised for transporting other units of the same Brigade to the left bank of the Scheldt. It was not until 6.40 that the Belgians became aware of what had taken place at De Distel; they thereupon made an attempt by means of artillery fire to dislodge the enemy troops which had crossed the river. However, owing to the difficulty caused by the dense mist in ranging the guns, their fire proved ineffective, and the enemy was, in consequence, able to proceed with the establishment of a bridge-head and also to consolidate his position. As the situation developed, General Michel (Commanding 4th Division), whose reserves were exhausted, sent a message to the Commander of the Belgian 6th Division calling for support; the latter at once complied with the request made to him. The reinforcements sent by the 6th Division were, however, unable to make any headway, as the enemy had by now succeeded in making good his position on the northern bank. Soon after noon a counter-attack was launched by the Belgians, but before the troops detailed for this task came into collision with the Germans, they were called off and ordered to retire. By nightfall small parties of Germans had penetrated as far as Berlaere and Vankryk—about 2,000 yards N. of Schoonaerde—but the main body had been obliged to entrench itself on the line Daal—Overheet—about 1,000 yards N. of the river bank; the Belgians remained in contact with the enemy's advanced troops in this locality throughout the night of October 7-8. Other developments quickly followed. The Belgian G.H.Q. was now established at St. Nicolas; the view taken there was that the Belgian troops were extended on too wide a front to drive the Germans back to the right bank of the Scheldt and that even the shortest delay of the Field Army in its westward march might seriously compromise the safety of the whole, or at least a very considerable part of it. The German pressure in the neighbourhood of Ghent was increasing hourly—it had been reported that several skirmishes had already taken place between German cavalry and cyclists and Belgian volunteers, civic guards and gendarmes in that locality. A telegram handed in at 11.30 a.m. at Zeebrugge, announcing that a British force of about 15,000 men with horse, field and howitzer batteries (i.e., the 7th Division) had arrived and was being disembarked, did not reach the Belgian G.H.Q. at St. Nicolas until 5 p.m. By the afternoon of October 7 Capper's Division had concentrated near Bruges—the general situation on the Western Front, as known at the Belgian G.H.Q. at this time, is set out in the original article. General von Werder, who had been given command of the left wing of the besieging force, with a view to reinforcing the German troops which were held up near Berlaere, pushed on the construction of temporary bridges over the Scheldt; good progress was made, and by daybreak of October 8 he succeeded in transferring the whole of the 37th Landwehr Brigade and also the 1st Bavarian Landwehr Brigade to the left bank of the river. In the meantime, the *pionniers pontonniers cyclistes* of the Belgian Cavalry Division, during October 7, destroyed the iron swing-bridges (over the Scheldt) at Melle and Heusden with tonite, and also took the necessary steps to extend the inundations, begun on September 29, to the region comprising Calcken, Uytbergen and Overmeire (an area of about 1,250 acres). Further, an officer of the unit proceeded in an armoured motor car to Wichelen, where a large quantity of timber, which the enemy would, no doubt, have wished to seize for bridging purposes, was stored; he managed to set fire to and destroy all this material. The same officer made an attempt to effect the destruction of the temporary bridge thrown across the river by the enemy at Schoonaerde by floating a fire-boat on to it on the ebb-tide ; contrary winds, however, drove his bark on to the river bank and he had finally to abandon the attempt. According to the author it was the "abstention persistante des autorités britanniques" to occupy Ghent which caused the Belgian High Command to give up the idea of making a stand on the line of the Scheldt with the Belgian Field Army. About noon on October 7 King Albert, at an audience, personally gave an express order, as a final instruction to General Deguise, the Governor of Antwerp, directing him to hold out to the bitter end ; the King then proceeded to St. Nicolas, where the Belgian G.H.Q. was established. The Belgian 2nd Division had been placed at the disposal of General Deguise, and its Commander, according to his instructions, now took over the command of the "Second Line" of defence. The permanent works of this Line and their garrisons, however, still remained under the direct orders of the Governor of Antwerp. It is stated that the forts of the "Second Line" were not in a condition to meet any serious attack, and that this fact had been known for some time prior to the outbreak of hostilities by the Belgian Government and Parliament. Nevertheless, steps were taken to occupy this Line. Under direct instructions from the Governor, measures were set on foot on October 7 by the *compagnie de torpilleurs* to prepare the bridges of boats at the Tête de Flandres and Burght for destruction. On the same day the "compagnie de pontonniers" were ordered to dismantle the pontoon bridges at Rupelmonde and Hemixen and to destroy the permanent shore bays—these were of iron construction—at these places. The Governor had no mobile troops at his disposal for carrying out reconnaissances, and, in consequence, made enquiries as to the whereabouts of any airmen who might be available for this duty. He learnt that the Belgian High Command had moved the headquarters of the Air Force to Ostend, and that the squadrons of this Force which had been collected at Ghent, considering themselves to be in too exposed a position there, had also retired to Ostend. In their attack on Antwerp the Germans decided to husband their infantry, and to prepare the way for an advance carefully by artillery; consequently, as they still had a few field guns only on the north bank of the Nethe, the infantry was moved forward with the greatest caution. In order to provide for the close support of the infantry by the guns, light and heavy, bridging operations were actively pushed on by the engineers with the besieging force. During the night of October 7-8 the German preparations were sufficiently advanced, and the bombardment of Antwerp was begun, the central parts of the city, its southern suburbs and the old ramparts all receiving their share of attention from the German gunners.

Major B. E. M. Hierman contributes an article entitled *La problème des communications. Son influence sur l'organisation du génie,* to the numbers of the *Bulletin* under notice. Owing to the systematic destruction of roads and bridges carried out during the Great War, questions relating to the repair of the former and of the construction and re-construction of heavy types of temporary bridges, suitable for carrying mechanical transport and heavy artillery, now loom large as war-time engineering problems. To meet a situation in relation to "communications" similar to that which came into existence during the Great War, the Commanders of the Engineers with the various formations will naturally require an ample supply of suitable material, and a sufficient body of specialised troops to enable them efficiently to carry out their duties, including road repairs and the construction of heavy bridges. To secure this end Major Hierman puts forward certain proposals as to the numbers of units necessary as Divisional Engineers, Corps Engineers and Army Engineers, and the materials and equipment which should be provided for them in the Engineer Parks.

W.A.J.O'M.

MILITÄRWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*July-August.*)—*Moltke or Schlieffen?* An article by Heinz Zatschek, which does not attempt to come to any conclusions, but by putting the affair of the Belgian Invasion in a new light, to reopen the discussion. It is a clear exposition of the strategical considerations which brought about the changes of plan. Little evidence is available as to Moltke's views, but it is certain he would have wished to avoid the invasion of Belgium in 1914; perhaps to draw the French forces into Lorraine, defeat them, and by following quickly on their heels, to overrun the fortified line. (To be continued.)

The Second Investment of Przemysl. Continuing from the last number' Major Stuckheil relates the failure of the sortie. After two days' fighting the position was evidently hopeless, and the general retreat within the fortress ordered. Summing up, the author attributes the failure to (1) Too stereotyped a form of attack, (2) Impossibility of effecting surprise, (3) Good espionage work by the Russians, but also treachery in the garrison, coupled with general indiscretion of the Austro-Hungarian officers, and leakage of news transmitted by wireless, (4) The fact of the bad morale of the garrison at this time, and (5) Bad equipment.

The Second Tactics Problem is set in this number.

Considerations as to the Necessity of Cavalry. By Colonel Friedrich Kubin.—The author considers Cavalry in view of the needs of the reduced Austrian Army, and concludes that "the horse remains the most economical and certain means of supplementing the individual mobility of the soldier." Each of the six squadrons of the Austrian Army is organised into three mounted troops, one M.G. troop (two guns), and one troop mounted sappers.

The Next Great War, by Capt. Liddell Hart, is begun.—It is translated in full, but no comments are made.

A composite Article, entitled "*A Review of Military Science.*"

1. *Politics and the Conduct of War.* By Major General Hugo Schäfer. — . . . . "The cloud of War had already been in the sky for many decades, general preparation was made for it. It was mere chance where, when, and by whom the stone was set rolling . . . . And if the whole of the facts are faced, one is bound to come to the conclusion that Germany

was, politically, very poorly prepared for War, while the work of the Entente was masterly. . . . . In particular, Asquith's writings give one a frank and instructive insight. . . . . Britain allied herself against the growing might of Germany. . . . . Yet at the time of mobilisation, the Kaiser still hoped that Britain would remain neutral. Britain and her world-wide Empire . . . . was firmly and unitedly organised, not only politically, navally, and militarily, but also in its administration and economically. . . . ." This propaganda is followed by a catalogue of the chief War writers, and of the chief questions over which they fail to agree.

2. *Tactics.* By Col. Joseph Feichtmeier.—A lucid sketch of the changes brought about during the War in the tactics of offence and defence, particularly by the multiplication of M.G.s and the perfection of aeroplanes. "Tactics have changed from a one-dimensional to a three-dimensional art." The effect of the War was to draw a clear distinction between the troops which could bring a great weight of fire to bear on the enemy, and the troops who finally attacked him. In defence, masking and camouflage are more important than protection. The article contains little that is new.

3. *The Munitions of War.* By Colonel of Engineers Rudolf Huppert.—An interesting article shewing clearly the distinction between the aims and the achievements of modern experiment. For their defence against tanks, infantry must have some arm combining attacking power, great mobility and the maximum of invulnerability, in fact, practically a form of tank. In the matter of hand-grenades, and smoke-bombs, the ideal, at present unattainable, would be a mechanism which need not be released before throwing ; it should detonate on impact, and at the same time "duds" should be harmless.

As for the means of traction for the Artillery, the author concludes that for the present horses are indispensible for all divisional artillery, but that the mobile reserve should be equipped with motor transport. The horse must be eliminated when possible, owing to the dangers of poison gas.

(*Sept.-Oct.*)—A large part of this number is devoted to the achievements of the ex-Chief of the General Staff, Field Marshal Conrad, who died on 25th August, 1925. Much of this is of more interest to Austrians than to Englishmen ; as, for instance, the first article, which is the funeral address pronounced by the Austrian Minister for War.

The Second Article is "Field Marshal Conrad," by Major-General Hugo Kerchnawe, a eulogy pure and simple. It gives a sketch of his career, and mentions some of his more important military writings.

Of greater interest, and more judicial, is the article by the Prussian, Major-General Rudolf Borries, who shows great admiration for Conrad's genius, but was not blind to his faults. No situation could be so bad, that he could not find an ingenious solution, but his optimism, and the tasks he imposed on the troops were often excessive. He opposed the appointment of a Generalissimo for the Central Powers.

Lt.-Col. Rudolf Kiszling contributes "*Field Marshal Conrad's Strategic Plan against Russia.*" Conrad's idea was formulated in 1909. The two

Armies of the left wing were to advance to the San-Dniester line, and at the same time were to be prepared against a possible enveloping move by the Russians. The Germans were to make a corresponding attack towards and over the Narew. The Allies were then to move eastwards, and together with the Austrian Right, to defeat the enemy centred on Rovno and Proskurow. Subsequently they were to be driven towards the Black Sea or Kiev. This was almost the only pre-War strategic plan which, in spite of checks, was realised in its entirety.

Major-General Steinitz contributes, "*Conrad and his Development of the Infantry.*" The infantry régulations of 1911 were the first to reject the close-formation theory, the chief credit for the change being Conrad's.

Field-Marshal Conrad's Memoirs. By Edmund Glaise-Horstenau. The author, who implies that he was intimate with Conrad, states that his memoirs are based entirely on documentary evidence, and that his object in writing them was to give an unbiassed account of events as they happened. The five volumes completed before his death occupy the period from the beginning of his Service to the end of December, 1914.

The War in the Dolomites. By Lt.-Col. Valentin Feurstein.—(3 maps). (The beginning of this article was published in the last number). The author has evidently a rather pòor opinion of the Italians, and is eloquent in praise of the low-category (largely volunteer) troops, who took part in the fighting. Each sector of the front is considered in turn, firstly a brief explanation of the strategical considerations, followed by an account of the fighting. The whole gives a good impression of the prevailing conditions.

An article *The New English Vickers Tank,* is taken from the *Militarwochenblatt,* and supplemented by Captain Fritz Heigl. Details, for which the author cannot absolutely vouch, are given of the armour, road and cross-country speeds, armament, effective range, etc.

The Review of Military Science is continued. In an editorial note it is explained that under this heading, in addition to longer articles on the developments of Military Science, short extracts will be made from noteworthy articles in certain periodicals. A list of 72 periodicals follows. Britain is represented by *Flight, The Royal Artillery Journal,* and *The Royal Engineers Journal.*

1. *Tactics.* By Colonel Feichtmeier. On mountain warfare the author has no new ideas. In village fighting, the reserve of the defending side must be kept in hand, and the counter made so as to cut off the village by envelopment.

2. *Active Service.* By Colonel Buyer. Reconnaissances, Protection Communications, etc., are dealt with. There is nothing new in the article.

3. *Organisation.* 4. *War History.* 5. *Small Arms and Artillery.* 6. *Aircraft.* 7. *Science and Warfare.* 8. *Naval Affairs.* All these are dealt with only by notices of articles appearing in the 72 magazines mentioned. Under 7 is a notice of an article which appeared in *Science for All.* An invention is claimed by which a cloud two miles square was precipitated as rain in 3½ minutes by means of "shooting" electrically charged sand from an aeroplane. It is thought it can be adapted to use against artificial smoke-screens.

T.H.B.

HEERESTECHNIK.

(*July, August and September* numbers.) The July number contains an official article "Equations of motion for Road and Cross-country Vehicles." Two examples are worked out, to find the power necessary for a motor vehicle to maintain a certain speed under certain conditions, and to find the maximum speed of a certain vehicle under a certain load. The article is not of particular interest.

Major Justrow, who contributed an article to *Heerestechnik*, of November, 1924, on Range, Muzzle Velocity, and Weight of Projectiles, and who was criticised for his assumptions, methods, and conclusions by General Rohne in *Artilleristische Monatsheften*, argues the case at length. Most of the article is of personal interest. He believes that 2,400 atmospheres will prove to be the limiting internal pressure for field guns, and that after that muzzle velocity can only be increased by lengthening the barrel.

Notes on the new *Field Fortifications Manual, Part* 1, are completed by Major Klingbeil. In the front line, protection must be limited to weather and splinter-proof shelters; deep dug-outs are man traps. Further back, dug-outs should be small, several small ones at minimum internal length of 8 metres are best. As obstacles against tanks, the following natural features are recommended: water at least one metre deep, marshes, steep banks (slope over 1 in 1, and at least two metres in height) and woods with close-growing strong trees. When an attack is held up, in open warfare, the troops, deployed in depth, dig themselves in; according to the tactical situation and to the direction of the whole line, unit commanders link up these rifle pits and M.G. emplacements to establish firing trenches; these are developed into strong points, and finally they are all linked up. In actual battle, the forward area becomes a mass of shell holes, and all repairs to trenches, except as they concern the safety of the individual soldier, are useless. In laying out trenches, arrangements must be made for systematic drainage.

The manual is clear as to the use of the sappers. "For definite jobs of longer or shorter duration, platoons or companies of sappers under their own leaders are put at the disposal of the commanders of units of the "principal arms." As a rule, sappers should not be employed as infantry. Immediately on completion of their job, they return to their units. It is emphasized that on the occasion of a successful break through, the sappers must be reassembled by units, and made available for duty as such. Sapper officers of all ranks make suggestions to the unit commanders for the disposition of their weapons, and for the preparation and execution of technical steps in the lay out of, and fighting for, field fortifications."

Small Arms Abroad.—A lecture delivered recently by Brig.-Gen. Thompson (U.S. Army), together with a German opinion, is published under this heading. In America, light M.G.s (Lewis Guns) are regarded as of more moral than concrete effect, and bursts of fire with them are restricted to ranges of less than 100 yards. The needs of the Army can be met either by simplifying the light M.G. or by inventing a self-loading rifle. The former could only be done by lowering the muzzle velocity, and so using a lighter barrel. According to the German opinion this is useless, since such a weapon would lose all the good points of the M.G. and retain all its defects.

The Importance of Petroleum.—Under this heading the oil-fields of the world are enumerated, and the question of possible substitutes is touched upon. There is nothing new in the article.

Contribution on the Question of the Formula for Taxation, by Mr. Stadie. The motor taxation question is discussed, and its influence on design. The conclusion is that motor spirit should be taxed. The article is interesting, as England and Germany have similar methods of assessment. Much of Mr. Stadie's information is drawn from British sources.

Ordnance Manuals and Drawings.—Under this heading is an article appealing for greater use of the official handbooks; also giving the recommendations (as to technical drawings) of a Committee appointed to standardize practices in German industry. These recommendations are given in full, and they will be adopted in the German Army. T.H.B.

REVUE DU GENIE.

(*July*, 1925).—*The Working of Quarries for the VIIth Army.* (Concluded).—A description of the working, from the beginning of 1917, of a quarry at Lauw (Alsace). In the lay-out the levels were so adjusted and the Decauville track was so sited that no manhandling of the stone was necessary and all the trucks moved round the tracks in the same direction. All the buildings were of reinforced concrete. Careful organisation enabled the price of the stone to be reduced from 7 fr. 50 to 5 fr. 25 per yard cube, despite the fact that the workmen were either soldiers or inefficient civilians. In the beginning of 1918 a compressor plant was installed in order to use Ingersoll Rand compressed air hammers, worked by three men each; the price of stone produced by them was 3½ per cent. less than that produced by hand. Dynamite or cheddite were used as explosives, charges used being about ½-lb. The holes for them were at least 1¼-in. The stones from the crusher were put into small trucks and either unloaded directly into railway wagons or into hoppers for loading lorries. Three crushers were installed. Two hundred and nine men were employed, and for the first year the average daily production was 275 tons; after 18 months it had reached 440 tons. A great effort was made, with some success, to increase production by means of bounties, the principle being that half the money gained by the decreased cost of production, due to the increased amount, should be distributed in bounties.

Lighting and Ventilation of Mine Galleries.—Chapter II.—Ventilation.—The basis on which to work is the amount of air necessary in any circumstance, velocity of the air currents and the lengths of gallery which need no ventilation. Natural draught ventilation should always be assisted by some artificial means, in case the air pressures get changed and reverse the flow of air. The two methods of artificial ventilation are the blowing system and the sucking system: the conditions under which each one of these is the better, or in which they can be combined, are discussed. The uses, and details of construction, of shafts and boreholes to promote a natural draught are elaborated. Information on fans comes under the following heads:—Methods of working, power (for electrical and mechanical fans), velocity of issuing air, delivery, angular velocity and static pressure produced by it. Many types of fan are described. An empirical rule for finding the horse power required for any lengths of pipe-line is to use ¾ h.p. for each 50 m. of line; for more than 50 metres provide coupled fans. This rule only holds up to 150 m.

Building of a Bridge at Pinterville (Eure) by a detachment of the 3rd Regiment of Engineers—15th-20th October, 1924. This pile bridge was to replace one demolished in 1918 and was to be capable of carrying 3-ton axle loads. The bridge was about 120 feet long and was supported by five piled piers 20 feet apart and two abutment piers also of piles. The width of the bridge was 13 feet; in each pier there were 7 piles and five in each abutment. The piles varied from 11 to 18 feet in length and were 7¾-ins. square, and were driven 7-ft. to 10-ft. into hard chalk. The detachment consisted of four officers and 123 other ranks. Work was carried on night and day in six-hour shifts in squads of 37 men, divided into three gangs; one of eleven men, woodworkers, one of 19 working the pile drivers and one of seven doing odd jobs. The pile driving took 50 hours for 45 piles, using one driver. The whole bridge took 120 hours, including 18 hours for a light footbridge. Twelve hours were lost owing to bad weather.

A work table and the necessary calculations are appended. All the calculations are carried out by using the appropriate formula from various books.

J.E.G.McC.

(August).—Les travaux d'adduction d'eau a Souéida (Syria). A full description of the execution of a project for laying on water from a distance of nearly 20 kilometres to the French Military post at Suéida. 15 kilometres were in cement pipes made *in situ*, the remainder in iron. The daily average of personnel employed was 210 and the whole work was completed in a little over eight months.

All the characteristic impediments that are liable to occur under such conditions did occur, and were surmounted. The article contains many hints both as regards personnel, materials and organisation which would be of use to engineers under similar circumstances.

Étude sur L'Éclairage et la Ventilation des Galeries de Mines (concluded). The writer gives formulae for calculating the loss of pressure (and thence the power required to produce a definite quantity of air) due to varying sizes of piping, elbows, etc., and gives examples. Tables are appended of various blowers, and graphs for calculating the flow of air in straight pipes of varying sizes. Additional tables are included in connection with the previous article, showing the sizes of wire for various lengths of circuits for a given range of current and pressure drop.

The "Cordeau détonant" used in Czecho-Slovakia. Stated to be filled with fulminate of mercury and paraffin wax, to weigh 35 lbs. per 100 metres, perfectly uniform in quality, flexible and capable of forming joints or branches by binding. Its sensitivity is markedly increased at temperatures in excess of 50° C. It is detonated by the impact of a projectile at a velocity over 2,600 f.s. Prolonged immersion in water produces no ill effect. The fulminate is treated with paraffin wax, and, provided that the latter has not escaped, the *cordeau* can be ignited and will burn without detonation. The *cordeau* is stated to be of the same nature as was in use in the Austro-Hungarian Army. (This fuze, or a similar one, was tried at the S.M.E. in 1907 and subsequent years).

(*September*, 1925).—*The Exploitation of the Forests in Les Landes* 1916-18. Summarises the general organisation for provision of timber under the "Inspection Générale du Service des Bois" organised in 1917 which at the period of maximum output produced 42,700 and purchased 154,000 metres cube of timber of sorts. A description of the organisation for clear felling an area of 358 *hectares* in Les Landes, where one officer and some 300 other ranks were employed.

Furnaces for the Production of Charcoal. Describes several appliances exhibited at a competition recently held.

The Housing Problem. An appeal for the provision of married quarters for re-enlisted N.C.O's, claiming that the net cost, allowing for interest and amortisation, would not be more than 500 francs per annum per head.

Floating Bridges on the Rhine. Extract from a paper published in another periodical, enumerating the various floating bridges and describing a typical example.

The Passage of the Danube at Sistovo, 23-11-16. A translation, with illustrations, of a paper by an Austrian Officer, describing the preparation and execution of this passage. Preparations were begun on August 10th, a month before Roumania declared war. The force consisted of 3 divisions and was ferried over the river eventually under cover of a fog against a somewhat feeble opposition. A floating bridge 927 metres in length was commenced on 24-11-16 and finished in 24 hours. The article contains a full description of the assemblage of the equipment and the methods of preparation and particularly of concealment.

A Map Exercise on the crossing of a river and canal. Gives a general and special idea, orders to the divisional "commandant du génie," his instructions, appreciation and orders. H.G.K.W.

MILITÄR WOCHENBLATT.

15th March, 1924. The leading article of this issue deals with gas warfare. After referring to a recent article in *Heerestechnik* on the stage of the preparations for the future gas war which has been reached in various countries, so far as this has been made public, the article observes that it shows how feverishly in spite of the Washington Agreement the development of this weapon is being worked at on all sides. It then seeks to discover the lines along which the tendencies are moving, for in the last war the use of gas was only elementary. After proving to his own satisfaction that the French were the first to break the rules of the Hague Convention of 1899 regarding the use of poison gas, the writer refers to the American gas "Lewisite," which is now enabling the Americans to give the lead in this matter when formerly they were entirely dependent on the French. Incidentally he observes that 27% of the American casualties were due to the German gas. (In this connection it may not be out of place to recall a yarn of the war concerning the American gas mask, one criticism of which was to the effect that "the twine you wind round your belly is all right, but the rest's nowhere"!) As regards the Lewisite, which an exaggerated claim asserts to be so strong that a few drops on the hand are enough to kill a man, it is said that 150 tons of this had been prepared in November, '18, when the war came to an end. For safety's sake this was sunk at sea, but complete formulæ are preserved for its manufacture if necessary. It is considered most important to possess a mixture of gases, whereby by adding a "camouflage" gas the mixture is not remarked as poisonous —a gas without smell, with which, according to Belgian information, experiments are proceeding at Puteaux, near Paris. The ideal for many is a gas which works through the ears on a man's sense of balance, robbing him of his wits or even of consciousness. This is all the writer has to say about actual gases, observing that America is the only state to publish details of its poison gas, all other nations preserving silence about their activities.

As regards the use of gas in war, the writer then refers to various authorities, Belgian, French, American, English and Swiss, to support the contention that since the discovery of gunpowder nothing has tended to alter the conditions of warfare so much as gas, one of the four weapons of the future "war to a finish"—infantry, artillery, airmen and gas. Whereas in the last war primitive gas cylinders were first used, then projectors and gas shell, the question of bombing from aeroplanes has since been most to the fore. The writer then quotes Gen. Debeney to show that in the next war the use of gas bombs from aeroplanes will be so extended and far reaching as is hard to picture now. With regard to the defensive use of gas, the *Bulletin Belge* gives two examples from 1918, which are of interest in the study of the future use of gas; one was the German offensive in March, 1918, when "yellow cross" was used as flank protection to the attack, and the other the Kemmel offensive where mustard gas was discharged on the ground in front of the objectives reached, so as to protect the position won from counter attack, and also incidentally prevented, at first, any further advance of the attack.

Pursuing further this idea of protection by gas screens, one reaches the notion of laying down an impassable gas barrier in the no-man's-land between the two front lines, which would be more effective than any trenches, wire entanglements or similar devices of position warfare. And so on to yet more fantastic ideas.

Thus we see the use of poison gas in full development everywhere. Gas fantasies, "*rêves d'hier, hypothèses et projets d'aujourd'hui, réalités de demain.*"

And yet it is asked whether this weapon, the use of which was prohibited at Washington, had not better be dispensed with. But the reply is always: "No, impossible." So, says the English Captain Auld, one makes a step forward, and then, though it is a thousand times more cursed and pernicious, withdrawal is impossible.

In conclusion, the writer says the next war will be begun with the contestants "well provided with gas and poison-projectiles," and at the same time each will seek to prove to the world that it is the wicked enemy that must bear the responsibility for first using this terrible weapon.

E.G.W.

CORRESPONDENCE.

BROKEN LINTELS.

To The Editor, *The Royal Engineers' Journal.*

DEAR SIR,

On page 516 of the September number of the *Royal Engineers' Journal* there is a reference to an article in the *Revue du Génie Militaire* for April, 1925, entitled "Notes on a Detail of Construction in the Roman Arenas at Arles and Nîmes." In both these structures certain stone lintels over the arcades running right round the arenas are nearly all fractured. The Romans were as a rule sound constructional architects and it is surprising to find such an example of faulty design.

The present writer visited both places at Whitsuntide, 1923. At Arles the building was not carefully examined as attention was chiefly given to a mild entertainment with bulls which was in progress and the arena was packed with people. It may be mentioned that the show involved no danger to the bulls, which were turned into the arena with bunches of ribbons on their horns. The sporting youths of Arles went into the ring and a prize was given to the first to get the ribbons off, a somewhat risky performance. There was, however, not much excitement except when on two occasions the bull jumped the barricade round the arena and landed amongst the people.

At Nîmes, however, the writer and a small party were escorted by M. Emile Espérandieu, who is the curator of the Roman buildings in the town, including besides the arena, the famous Maison Carrée and many others, so that there was every opportunity for examining the building carefully. The fractured lintels were very conspicuous, especially as they had been repaired with iron cramps.

These Roman failures having been noted, attention is now invited to an almost precisely similar case in quite another part of the world. In the journal for December, 1924, there is an extemely interesting article by Colonel C. W. Davy, C.M.G., on the famous ruins of Angkor, in Cambodia, dating from about the twelfth century. On page 622 there is a sketch of a broken lintel which might almost pass for Nîmes, the chief difference being that the galleries there and at Arles face inwards towards the arena, and at Angkor they, apparently, run round the outside of the buildings. The present writer made a sketch at Nîmes showing the failure, but this has, unfortunately, been mislaid.

In Fergusson's *History of Indian and Eastern Architecture*, there is a description of the Angkor buildings, called by him Nakhon Wat, and he gives a cross section similar to Colonel Davy's referred to above but he says nothing about a structural failure. It is probable that Fergusson had not visited Angkor personally. No fracture is shown in his section. His book was published in 1876, and at that time the illustrations were all engravings from photographs, excepting of course, cross sections and plans of buildings. He does not say how he obtained this particular section. If he ever went to Angkor it is difficult to believe that such an experienced architect would have failed to notice the fracture and show it in his section, nor does it seem likely that they all occurred subsequent to his visit.

Yours faithfully, WM. PITT, *Colonel.*

October 20th, 1925.

PARIS, OR THE FUTURE OF WAR.

SIR,

When reviews of a book question or condemn its opinions the author is not called on, nor is it meet for him to reply. Nor need he worry, for history has amply proved Quintilian's aphorism "the critics condemn what they do not understand," and when Dr. Johnson said, "The great contention of criticism is to find the faults of the moderns and the beauties of the ancients," he might well have applied it to military literature.

But when facts are challenged the case is different. I refer to the review of "Paris, or the Future of War" in the *R.E. Journal* for September, and as this somewhat heated attack is made in the organ of a corps and an institution where I have received much encouragement in earlier years, and which stand out for progressiveness and freedom of opinion, I have a double incentive to reply.

The main challenge as conveyed in the opening remarks—questionable taste I ignore—is not to my opinions, as expressed in "Paris," but to my facts. To pin down the reviewer to more than one or two definite contradictions is as much as is possible, for instead of doing me the bare justice of outlining the purport of my theme or my main points, he devotes most of his space to a merely declamatory depreciation.

The solitary rock of real criticism beneath this wordy foam appears to be that I have done official military authorities an injustice when I say that during recent generations the military objective in war has been the destruction of the enemy's main armed forces on the battle-field. The reviewer says of me, "His references give an inaccurate impression of phrases of the regulations which he entirely divorces from their context, and from the spirit exhibited on every page of the manuals. For example we are told that in the words of *Field Service Regulations*, the accepted military objective in war is the enemy's main forces on the battlefield. The author is endeavouring to show the blindness of the soldier to the moral objective, forgetting, or possibly not having read, the neighbouring paragraph which describes the first duty of the general staff as being 'to 'appreciate the course of action which . . . will most rapidly influence 'the enemy people in the required direction. This demands . . . a 'careful study of the psychology of the enemy people, of their national 'characteristics, resources, and means of existence.' Such a travesty of facts will be patent to the military student . . ."

To this I would reply that "One swallow does not make a summer," nor does one isolated phrase in *F.S.R.* establish the fact that military authority in the past has seriously studied any other means to victory than the destruction of the enemy's main armed forces.

Having had a considerable share in the writing of manuals I know well, too well, the former official insistence on a meaningless ambiguity of diction and dislike of anything that savoured of definiteness. *Field Service Regulations* have always been truly catholic, worded with such generous vagueness as to give countenance to almost every conceivable course of action, or inaction. "The devil quoting scripture to his purpose" has not a simpler task than a commander seeking to justify himself by picking on one of the many ambiguous or contradictory phrases in the manuals.

My arguments in "Paris" were based on the general tenor of our past doctrine, not on "phrases divorced from their context," and if R.P.P.-W. seriously maintains that the "armed forces" objective has not dominated our doctrines, I would ask him to mention any part of any manual where other means of subduing the enemy's will to resist are studied and discussed. But to dispose of his accusation that I have travestied facts there is actually no need of argument. His isolated quotation is taken from *F.S.R.* Sect. 5, para. 2. One puff of wind from para. 3 blows it away completely. "In framing a plan of campaign the *ultimate* aim, which is *the destruction of the enemy's main forces,* must always be held in view and all other undertakings subordinated to this." If many phrases in *F.S.R.* are vague this at least is not. Its position in the text might almost have been chosen designedly to "put the lid on" any unconventional searchings, encouraged by the preceding paragraph after other objectives.

And to the evidence of *F.S.R.* itself can be added many others of hardly less authority. In Admiral Custance's book, "A Study of War," which received universal and unstinted adulation from reviewers in the various military journals, so unquestioningly is this dogma embraced that the author opens his chapter, "The Military Aim," with the words "Battle being the decisive act . . . it is evident that the decision is complete when the one armed force has been destroyed in battle . . . Hence, the military aim of each side is to destroy in battle, or to neutralize the action of the opposing armed force."

In this place I am not concerned with the delightfully ingenuous lack of reasoning by which this dogma is postulated without examination—as if not even requiring argument—but merely quoting it to show how completely the "armed forces" objective has dominated and obsessed orthodox military thought.

I will leave it to your readers to decide whose is the "travesty of facts," who "divorces (phrases) from their context and from the spirit exhibited on every page of the manuals." R.P.P.-W.'s criticisms might, perhaps, be termed verbal boomerangs—remarking merely that if such is the value of the reviewer's "facts," such also is likely to be the value of his more nebulous general criticisms.

I am, Sir, Your obedient servant,

B. H. LIDDELL HART.

AERIAL SURVEYING.

SIR,

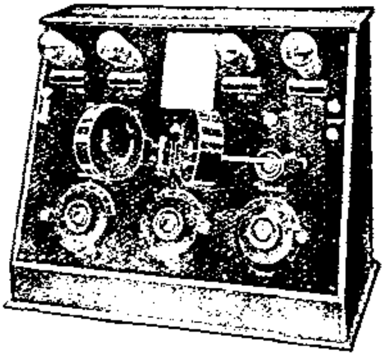
In the September number of the *Royal Engineers' Journal* appeared a review by me of "Aerial Surveying by Rapid Methods." Towards the close of this article appeared a very rough graph showing the cost and scales of vertical air photography as opposed to ground surveying. I much regret that I did not look at the graph before it was sent off to you. As it appears, the cost is shown along the horizontal (across the page) lines, while the scales are shown on the vertical (up and down the page) line. They should, of course, be reversed. The cost are the vertical and the scales are the horizontal lines.

Yours faithfully, H.St.J.L.W.

A·J·S

The New Model Standard Receiver.

Sir Oliver Lodge's choice after test.



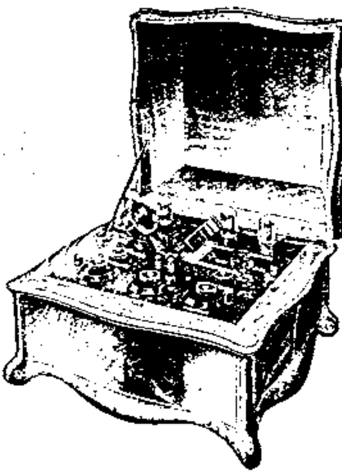
The New Model A. J. S. Receiver is extremely "flexible" and will function satisfactorily on any wave lengths from 150 metres to 20,000 metres. The instrument as shown operates up to 550 metres, beyond that long wave coils are necessary. Constant Aerial Tuning forms a salient feature of the New Model, and its power of assimilating weak signals enables it to be used on Frame Aerials. While embodying all the latest phases in Wireless reception, the A. J. S. New Model, like its prototype, is Supremely Easy and Easily Supreme, and in every respect maintains the A. J. S. tradition of "Quality First."

TYPE F.6.

PRICES:

RECEIVERS ONLY.		COMPLETE SETS.	
Two-Valve Panel ..	£11 10 0	Two-Valve Set	£16 17 6
Three-Valve Panel ..	£14 17 6	Three-Valve Set ..	£21 13 6
Four-Valve Panel ..	£18 0 0	Four-Valve Set	£26 15 0

Table-de-Luxe Receiver. Type T.M.1.



Constructed to contain an A.J.S. Four-Valve Receiver, this Cabinet combines the maximum of wireless efficiency with the minimum of space. Produced in Mahogany it is of distinctly handsome appearance. It forms a compact and attractive article of furniture when placed upon any convenient table, and is sufficiently portable to be carried on the seat of a car or boat, to any outdoor function. The materials and workmanship employed in the production of these Cabinets are of the best throughout, and fully maintain the A.J.S. tradition of "Quality First."

PRICE: With all accessories ready for use, £35.
Without accessories .. £28 15 0.

A. J. STEVENS & Co. (1914) Ltd., Radio Branch, WOLVERHAMPTON.

Telephone: 1748 (7 lines). Wireless Call Sign: 5 R.I. Telegrams: "Reception, Wolverhampton."

London Offices, Show & Demonstration Rooms:

122/124, CHARING CROSS ROAD, W.C. 2.

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

THE Institution has in course of preparation a new volume of the series "The Work of the Royal Engineers in the European War, 1914-19." The new volume will be "Miscellaneous," and will contain the following sections:—

(1) The Organization and Expansion of the Corps, 1914-18.
(2) Engineer Intelligence.
(3) Camouflage.
(4) Concrete Defences and Factories.
(5) Forward Communications.
(6) Machinery, Workshops and Electricity.
(7) Inundations.
(8) Anti-Aircraft Searchlights.
(9) Schools.

Of the above two only (Nos. 2 and 8) have already appeared in the *Royal Engineers' Journal.*