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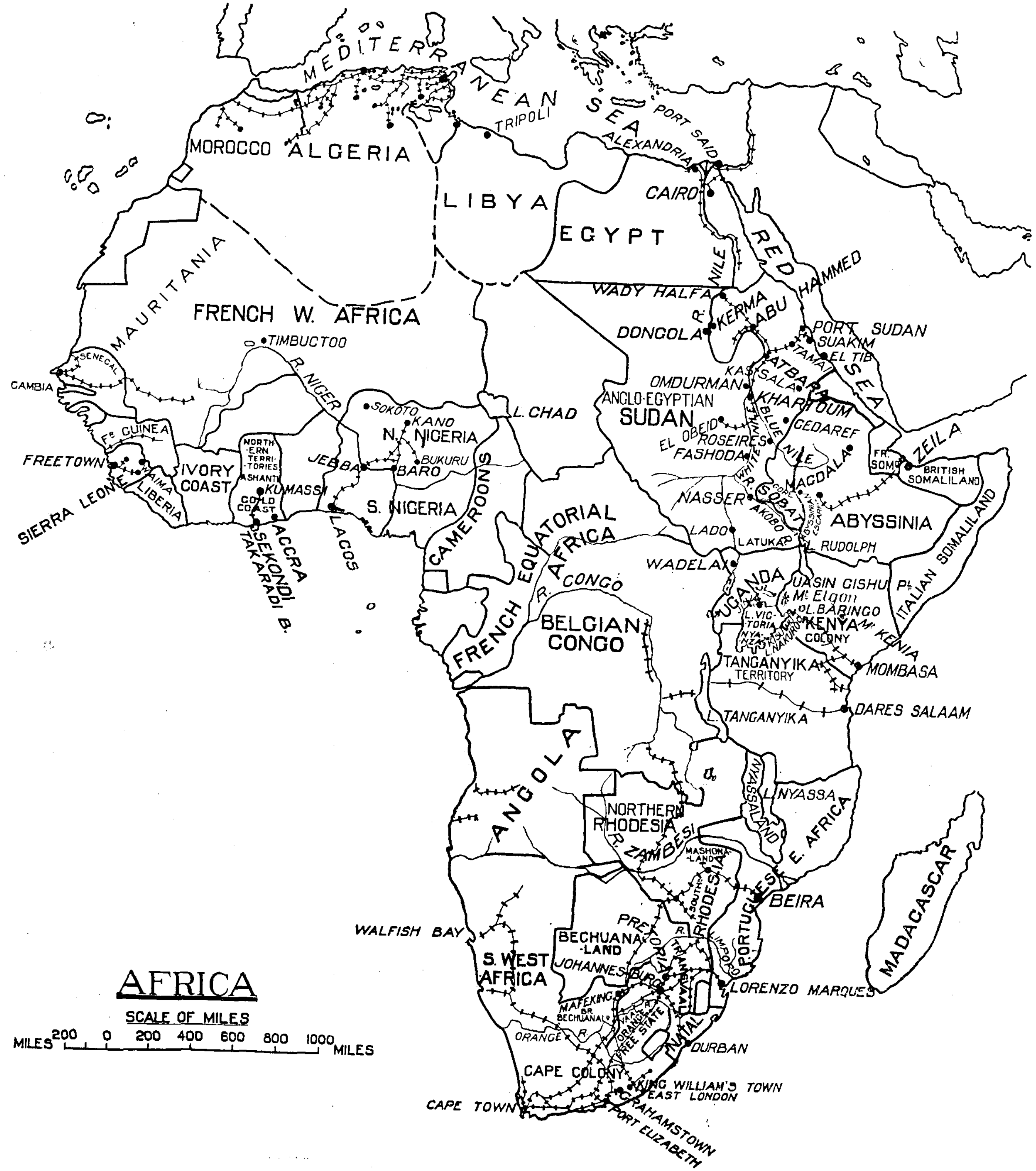
SOME ROYAL ENGINEERS AND THEIR WORK IN AFRICA.



SOME ROYAL ENGINEERS AND THEIR WORK IN AFRICA.

A LECTURE DELIVERED AT CHATHAM ON 24TH FEBRUARY, 1927.
By COL. COMMANDANT H. L. PRITCHARD, C.B., C.M.G., D.S.O., *A.D.C.*

The Lecturer's thanks are due to many R.E. Officers who sent him first hand nformation about the work described in this lecture.

INTRODUCTION.

In this lecture I want to describe the great *variety* of the opportunities, the work, and the achievements of some Royal Engineers in Africa during the last thirty to forty years.

That work, and those achievements, have helped in great measure to open up a vast continent, which, forty years ago, was practically closed and unknown.

I have said that I am going to refer to the work of *some* Royal Engineers, because, in a lecture of one hour, it is impossible to deal exhaustively with the work of all the R.E's. who have laboured in Africa, or to name them all.

THE SCRAMBLE FOR AFRICA.

Here we have a map of Africa, which the Survey School kindly prepared for this lecture.

On that map you see the boundaries of the territories of various European nations clearly marked.

But thirty to forty years ago the map of Africa was a very different thing.

Up to that time European nations had in most parts of Africa contented themselves with trading stations on the sea coast, to which the natives from the Hinterland brought their produce to exchange for European goods.

This happy-go-lucky arrangement gave place to what has been called " The Scramble for Africa." The French began it. They started to go into the hinterland of their coastal settlements on the West Coast, making treaties with native chiefs to accept, first, French protection, and then sovereignty.

We soon discovered that unless we did the same thing the French would divert the whole trade in the hinterland of our coastal trading stations to theirs. Consequently we set about securing the allegiance of the tribes behind our settlements.

The Germans were late in joining in the scramble. By the time they took a hand in it the British and French had secured most of the best territory, but the Germans elbowed their way in, and we were all engaged in pegging out claims to territory by making treaties with native chiefs.

Military Expeditions in West Africa.

This scramble for Africa somewhat bewildered the native chiefs. Their tribes were nearly always at war with each other, so that many of them welcomed the protection offered by a European Power, and were quick to claim protection when attacked.

Other tribes, however, resented the arrival of the white man, and made war upon him.

These were the causes of numerous military Expeditions, particularly in West Africa, on which the R.E. were well represented.

The expeditions were nearly always organised entirely with West African or West Indian Troops, led by British officers, but in a few cases small bodies of British troops were employed, notably in Lord Wolseley's expedition to Ashanti in 1875, again in the second Ashanti expedition of 1895, and in the suppression of the Ashanti rebellion in 1901.

In West Africa these expeditions travelled usually through dense primeval forest of enormous trees running up to 200 ft. in height, with thick undergrowth and swamps below them, all interlaced with forest creepers. In such forests the sun is never seen, except in village clearings.

To penetrate this forest one must either use native tracks, which become overgrown with extraordinary rapidity directly they fall into disuse, or else one must cut every foot of one's way.

Tactics of "Bush" Fighting.

In this sort of country, commonly called "Bush," the tactics of bush fighting do not vary much.

A column on the march has to proceed in single file, all food, and ammunition, and stores, being carried in 50lb loads on the heads of native carriers.

These carriers, though willing to do this duty, have no desire to be involved in fighting, and usually fling down their loads and disappear directly there is any sign of it.

To stop such a single-file column the hostile natives usually built a series of stockades at intervals across the path, and they would construct, and very cleverly camouflage our old friend the "deep military pit," complete with pointed stakes, but they improved upon our specification for this pit, by putting poison on the business end of the pointed stakes.

On either side of the path approaching the stockade, parties would lie in ambush.

The leading files of the column usually suffered when they came upon these stockades round a bend in the path. It was impossible to march with flank guards laboriously cutting their way through every foot of the forest on either side of the path.

Having, however, found the stockade and ambushes by the system of "trial and error," the normal procedure to overcome the defence was for those who were not thus engaged at a disadvantage in the vanguard, to cut their way into the forest on either side to turn both flanks of ambushes and of stockade.

The defenders usually fled when the flanks were turned. The stockades did not run far to either side of the path. If they did not fly at once the fighting was at any rate on equal terms, in which the white man's leading gained the day.

The stockade then had to be cleared away, or a path cut round it, and the column resumed its march, to repeat the procedure at the next stockade.

Eventually a village would be reached, protected by an extremely strong stockade, often formed of growing trees. Here the R.E. would be called upon to blow a breach.

Lt. W. H. Robinson, R.E., who blew up numerous stockades successfully, was eventually killed at a stockade at a place called Tembé.

R.E. Work on West African Expeditions.

Besides demolitions, the R.E. were required on mapping, telegraph laying, bridging, water supply and hutting.

As maps did not exist, it was the duty of the R.E. to map the route followed by the expedition, by route traverse and sextant observations for latitude. Chronometers were not usually available.

As regards the bridging of rivers for single file traffic, this was done either by the local inhabitants, or by bridging parties of natives marching with the column. The natives were very expert at the work, but it was the business of the R. E. to get them on to it.

The usual method was to cut forked trees at the river bank and use them as the uprights of pile trestles forced by hand into the sandy river bed. The transoms rested in these forks. Roadbearers, also cut at the river bank, were lashed to transoms by creepers torn from the trees and a corduroy roadway similarly lashed on to the roadbearers.

When British troops accompanied the expedition, as in the invasion of Ashanti, the R.E. had more work to do. In the expedition of which Major Sinclair was the C.R.E., the British were not landed until an advance guard of native scouts, organised by Major Baden-Powell, backed by native troops, had penetrated several marches inland.

Behind this screen, hutted camps of bamboo huts were put up for the British at the end of each day's march.

Split bamboos make an exceedingly comfortable guard bed, and serve to keep the white man off the ground, which is important for health's sake in West Africa. The roofs of the huts were thatched with palm leaves, which were abundant in the forest.

For water supply in these prepared camps for British troops, a boiled and filtered supply was provided entirely from forest materials. Troughs, hollowed out by the natives from tree trunks, water boiled in new earthenware pots, quickly made by the native women, other pots made into filters by the insertion of a sandbag filled with charcoal freshly burnt from forest timber.

The R.E. officers and N.C.O's stationed at Sierra Leone, whose normal duty was the building of coast defences and barracks, almost invariably in the course of their tour of service, came in for one or more of such expeditions as I have been describing, *e.g.*, Mackay, G. H. Boileau (now a Chief Engineer in India), Robinson, who was killed at Tambi; Major General Gwynn, who is now Commandant of the Staff College, began his active service in this way.

Colonel Ellis' Expedition.

Captain Sloggett, R.E., Lt. Gwynn, R.E., and two R.E. N.C.O's, proceeded with Col. Ellis' Expedition to fight the forces of a Chief called Samory, who was harrying tribes under British protection.

The French were also at war with Samory, who had been raiding their territory also.

The French and British Expeditionary Forces, starting from bases widely separated, and moving in dense forest, were unaware of each others' whereabouts, with the unfortunate result that one night they encountered each other. Both forces being under the impression that they were in contact with Samory's tribesmen, a severe action ensued, in which the British Forces suffered heavy casualties, but the French Force was wiped out.

While the respective Foreign Offices in Paris and London were engaged in clearing up this little misunderstanding, Colonel Ellis, although his carriers had bolted, proceeded to his original objective, *i.e.*, Samory's forces, and wiped them out, too.

Lt. Gwynn, who was Intelligence Officer of the Column and commanded the Advance Guard, was severely wounded.

The Fort at Kumassi.

When the second Ashanti expedition took over that country in 1896, Lt. MacInnes, R.E., who was afterwards killed as a Brigadier General in France, built a Fort round the new Residency at Kumassi, which is the Capital of Ashanti.

The R.E. build a lot of forts in various parts of the world, but it is not often that they have the compliment paid to them of a full-dress siege. But MacInnes' fort at Kumassi had to stand a siege of many weeks, and held out successfully.

In 1901, the Ashantis rose in rebellion, cut communications between Kumassi and the coast, and besieged the Governor of the Gold Coast in Kumassi Fort.

The Ashantis had got into their heads, quite erroneously, that we were trying to find and secure their golden stool. This stool they had hidden when we conquered the country, as it was the throne of their kings, and they believed it contained the soul of their nation.

We were busy with the South African War at the time, but an Expedition had to be organised to march up from the coast and relieve Kumassi; Captain R. S. McClintock, R.E., was a D.A.Q.M.G. of the relieving force. He is now G.S.O., Scottish Command.

Boundary Commissions and Survey.

The scrambling for Africa, of course, led to numerous disputes between European nations concerning the boundaries of their respective territories.

To settle thsee disputes amicably the usual procedure was to set up boundary commissions, on which R.E. officers, on account of their knowledge of survey, were always appointed, and usually an R.E. officer was in charge.

These commissions not only surveyed the boundaries, but were also required to study the whole tribal system of the country and its resources, and deal with administrative and political questions.

After the boundaries had been settled the next task was to survey the vast areas of territory acquired.

It is not possible to give the long list of boundary commissions, or the names of all the R.E. Officers who worked upon them, and who afterwards surveyed the territories, but it is safe to say that wherever you see a boundary of British territory on that map of Africa, there you see the hard work of some Royal Engineers.

About twelve thousand miles of African boundaries were delimited by Royal Engineers.

Conspicuous among these Surveying Officers, at first working in Africa, and later organising and co-ordinating the work of boundary commissions, when he was head of the Survey Branch of the War Office, and afterwards Director General of Ordnance Survey, was Captain C. F. Close, R.E., now Colonel Sir Charles Close.

Among other R.E. Officers employed on this work as subalterns, captains and majors, I will name a few: Kenny, S. C. Grant, Johnstone, O'Shea, Gillam, Woodroffe, Jackson, Watherston, Guggisberg, Gwynn, Maud, G. E. Smith, Whitlock, Austin, Jack, G. C. Williams, and many others.

Major Watherston was Director of Surveys on the Gold Coast, and afterwards was Chief Commissioner of the Northern Territory of that Colony, where he unfortunately died of blackwater fever.

Major Guggisberg, after surveying in Gold Coast Colony, was Surveyor-General of Nigeria, with Waterhouse and Bulkeley working under him. He is now Governor of the Gold Coast.

Colonel W. G. Morris carried out the geodetic triangulation of South Africa, based on which L. C. Jackson and Winterbotham completed the survey of the Orange Free State.

In the Sudan the Survey Department was created by Colonel the Hon. M. G. Talbot, who was succeeded by Lt.-Col. Pearson, who worked for many years surveying the Sudan, and died there just as he was about to retire.

In Lower Egypt, Capt. Lyons, R.E., (now Sir Henry) was Director of Survey, Geology and Archæology. He is recognised as one of the greatest authorities on Egyptian Archæology.

One would have to continue for a very long time if one were to attempt to give a complete account of the survey work done in Africa by Royal Engineers.

It carried them as explorers over vast areas of an unknown country that had never seen a white man before.

It gave them unrivalled opportunities for big game shooting. In fact, when G. E. Smith (better known as "Uganda Smith") first returned from British East Africa with his stories of the vast herds of every kind of big game roaming the country, his reputation for veracity was severely tried, but has since been amply vindicated.

The work led them into positions in the administration of the territories acquired. Frequently they broke off their work to take part in military operations.

Lt. Foulkes and the Emir of Kano.

For instance, when Major McD. Elliott, R.E., was in charge of the boundary commission, delimiting the Anglo-French boundary of Northern Nigeria, Sir Frederick Lugard, Governor of Nigeria, found it necessary to dispatch an expedition which was first to capture Kano, and then proceed against the Sultan of Sokoto.

Kano was captured, but the Emir of Kano escaped, and was likely to raise the tribes on the flank of the expedition when it marched on Sokoto.

Lt. Foulkes and Lt. Frith were working under Major McD. Elliott, and at that time Lt. Foulkes (who is now Chief Engineer Aldershot Command), was working detached some distance north-east of Sokoto, on the edge of the Sahara Desert. He had an escort of fourteen Hausa soldiers. No doubt the size of his small force was much exaggerated by native rumour, with the result that friendly natives near Gober, where the Emir of Kano was sheltering, sent word to Lt. Foulkes that the King of Gober was likely to side with the British, and that if Foulkes would support him with his force, he would probably hand over the Emir of Kano.

On receipt of this information Foulkes, who had previously taken part in several West African Expeditions, mounted his servant, and a corporal, and four Hausa soldiers, on country ponies, and rode continuously for 53 hours without resting, except to water and feed the ponies. Having thus covered 175 miles, he arrived at the walled town of Gober with his servant and the Corporal. The other four had been unable to keep up.

Foulkes decided to bluff. He interviewed the King of Gober, stated he had a large force in the neighbourhood, and demanded that the Emir of Kano should be handed over to him. The King of Gober was bluffed, and handed over the Emir, whom Foulkes forthwith hustled off and delivered to Sir F. Lugard, with the result that the Expedition was not troubled by the Emir's people in the march to Sokoto.

DEVELOPMENT OF WEST AFRICA.

The survey work which has been described, of course, facilitated the development of newly acquired territories, and in this development work the R.E. played a considerable part.

The Governorship of the Gold Coast Colony has become almost a perquisite of the R.E. As Governors we have provided Sir Henry Macallum, Sir Matthew Nathan and Sir Gordon Guggisberg.

When Sir M. Nathan was Governor of the Gold Coast Colony, from 1900-1904, he caused the first railway to be built in West Africa. He found the mining concessions in chaos. For the survey of these concessions he secured Captain Watherston, R.E., with some other officers and several R.E. N.C.O's. Their valuable surveys gradually evolved order out of chaos in the concessions.

Guggisberg succeeded Watherston, and E. F. W. Lees took over from Guggisberg. C. B. O. Symons and King were among the officers thus employed.

Major Sir M. Nathan has since held several very important Government appointments, *e.g.*, Governor of Natal, and then of Hong Kong, Permanent Under Secretary of State for Ireland, and has only recently returned from being Governor of Queensland.

Watherston and Guggisberg many years ago selected a site at Takeradi Bay, where they were confident a deep water harbour could be built, but they were up against vested interests at existing landing places, and could get no backing for their scheme.

Now, however, that Sir Gordon Guggisberg is Governor of the Gold Coast, he has caused the Takaradi harbour scheme to be put in hand, and it is approaching completion. Harbour work on the West Coast of Africa is uncertain work. There is always the possibility of sand silting up, but, if the scheme proves a success, and if it becomes possible for large ships to lie alongside permanent deep water quays, Sir G. Guggisberg will have conferred a great boon on the Colony, which must increase its prosperity vastly.

Up to now, all goods have been landed in lighters and passengers in surf boats, from which they are carried ashore on the backs of natives. They embark in the same way.

Getting on to the gangway of a steamer from a surf boat can be quite an exciting experience. I once had to assist a drunken man to perform this feat. It would have been all right if he had been drunk enough to be treated like a sack of potatoes to be flung on the gangway, but unfortunately he was not. He had his own ideas as to the right moment to jump for the gangway, and the moments he selected were not the right ones.

Sir Gordon Guggisberg's Governership of the Gold Coast has been remarkable for the progress made by the Colony in that period. The mileage of motor roads has increased from 1,300 to 4,000, and of railways by 250 miles. The result is apparent in the trade and revenue. For instance, revenue has increased from 1½ millions to four millions per annum, and the bank balance from £160,000 to three millions.

Major W. E. Lees, R.E., was Director of Public Works in the Gold Coast and Northern Territories from 1904-10. As such he was responsible for the construction and maintenance of roads and building works, excluding railways and harbours.

These works included the water supply of two large towns, Accra and Sekondi, costing 1¼ millions each, town planning, Government buildings for Hospitals, Court-houses, Post-offices, Schools, Prisons, Lunatic Asylums, Police Barracks, etc.

In 1909 a special roads branch was formed under Major Leslie, R.E., with other R.E. officers under him. To-day, R.E. officers are employed on this work.

As a result of all the work that has been referred to, one can nowadays travel in West Africa by rail and road for many thousands of miles where formerly one had to walk every yard, as horses cannot live within many marches of the coast.

The most rapid mode of travel used to be in a hammock, slung fore and aft on cross bars, which rested on the heads of four natives striding along.

There was one R.E. subaltern who, when he landed in West Africa, weighed 18 stone. When the natives who were detailed to carry him in a hammock saw him they fled into the "bush," so he had to walk everywhere. Walking in West Africa is very good for the figure, but I am afraid it was not a permanent cure, as I am told that he now weighs 22 stone.

Nigeria.

Sir George Taubman-Goldie.

We will now travel on to Nigeria, and here we come across a very remarkable man who began his career in the Corps.

It is entirely due to Sir George Taubman-Goldie that the enormous territory known as Nigeria belongs to the British Empire. It is an exceedingly valuable possession with great possibilities for development.

Sir G. Taubman-Goldie revived the method of Government by Chartered Company, on the precedent of the old East India Company, and Rhodes was copying Taubman-Goldie when he applied the same system to Rhodesia. Sir William Mackinnon, in East Africa, was also inspired by Taubman-Goldie's example.

It was in 1877 that he first visited the Niger Country, and by 1879 he had amalgamated all the British trading concerns on the Niger into a single company called the British Niger Company. In 1881, he applied for a charter for the company which, when granted in 1886, gave the company practically sovereign powers.

Several French trading companies were competing keenly on the Niger, but the British Company bought them out. At the same time, Goldie concluded over 400 political treaties with tribal chiefs who accepted British sovereignty.

The Germans next appeared upon the scene, and, strongly backed by Bismarck, tried to compete both in trading and in political ascendancy.

Protracted negotiations ensued with both Germany and France, throughout which Goldie was the constant adviser and watchdog alongside Lord Salisbury at the Foreign Office, and Mr. Joseph Chamberlain at the Colonial Office, and it was not till 1898 that an agreement was signed with both France and Germany which secured Nigeria to Great Britain.

Goldie governed the affairs of Nigeria from the London offices of the Niger Company which, unlike some other Chartered Companies, paid a good dividend. On January 1st, 1900, the administration of Nigeria was taken over by the Imperial Government.

In 1903-4, Goldie, at the request of the British South Africa Company, visited Rhodesia, and drew up the first scheme for the self-government of that country.

Sir Percy Girouard as Governor of Nigeria.

The next prominent Royal Engineer to whose work in Nigeria I would refer, is Sir Percy Girouard, first as High Commissioner of Northern Nigeria, and later as Governor of the whole Colony.

It was during his vigorous administration that great progress was made in developing the country, and it was entirely due to him that a great stride forward was taken in railway development by the construction of that important and economically successful line, the Baro-Kano Railway.

The Baro-Kano Railway.

This railway was mainly constructed by Royal Engineers under the general supervision of Mr. Eaglesome, who was Director of Railways and Public Works in Nigeria.

As you see from the map, the railway starts from Baro about 400 miles up the river Niger, to which boats with four feet draught can navigate all the year round, and runs for about 300 miles up to Kano, in Northern Nigeria, opening up a country specially suitable for cotton growing, and rich in tin. Of course, the railway facilitates the administration and development of the country. Previous to its construction all goods were transported on the heads of native carriers. The railway had been projected, and much desired, for some years before it was built, but the estimated cost had made it prohibitive. The original survey was for a railway with 1/50 ruling gradient. When Girouard arrived in Nigeria he examined the proposed route of the railway himself, and selected a better one with a ruling gradient of only 1/143 up and 1/166 down. Moreover, he guaranteed to build it for £3,000 per mile. This guarantee persuaded the Treasury to finance the line in 1907.

For its construction, Sir Percy Girouard obtained the services of three R.E. officers, Captain Mance, Lt. Maxwell and Lt. Hammond, and thirty N.C.O's and men of the 8th and 10th Railway Coys., R.E.

The work was in charge of Capt. Mance, who was afterwards head of the Railway Directorate at the War Office during the Great War.

In order to push on the work without delay railway stores and plant were shipped to Nigeria before the usual facilities for landing them at Baro had been provided. Ingenious improvisations had to be made for landing locomotives and a large tonnage of material.

Lt. Hammond was in charge of the Locomotive and Workshops Department, with Lance-Corp. Hatfield as running shed foreman, and Lance-Corp. Goddard as works' foreman.

Lt. Hammond is now Brig. General, and has for many years been specially employed by the Colonial Office to inspect and report upon Colonial railways all over Africa. He is at this moment returning from performing this duty on the railways in Iraq, and in Nyasaland. He served on a committee appointed to advise the Colonial Office as to the allocation of a loan of ten millions to various East African Colonies for railway development.

Captain Mance put Lt. Maxwell in charge of the platelaying. He is now Col. G. A. P. Maxwell, General Manager of the Railways which we took over from the Germans in Tanganyika Territory.

A record in platelaying was established by the laying of 6¼ miles of main line and 400 yards of siding in one day, a truly wonderful performance.

Of course it must be understood that nothing like this can be done day after day, in fact their best record for 90 consecutive days was 120 miles, which gives the very satisfactory daily average over a period of three months of 1⅓ miles.

Conspicuous in this platelaying success was Coy. Sergt.-Major Curtis. During the great War he rose to the rank of Captain. The latest news I have of him is that, in 1924, he was back in Nigeria as an Assistant Engineer on the construction of the Nigerian Eastern Railway.

The railway was completed in three years, which was much below previous estimates of time. Sir Percy Girouard had aroused the enthusiasm of every official in the Colony to co-operate in solving numerous ancillary problems, such as the supply and feeding of native labour, and the steady supply of shipping on the Niger up to Baro.

Lagos-Yebba Telegraph Line.

The first telegraph line in Nigeria from Lagos to Yebba was built by Lt. E. V. Turner, R.E., who took out 20 N.C.O's and men from Aldershot, and completed the job within a year. Later we come across Turner in charge of the Telegraph Administration of the Sudan, and he is now Colonel on the General Staff for Signals at the War Office.

The Congo.

Lieutenant W. G. Stairs, R.E.

Below the Niger we come to the Congo, which immediately recalls the name of Lt. Stairs, R.E.

He was one of the dozen white men selected by Sir H. Stanley to help him in his expedition for the rescue of Emin Pasha.

Emin Pasha had been appointed Governor of the Equatorial Province of the Sudan by Gordon, when he was Governor-General of the Sudan.

When the Mahdi rose in rebellion and captured Khartoum with his Dervishes, Emin Pasha was completely cut off, and no news came through from him. It was decided to organise an expedition to bring him out.

Sir H. Stanley was famous for his African explorations and for finding Dr. Livingstone. He was, therefore, asked to undertake the task.

Having selected a small number of men, including Stairs, to assist him, he journeyed up the Congo, which was completely unknown country, and reached Equatorial Africa, where he found Emin Pasha, and brought him out through East Africa. The expedition had thus made the first journey from west to east through the heart of Africa. They took Emin Pasha to Cairo, where his reception was so hospitable that he fell off a verandah and broke his neck.

Stairs had become so enamoured of African exploration that he resigned his commission in the British Army and accepted service under the King of the Belgians, with the mission to acquire, and develop, the Congo territory as a Belgian colony. It was mainly due to him that Belgium possesses that valuable country, in the acquisition of which he lost his life.

SOUTH AFRICA.

Now moving on to South Africa, we come to a large country where numerous R.E. have worked.

The earliest trace of R.E. work that I have come across is a road in Eastern Cape Colony.

The early settlers at the Cape waged intermittent frontier warfare with the Kaffirs in the neighbourhood of King Williams Town and Grahams Town. Through a "Pass" in the hills on that frontier there runs a well-graded road, which is in use to-day just as it was constructed. In the rock-cutting at the summit of the Pass there is an inscription to say that it was made by a Company of Royal Engineers in, I think, about the year 1840. I am sorry to say I have forgotten the number of the Company, but I believe it was the 42nd.

BECHUANALAND.

The Bechuanaland Protectorate was secured for the British Empire by an R.E., Colonel (afterwards General) Sir Charles Warren.

He was despatched as High Commissioner and Commander of a Force to forestall the Transvaal Boers who, under the orders of their President, Kruger, were preparing to annex Bechuanaland.

By a mixture of diplomacy and a judicious display of force, Sir Charles Warren manœuvred the Boers out of the country, and established a British Protectorate.

He had with him on this Expedition Lt. Haynes, R.E., who had previously worked with Sir Charles Warren on a dangerous secret service mission in Arabia.

CAPTAIN HAYNES IN MASHONALAND.

We next hear of Haynes in Mashonaland. In May, 1896, Captain A. E. Haynes embarked with his 43rd Fortress Coy, R.E., on the s.s. *Garth Castle*, to proceed to Mauritius for a tour of duty.

He probably thought he was about to spend some rather monotonous years in Mauritius, but the ship reached Durban just at the moment when a very serious native rising occurred in Mashonaland. A Relief Column to assist the settlers was being assembled at Beira under the orders of Colonel Alderson.

Haynes promptly took the initiative and telegraphed to G.O.C., Cape Town, suggesting that he should arm and equip the detachment of troops on board to join Col. Alderson. His detachment consisted of 4 R.A., 38 R.E., and 49 York and Lancaster Regiment.

The G.O.C. approved Capt. Haynes' suggestion. His small force landed at Beira and took part in Colonel Alderson's operations, which saved Mashonaland. Unfortunately, Haynes was killed in action storming Makoni's stronghold.

The Corps has a permanent memorial to Captain Haynes in a medal which is competed for annually at Chatham.

THE SOUTH AFRICAN WAR.

We now come to the South African War. In the last 18 months of that war the Army in South Africa was commanded by Lord Kitchener. When he returned to England on the conclusion of the campaign, we dined him at the Chatham Mess, and I remember that in his speech he told us that, while he was carrying on the war in South Africa, the Prince of Wales (now H.M. King George V) landed at Durban, on his return voyage from Australia. Lord Kitchener went to Durban to meet him, and was greeted by the Prince of Wales with the question, " How is it that on landing at Durban I find that the Governor of Natal, Sir Henry Macallum, is an R.E., the Prime Minister of Natal, Sir Albert Hime, is an R.E., and the C.-in-C. of the Army of South Africa is an R.E."

Lord Kitchener said that he replied to the Prince of Wales by referring him to the Corps motto, "*Ubique quo Fas et Gloria ducunt.*"

General Sir Bindon Blood, whom we often see at Chatham and Aldershot looking hale and hearty, commanded a group of columns in the South African War.

Lt. Colonel Hunter-Weston (now Lt. General Sir Aylmer Hunter-Weston) was a Column Commander; also Lt. Colonel Gorringe (now Lt. General Sir George Gorringe).

THE BLOCKHOUSE LINES.

The Engineer-in-Chief in the South African War was Major General Sir Elliott Wood. It devolved upon him to make practicable Lord Kitchener's blockhouse scheme, which eventually rounded up the Boer Columns.

The whole vast area of the theatre of war was divided up like a chess board, with lines of blockhouses connected by barbed wire fence. Several thousand blockhouses, and thousands of miles of barbed wire fencing, had to be rapidly erected by the organisation created by Sir Elliott Wood.

It was first necessary to settle the best type of blockhouse, suitable for rapid mass production, easy transport, and quick erection.

The Boers at this stage had lost all their artillery, so it was only necessary for the blockhouse to be bullet-proof.

Major S. R. Rice, commanding the 23rd Field Coy., R.E., who was afterwards Engineer-in-Chief in France in the Great War, evolved for this purpose the corrugated iron and shingle blockhouse, which is now in our text-book, and started with his Company the first factory for its mass production.

ARMOURED TRAINS.

On the railways these blockhouse lines were reinforced by several armoured trains, mounting machine guns, field guns, and search-lights, which were constructed, trained and commanded by Major H. C. Nanton, R.E. These armoured trains used to concentrate rapidly on the section of railway line which the Boers were reported to be about to cross, and made a formidable reinforcement to the blockhouse defences.

Railway and Telegraph Work in South African War.

On the Railway and Telegraph systems of South Africa the R.E. had an enormous amount of work to do in the South African War, under the guidance of Lt. Col. Girouard as Director of Railways, and of Col. Hippisley as Director of Telegraphs.

Railway Work.

Lt. Colonel Girouard had to organise a transportation Staff to work in harmony with the Cape Government and Natal Government Railways, and also had to create an organisation to take over, repair, and work, the enemy's railways, as our Army advanced into the Free State, with its 400 miles of railway, and into the Transvaal with a further 900 miles, total 1,300 miles of enemy's railways.

The enemy carried out the most wholesale destruction of the railways as he retired. Of the bridges, he demolished 53 spans of 100 ft. or over, 27 spans between 75 ft. and 100 ft., and 210 spans less than 75 ft. Some of these bridges spanned deep ravines.

At most stations the water supply was destroyed, and frequently the permanent way was blown up for several miles.

Nevertheless, railway communication was opened with Johannesburg eleven days after Lord Roberts arrived there, and with Pretoria sixteen days after the Army's arrival, and with Mafeking thirteen days after its relief.

The conquered railways were repaired, staffed, and worked, partly by R.E. officers, N.C.O.'s and men; the R.E. Coys. being the 8th and 10th Rly. Coys., R.E., the 6th, 20th, 31st, and 42nd, Fortress Coys., R.E.

These were an invaluable nucleus, but their numbers were small, and the great bulk of the railway men came from various sources.

Firstly, there were the British railway employees of the Orange Free State, who left their employment on the declaration of war, and returned with us to their old posts on the railways.

In the Transvaal, however, the railway employees were all Dutch from Holland, and these declined in a body to work for us, and were deported, thus effecting a more complete and simultaneous railway strike than we have ever had in England.

Some railway men were obtained on loan from the Cape Government Railways, some were recruited in England, but a very large number of men were obtained by calling for the services of railway men who were to be found in the ranks of the Forces, particularly among the Colonial Troops.

Several men, who had never worked on a railway, but were tired of trekking about Africa, reported themselves as expert railway men, prepared to take on any job, even driving a locomotive, or working a signal-box. These had to be weeded out and returned to their regiments, not before, however, one of these amateur engine-drivers had upset a train containing a whole Battery of Artillery into a river bed.

With this heterogeneous, but zealous, body of several thousand men, more or less expert, the working of 1,300 miles of damaged railway had to be taken over and organised.

Conspicuous in this improvised railway organisation was the Railway Pioneer Regiment, officered and recruited from the highly-skilled mining engineers and artisans of Johannesburg. The raising of this unit was initiated by a very eminent mining engineer, Mr. Seymour, who took the post of second in command as a Major. He was, unfortunately, killed in action.

To help the formation of this unit a few R.E. officers and N.C.O.'s were posted to it, three of whom have since attained considerable distinction. Lieut.-Col. Capper commanded the Railway Pioneer Regiment. He is now Lt.-General Sir John Capper. Captain E. D. Swinton was a company commander. He is now Major-General Sir Ernest Swinton, Professor of Military History at Oxford. Lt. S. H. Wilson was a company officer. He is now Brig.-General Sir Samuel Wilson, Permanent Under Secretary of State for the Colonies.

The Railway Pioneer Regiment did some magnificent work in the reconstruction of demolished railway bridges.

Among the officers who assisted Lt.-Col. Girouard to carry out this railway work were Capt. Waghorn, now Brig.-General Sir W. Danvers Waghorn, who finished his career as President of the Indian Railway Board. Major Twiss, who was afterwards Director of of Railways in France during the Great War. Major Murray, now Sir Valentine Murray. Lt. Micklem, who carried out the bulk of the rapid repair work, was wounded in the foot when De Wet raided the construction train. As he had previously been wounded in the foot at the Battle of Khartoum, General Maxwell wired to him that his feet were too big for military purposes. Lt. Stevenson was Locomotive Superintendent. He is now Major-General Stevenson, recently Chief Engineer at Aldershot. He was assisted by Lt. Newcombe and by Lt. Oakes, who is now Asst.-Director of Transportation at the War Office. Major W. S. Nathan, brother of Sir Matthew Nathan, was Staff Officer to Lt.-Col. Girouard. He is now head of the Chinese Mining Engineering Company. Lt. Leggett, now Sir Humphrey Leggett, Captains F. G. Fuller and Sewell, Lts. North, Cunnington and C. G. Fuller, and Captain H. G. de Lotbinère were also amongst the officers employed on this work.

Lt. Manifold, now Major-General Sir Graham Bowman-Manifold, was responsible for repairing the destroyed railway telegraphs and for working them.

Telegraph Work in South African War.

While Lt.-Col. Girouard was doing this work on the railways, Lt.-Col. R. L. Hippisley was doing analogous work on the telegraph systems of South Africa. He put Capt. Fowler (now Lt.-General Sir John Fowler) in charge in the Free State. He was afterwards Director-General of Signals in France in the Great War.

Captain E. G. Godfrey-Faussett was responsible for the telegraph system of the Transvaal.

Crown Colony Government of South Africa.

Work of R.E.

When peace was concluded in South Africa, Crown Colony Government was established in the Transvaal and Orange Free State, and these countries had to be reconstructed and administered.

In this work the Royal Engineers played a considerable part.

Sir Percy Girouard was appointed Commissioner for Railways, and kept some R.E. Officers working with him. A programme of 1,000 miles of new railway construction was put in hand.

Lt.-Col. Fowke (now Lt.-General Sir G. Fowke), who was afterwards Adjutant-General in France during the Great War, created and administered the Public Works Department of the Transvaal. In this he was assisted by Capt. R. N. Harvey, now Major-General Harvey, who is Engineer-in-Chief in India.

Colonel H. M. Jackson created and administered a Survey Department for the Transvaal and Orange Free State.

Major Leggett worked on the repatriation of the Boers.

Col. W. Peacock was Chief Engineer in South Africa after the war, and constructed large cantonments for the considerable force that was garrisoning South Africa for some years after the war.

R.E. in South Africa To-day.

At the present day we find the Royal Engineers still prominently represented in South Africa by Sir John Chancellor, who is Governor and Commander-in-Chief in Southern Rhodesia, having previously been Governor of Mauritius and of Trinidad.

Col. C. F. Birney is General Manager of the Rhodesian Railway system, stretching up to Katanga, in the north, and to Mashonaland in the east.

Rorke's Drift.

We must not leave South Africa without referring to that very gallant feat of arms at Rorke's Drift, in Zululand, which is always associated with the name of Lt. J. R. M. Chard, R.E., and for which he was awarded the Victoria Cross.

There had been a disaster at Isandhlwana; our force there had been wiped out by the Zulus, who then started to pour down upon Natal. Their route took them through Rorke's Drift, where Chard and Lt. Bromhead, of the South Wales Borderers, had constructed a strong defensive post. The Zulus decided to attack the post, and expected to have no difficulty in mopping it up before they went on to Natal. A terrific fight lasted for over twenty-four hours, with desperate hand to hand fighting. Thousands of Zulus were slain and they were beaten off. Discouraged by their losses, they gave up their proposed incursion into Natal. It was generally recognised that Lt. Chard's skilful and gallant defence at Rorke's Drift saved the Colony of Natal from a frightful disaster.

Captain B. L. Sclater, R.E., in Nyasaland and East Africa.

In Nyasaland, or British Central Africa, we find the work of an R.E. who played a great part in opening up Africa.

Captain Sclater, R.E., made the first road from the coast into and through Nyasaland.

I have not found any particulars of his work in Nyasaland, except that it was road work, but, when he had finished there, he moved on to East Africa to make an unmetalled road for ox transport from Mombasa to Lake Victoria Nyanza.

On that work he was assisted by Lt. G. E. Smith, R.E., better known as "Uganda Smith." He is now Brig.-General Smith, retired, and he sent me a most interesting pamphlet which he published, describing the work which Sclater and he did in the construction of this road.

The first 180 miles of road from the Coast had been made by the Imperial British East Africa Coy., and Sclater's job was to carry it 400 miles further through only partially explored country to Victoria Nyanza.

Five R.E. N.C.O.'s assisted them: Lce.-Corp. Smith, Corp. Ellis, 2nd Corp. Clarke, Lce-Corp. Simmonds, and Lce.-Corp. Brodie.

Exploring and reconnoitring for the road through all kinds of country, plains, hills, ravines, forest, bush, etc., laying out the road, and constructing bridges, were the engineering problems that confronted them, but problems of a different nature also had to be dealt with.

In 1895, British East Africa had few white people in it. Negotiations with native tribes for the supply of labour, the organising of caravans of transport to obtain food, and to supply it to the working parties; the arrangements for payment. These questions all required considerable organising and administrative talents. Captain Sclater possessed unusual powers of influencing natives and gaining their friendship and co-operation.

Several times they had to interrupt their work to march to the assistance of some of the small garrisons that were dotted about the country to keep order.

In those days there was no coinage current in East Africa. Payment was arranged by barter, and currency varied in every district. It might be brass wire, iron wire, American and Bombay sheeting, beads, old uniforms, cartridge cases, knives, looking-glasses, etc., etc.

Lt. Smith writes in his pamphlet :

> " I found it necessary to enquire into the price of food and animals which had been bought in my absence. It was a difficult job. My headman, following their usual custom, used to allude to every item as being worth so many sheep, and each sheep as being worth so many rings of brass wire, but I soon found that, though a sheep might be worth ' x ' rings of brass wire, and an ox worth ' y ' sheep, the ox was not worth ' xy ' rings of brass wire. I had to invent a fabulous animal, which I called an ' exchange sheep,' to get over this difficulty, the ' exchange sheep ' being worth about half what the real animal cost."

It is quite evident that Lt. Smith was not followed into the heart of Africa by a Local Auditor.

Their adventures with wild animals, and the excellent big game shooting, made a pleasant variant to the normal work. There used to be several trophies of Uganda Smith's rifle in the R.E. mess.

The unmetalled road, 400 miles in length, was completed in a little over 18 months for an expenditure of £17,000, which is £42 10s. 0d. per mile, a fabulously cheap performance. I think Smith must have done some skilful work with the currency, and inflated his "exchange sheep " a bit.

The road being finished, the Government then asked Sclater to create, and organise, a Government ox-transport service along the road from the coast to the lake.

Sclater started to do this, but, unfortunately, his energetic work over a period of years in tropical Africa had undermined his health, and he died at Mombasa.

THE UGANDA RAILWAY.

Roads alone will not develop a new country. Railways also are necessary.

In 1891-92, Captain (now Major General Sir) J. R. L. Macdonald, R.E., surveyed for a railway from Mombasa to Uganda.

The party consisted of Macdonald, Captain J. W. Pringle (who is now Sir John Pringle, Chief Inspector of Railways to the Ministry of Transport), Lt. P. G. Twining (afterwards Director of Fortifications and Works), and Lt. H. H. Austin (now Brig. General), all of whom had gained their experience on railway surveys in India, on the Kabul River, and in the Zhob Valley.

They divided into two survey parties, which in nine months marched 4,280 miles, surveyed 2,724 miles, and located a railway route 657 miles in length.

When the railway was subsequently built Macdonald's location was adhered to, except in the last section approaching lake Victoria Nyanza, where an alternative route was followed, but now, after a lapse of thirty years, they find that Macdonald was right, and a line is being built on his original location.

Expeditions in East Africa.

In 1897, Macdonald was given command of an important expedition, which set out from Mombasa to forestall Marchand at Fashoda.

The French had started Marchand from West Africa to get a footing on the Upper Nile, hoping thereby to neutralise the effect of Lord Kitchener's approaching re-conquest of the Sudan. Macdonald's Expedition was a counter to Marchand's.

When, however, he was passing Uganda, he was recalled to that Colony to put down a very serious mutiny of native troops. This duty, perforce, occupied so much time that his expedition to Fashoda had to be abandoned as too late.

Macdonald, Austin, Gwynn, Maud, L. C. Jackson, led numerous survey expeditions, exploring and mapping the country between East Africa and the Sudan and Abyssinia, delimiting the frontiers between the two last named.

One of Austin's expeditions suffered terrible hardships, and he had great difficulty in extricating a small remnant of his followers from the attacks of hostile natives.

Other R.E. in East Africa.

One of the most successful Governors of British East Africa was Sir Percy Girouard, who moved to East Africa after governing Nigeria.

At the present day the Corps is represented in East Africa by Brig.-Gen. G. D. Rhodes, who is Chief Engineer of the Kenya Uganda Railways, engaged upon a programme of new railway construction costing four to five millions.

I have already mentioned that Col. G. A. P. Maxwell is General Manager of Railways in Tanganyika.

Abyssinia.

Abyssinia lies next to East Africa. The only European Force that ever fought its way into the heart of Abyssinia was commanded by an R.E., Field Marshal Lord Napier of Magdala, who captured Magdala in 1868.

R.E. Field-Marshals.

Talking of Field-Marshals reminds me that in my service I have seen four R.E.'s who have attained that rank—Lord Napier, Sir

Lintorn Simmons, Lord Kitchener and Lord Nicholson, so that I think we may say that the Corps has provided its quota of great leaders to the army.

SOMALILAND.

In Somaliland, Col. H. G. C. Swayne, R.E., was the pioneer of big game shooting, and the recognised authority on sport in that country.

There have been several expeditions in Somaliland in which the Corps has played its part, but we must pass on to the Sudan and Egypt.

THE SUDAN AND EGYPT.

GORDON AND KITCHENER.

In these countries, the first R.E. names that will occur to everyone are Gordon and Kitchener.

Their deeds are well known to you all. How Gordon was for many years Governor-General of the Sudan on behalf of the Khedive of Egypt. How, after he had left the Sudan, a revolt against Egyptian rule broke out under the Mahdi. The British Government, who had by then assumed responsibility for Egypt, did not consider that Egypt had at that time the resources in men and money to reconquer the Sudan. They therefore sent out Gordon to evacuate the Egyptian garrisons. How he was besieged at Khartoum, and killed there when the Mahdi captured the place after a prolonged siege, which was maintained entirely by Gordon's personality. Lord Wolseley's expedition had been despatched too late in 1884 to rescue the beleagured garrison.

It was at this time that Major Kitchener first came into public notice. Before Lord Wolseley's expedition had been sanctioned by the Home Government, and while it was still very uncertain whether Gladstone would be persuaded to despatch such an expedition, Major Kitchener went as an Intelligence Officer to Dongola, hundreds of miles beyond any support, to keep an eye on the Emir of that province, and hold him to the Egyptian cause. If the Home Government had not sanctioned Lord Wolseley's expedition there is no doubt that Kitchener would never have returned from Dongola. However, Lord Wolseley, as we all know, was allowed to proceed with the attempt to relieve Gordon at Khartoum. Later on, Kitchener commanded an Egyptian cavalry regiment, an Egyptian infantry brigade, was Governor of the Red Sea Littoral, reorganised the Egyptian Police, and was appointed Sirdar of the Egyptian Army.

SIR GERALD GRAHAM AT SUAKIM.

While Lord Wolseley's Expedition was making its way up the Nile, a Force was sent to Suakim to occupy the Dervishes in that area, and to prevent them moving to oppose Wolseley. The Suakim Force was commanded by an R.E., Lieut. General Sir Gerald

Graham, V.C. At El Teb and Tamai he gave the Dervishes two of the hardest blows they ever received.

OTHER R.E.'S WITH LORD WOLSELEY IN EGYPT AND THE SUDAN.

Many other Royal Engineers distinguished themselves in Egypt and the Sudan at this period. It is only possible to mention a few.

Col. C. M. Watson was on the Intelligence Staff when Lord Wolseley conquered Egypt in 1882, and played a great part in the capture of Cairo by Sir Drury Lowe's cavalry.

Colonel (now General Sir Richard) Harrison, was A.Q.M.G. of L. of C. Staff in the 1882 Egyptian Campaign.

Colonel Sir Charles Wilson was Lord Wolseley's Chief Intelligence Officer when he was trying to relieve Gordon at Khartoum, and took over command of Sir Herbert Stewart's Column when that officer died at Metemmeh from wounds. Sir Charles Wilson proceeded in a steamer right up to Khartoum, and brought back the news of its capture.

General Sir Herbert Chermside was Governor of the Red Sea Littoral.

THE RECONQUEST OF THE SUDAN.

In March, 1896, Sir Herbert Kitchener, as Sirdar of the Egyptian Army, received instructions from the Government to start upon his famous reconquest of the Sudan, which culminated 2½ years later in the battle of Khartoum.

Many Royal Engineers took part in these operations. Captain Gorringe (now Lt. General) was A.Q.M.G. of the Egyptian Army, and responsible for the organisation of supplies and transport on which the success of the Expedition so much depended.

Major Kincaid was on the staff of a division. Major Lawson (now Lt. Gen. Sir H. Lawson) commanded Arab levies.

RAILWAY WORK IN SUDAN CAMPAIGN, 1896-99.

A great feature of the Campaign was the railway work carried out by Lt. Girouard with R.E. officers, assisted by N.C.O's and men of the 8th and 10th Railway Companies, R.E.

Five-hundred-and-eighty-five miles of railway were built in 2¼ years—200 miles from Wady Halfa to Kerma in the Dongola Province, and then 385 miles from Wady Halfa via Berber to Abuhamed.

You will notice how often in this lecture I have had occasion to refer to the work of N.C.O.'s and men of the 8th and 10th Railway Coys., R.E. It really is remarkable how the men of these two small companies have left their mark all over Africa in the construction of important railways, which are serving that continent.

From Wady Halfa to Abuhamed the railway crossed 235 miles of waterless desert. A former Khedive of Egypt had tried to find water by sinking wells in many parts of this desert, but had always failed. It was not anticipated that we should have any better success, but two R.E. subalterns (one of whom is now Major-General Stevenson), after reconnaissance, found a place about ninety miles from Wady Halfa where they thought it worth while to sink a well, and, to everyone's surprise and satisfaction, a splendid unfailing water supply was found which has filled up every locomotive from that day to this.

Other attempts to find water were made elsewhere along this desert railway route to Abuhamed, but so far without success. The finding of this water facilitated the building of the railway across 235 miles of desert, although the problem of watering construction parties and locomotives still remained a formidable one.

The Corps lost two very promising subalterns in the construction of these desert railways—Lieuts. R. Polwhele and E. H. S. Cator.

Telegraph Work in Sudan Campaign.

Lt. Manifold (now Major-General Sir G. Bowman-Manifold) was responsible for the telegraph work throughout the campaign.

Administration and Development of the Sudan.

I cannot attempt to tell the story of the reconquest of the Sudan, or of all the fighting in Egypt and the Sudan from the time Lord Wolseley landed there up to the present day.

The British Government became responsible for the administration and development of these countries, and the R.E. took up a big share of the work.

Lord Kitchener was, of course, the first Governor-General of the reconquered Sudan.

Col. Gorringe was Governor of the Blue Nile Province. I have already referred to R.E. work on survey of the Sudan and Egypt.

Captain J. S. Liddell was head of the Sudan Telegraph Dept. When he took over the telegraphs of Egypt he handed over the Sudan telegraphs to Lt. E. V. Turner, who is now Colonel on the General Staff for Signals at the War Office. Turner was succeeded by J. P. Moir, who is now Chief Engineer Anti-Aircraft Defences of England.

Captain M. R. Kennedy became Director of Public Works in the Sudan. This officer first came into notice by designing a scaffold which would hang six brigands simultaneously in Crete, at the time when an International Force was operating there under the command of Major General Sir Herbert Chermside.

The designing of such a scaffold seems hardly sufficient qualification for appointment as Director of Public Works in the Sudan, but he selection was justified, as Kennedy carried out some very important works and buildings in that country.

Port Sudan.

Probably his most important work was the construction of a fine new harbour at Port Sudan on the Red Sea. As its name implies, it is *the* port of the Sudan. His Resident Engineer for this great work was Lt. Kelly, R.E., who was unfortunately killed in France in the Great War. Some idea of the size and nature of this harbour work can be given by the following few particulars:

There are five berths, each 410 feet long, which vessels run alongside.

One berth is equipped with four large electric coal transporters, delivering either direct into truck, or to a coal-distributing bridge in rear.

For general cargo, four 3-ton, and 7 ton, electric jib cranes are fitted, which can be used for cargo on any of the five berths.

A floating crane deals with loads up to 60 tons.

On the quays are four Customs' sheds.

In 1924, 699 vessels entered the port, whose total tonnage was 2½ millions, and they landed and shipped 481,000 tons of cargo.

The largest vessel that has entered the harbour had a tonnage of 27,000.

The Sudan and Egyptian Railways.

Major Girouard handed over the Sudan railways to Major Macaulay (now Sir George Macaulay) when he proceeded to take up the very important post of President of the Egyptian Railway and Harbour Board. When he left that appointment to proceed to the other parts of Africa in which we have traced his activities, Major Macaulay succeeded him in Egypt, after handing over the Sudan Railways to Captain E. C. Midwinter, R.E., under whom the system was greatly extended and improved. In this he was assisted by several R.E. Officers, among whom I would mention Newcombe, Sowerby, a very able R.E. Officer who died in Palestine during the Great War, and Russell, who recently handed over command of the Training Battalion at Chatham, in order to take up the appointment of Military Attaché in Chile.

Midwinter is now Controller of Sudan Railways in the London Office of the Sudan Government.

Blakeney, now Brigadier-General, and Clifford Hall, now Colonel, moved from the Sudan to work in the management and traffic departments respectively of the Egyptian Railways. Blakeney in due course became General Manager, and Hall, Traffic Manager. The latter is now a Director of the Anglo Egyptian Bank.

Military Works of Egyptian Army.

The military works of the Egyptian Army were in the hands of the Royal Engineers, first under Col. L. B. Friend, who was afterwards

Director of Fortifications and Works at the War Office. Major P. G. Grant, now G.O.C., Chatham, and Inspector of R.E., was also head of the Military Works of the Egyptian Army.

CONCLUSION.

We have now travelled over most of Africa.

I have omitted many names of R.E., and much useful work done by them in Africa. Notably I have omitted their good work in the Great War in Africa, because it is impossible to give an exhaustive account within the limits of this lecture.

To recapitulate, I have shown you how Royal Engineers have played a prominent part in every campaign, and in every expedition in Africa.

How they have played a great part in opening up and developing that great continent by surveying it, by constructing harbours, railways, roads, telegraphs, buildings, water supplies, and numerous other works, and last, but not least, by administering and governing some of its territories.

The Great War showed what excellent training for Engineers in war this work in Africa had given to the men who did it.

But the work they have done has only served to open up this vast continent, and to start its development. The African Continent awaits the Royal Engineer of the new generation to carry that development several stages further.

That brings me back to the point with which I started this lecture, which was to show you the great *variety* of the opportunities, and of the work, which come to the Royal Engineers, and I have been dealing only with Africa, which is only a portion of the British Empire.

By all means get into the Staff College if you can, but you can't all get into the Staff College, even under the latest Army Orders. Only 17 out of the 111 officers I have named in this lecture passed through the Staff College.

But, whether you go to the Staff College, or whether you don't, we may reasonably expect that the work which lies before you in the great British Empire will offer you as great a variety, and as many opportunities, as your predecessors enjoyed, and that you will thus be able to train yourselves by interesting and constructive work in the British Empire for your duties as Royal Engineers in War.

CO-OPERATION BETWEEN R.E. AND R.A.F. IN AND BEYOND INDIA.

By MAJOR A. V. GOMPERTZ, M.C., R.E.

SCOPE.

This article is offered as a corollary, not a disputant, to Brevet-Major Dewing's article in the June, 1926, issue. With the exception of the two premises given below, and of one point of detail, the former article may be applied equally to India. The scope of these notes is intended to cover the work which any R.E. officer must be prepared to take charge of in peace and war, in India, and in a war conducted from India, particularly beyond the North-West Frontier. Where detail is descended to, it is local detail only.

TWO PREMISES.

The first and most important of these is the diametric difference which obtains between the R.A.F. works and building services, at home and in India respectively. At home, as Major Dewing points out, this service is a civilian one, possibly enlistable on the outbreak of war. In India, all works for the R.A.F. beyond the province of their own technical sections for aeroplanes and motor transport, are executed through the single agency of the R.E., in the Military Engineering Service. This covers anything, literally, from patch repairs to a landing ground, up to the construction of an entire new R.A.F. Cantonment such as we have at Drigh Road.

Whether or not the home R.A.F. works organization is enlisted on the outbreak of war, it is, and foreseeably will long remain, out of the question to consider a similar system for India. There exists in peace time no civil R.A.F. works staff ; 1914-8 taught us fully the dangers of avoidable improvisation in all quarters ; and there is, moreover, in India no such civil reserve of competent engineers as is to be found in European countries. In a large or a long war based upon India the R.E. cadre would certainly be expanded by civil engineers with temporary commissions ; but it may be taken as virtually certain that the R.A.F. works service will remain in war, as it is in peace, the business of the parent Corps in the first place.

In the writer's opinion the arrangement is a very fortunate one, at any rate for the Corps. One of its direct effects is that, in peace time, an appreciable number of R.E. officers of all ranks are in a position to obtain a close insight into the working and requirements of the Royal Air Force, to a degree which would be very difficult to obtain in Great Britain ; and they are thus able to store up personal experience which should prove of great value to both arms in war.

The second premise, in respect of conditions in and beyond India, is the greater quantity of R.A.F. work which must fall to the R.E. compared with that which they would be likely to encounter in an European war. The writer begs to support most strongly Major Dewing's statement that "It is all very well to call the preparation of aerodromes the 'duty' of the R.A.F.; it certainly sounds like being the work of the Army." In India there is practically no other side to the question at all. In India, as at home, the personnel of the Royal Air Force has at its disposal very few men-hours indeed in proportion to those required for purely flying duties and those duties directly ancillary to them. In war this situation is likely to become much more marked still: neither in peace nor war can the taxpayer afford to maintain trained British airmen to do work which can be performed effectively and far more cheaply by local labour. Even landing grounds, which are very minor things when compared to aerodromes, need annually in India a good deal more work upon them than could ever be found by the R.A.F. personnel without disproportionate detriment to the flying service, and some of them in constant use are located hundreds of miles from the nearest R.A.F. unit. Standing regulations for landing grounds do, indeed, lay down that the R.A.F. shall only call upon the R.E. for such work as they are unable to perform themselves; but in practice, climate, wind, weather and soil, to say nothing of finance, ensure that the bulk of the work falls on the Corps.

The Sapper east of Suez must thus be prepared, whether he is with a Divisional unit or on the Works Directorate, to do any or all classes of work for the R.A.F.

Bearing this in mind, it is fortunate that a large proportion of the Works and the Field cadre of the Corps in India is located broadly where the entire local complement of the R.A.F. works, i.e., on and north-west of a line joining Karachi and Delhi. In consequence, the prospects open to the R.E. officer of getting experience of R.A.F. works at some time or other during his Indian service are quite good.

It may be of use to look briefly into the main classes of work which would probably fall to the R.E. on behalf of the Air arm in a campaign within the theatres visualized, confining the list to items in which the limits of the Indian etablishment of the R.A.F. would render it necessary for practically the whole of the work to be done by the Corps, with only a close and continual liaison with the R.A.F. to see that their requirements were accurately met.

Taking existing circumstances as they are, in the shape of squadrons, stations and the like: probably the first need in the tactical series would be for more landing grounds, both advanced ones for co-operation with the headquarters of Military formations, and emergency grounds for the safe landing of damaged machines and the execution of light repairs. As work upon landing grounds in India has special characteristics, which are in detail rather the province of the Sapper than of the Airman, a separate note on these is inserted later.

With the landing grounds, there comes at once the question of approaches to them from the existing ground communications, by road, or rail, or both, according to availability. A landing ground with no good communication to it by ground is less good than the proverbial sick headache. The road approach, moreover, should not only be good enough to stand ordinary medium loads, such as might be necessary in ordinary circumstances, but it should stand up at need to the heaviest R.A.F. vehicles, if time, labour and material permit. R.A.F. engines do not grow on trees, and the accident of a machine, with a write-off undercarriage and an undamaged engine, could make the easy access of a crane-lorry a very valuable asset when the engine supply base is hundreds of miles away.

Again, at the outset of operations, local bomb-proof, or, at the least, splinter-proof, protection for considerable stores of aerial bombs and fireworks could easily become a requirement of first importance at places far in advance of the usual arsenals and bomb-stores. So long as they are far enough back to be tactically safe—and in this both ground and air tactics are determining factors—the further forward that fighters, co-operation machines and bombers can leave the ground, the better.

So much for actual tactical considerations. Thereafter there come the questions of works which are second nature to the Sapper on the Indian establishment, to wit, hutting and/or housing, water supply, conservancy, workshops, electric light and power required in any excess over what the small R.A.F. portable plants can supply, assistance in the erection of hangars or their entire erection if they are big semi-permanent or permanent affairs, and so on. None of these items need any special note to the Sapper, save that of water supply, in view of the particular local conditions. On and beyond the frontier, water is an eternal question; and although it is so greatly important that both the strategical and tactical conduct of campaigns have to fall in closely with it, there are times when the Sapper will have to make special efforts to enable the field for strategy and tactics to be enlarged, just as was done upon the dry upland reaches north of the Somme in 1916, and in the arid country east of Port Said. As a general rule, the broad process will be the development of existing resources to the utmost, the use of a good deal of power plant of many designs is fairly certain to arise; but at times the active co-operation of civilian expert geologists and tube-well specialists may be a matter of high import. The Sapper likely to be employed upon works in the field on or beyond the frontier, for the Army and R.A.F. alike, can do no better than keep his water-supply knowledge thorough and up-to-date.

After this brief survey of possible works for the R.A.F., there remains to insert only a brief note on liaison. In practice, this can hardly be too close. There is never any question of the Sappers being under the R.A.F. for their technical work, although with big R.A.F. headquarters in the field there may be R.E. officers permanently attached, just as they are in certain positions in India in peace-time. It may be remarked that liaison does not lie only in office visits at stated hours; one of its strongest factors for efficiency is close personal acquaintance. In peace, in our own district, the R.A.F. were good enough to allow junior R.E. officers in direct charge of R.A.F. work to live in the R.A.F. Mess, if there was one in the station; the practice proved a great help, and should be equally good in war for all ranks employed on R.A.F. work alone.

LANDING GROUNDS.

Some special notes need to be made about landing grounds, since not only is this class of work one of the items whereat Sappers and Pilots come closest into co-operation, but out-station grounds are apt in practice to be almost entirely in R.E. charge, subject only to inspection by pilots.

Here it is necessary to differ in one detail from Major Dewing, who states that such grounds must be as broad as they are long and need only be 400 yards square for occasional use. The size varies with the main classes of machines likely to use them. The R.A.F. will always supply details; but in India a 400-yard square would not ordinarily be considered large enough for anything but a Bristol Fighter. For D.H.9-A's, the other normal type in India, it is best to allow not less than a 500-yard run. There are, of course, pilots who will put a machine down almost on the legendary "tennis court;" but the man to be legislated for is the ordinary pilot in trying weather, and it needs to be remembered that a machine can be put down without trouble on bits of ground where it may be very difficult to get it off again. The square shape is not vital, though of course desirable. The essential is to give a run of sufficient length in the direction of the prevailing wind or winds, of a breadth of 200 yards and upwards. In the writer's own district, landing grounds were of many shapes, from a 500 x 500 "L" shape of 300 yards width to the Aerodrome landing grounds of 1000 yards square. The R.A.F. fix what they will accept, and thereafter accurate ferrotype maps, continually up-to-date, should be distributed to those concerned, even in the case of temporary manœuvres landing grounds.

It has already been pointed out that in India a considerable charge of landing grounds often falls to the R.E.: the subject, therefore, needs careful study. Bad work at any time may cost a valuable machine, to say nothing of two very valuable lives, perhaps, as well. This is where the Sapper comes in. The Pilot knows what he wants; but it is not within his work to know exactly how to obtain and maintain it on all the different classes of ground in India. That is the Engineer's job, and it is thus of the first importance for the Sapper to know where a machine can land and where it cannot, and how to set matters right.

The easy grass of Britain is, in India, rather the exception than the rule; there are grounds of sand, of earth, of "put" (best defined as sun-baked mud), of powdery shale, and of any or all of these mixed with rock. Nor is there any golden rule for all their maintenance year in and year out. Quoting at random, the "put" ground at Sibi is a death-trap of deep heavy mud after a lot of rain: when dried out, its surface is a shiny billiard-board for the wheels, whilst it still breaks up comfortably well under the tail-skid so as to stop the machine quickly. From year's end to year's end it needs virtually no care, save for its barring from use during and after rain, and for the filling in of rat-burrows, which make wheel-traps as the rain washes them bigger. At Reti, one "hop" from Sibi for a 2-tanker Bristol, is a sand ground which can behave very well in ordinary weather, although a couple of hours of sandstorm can raise mounds costing at least an undercarriage. At Quetta is a big ground of sandy earth on a very slight slope; in 1924 a single hot-weather downpour tore nullas in it big enough to wreck the largest machine in the world.

It may be judged, then, that for the care or selection of landing grounds alone, quite apart from the much wider questions of reconnaissance and intelligence dealt with by Major Dewing, it is very desirable that the Sapper in charge of R.A.F. works should know the Pilot's point of view. This he can only get by being thoroughly at home in the back seat of a Service machine.

If he is to do his work with 100% efficiency, he must be fully at home in the air; he must know when a bad landing (seen or felt) is or is not the fault of the ground; he must know gliding angles by heart, and he must be able to pass fairly accurately any landing ground for any normal type of machine. The R.A.F. officer is naturally the final and only judge in these matters; but, as already indicated, he has neither time nor opportunity to find out exactly what in India is necessary to make a landing ground out of a particular wilderness. That is the Sapper's job; and the more he knows of the Pilot's outlook, the better will his work be for the side. To attain this, he must—"must" is the word—fly.

Suggested Training.

The following remarks constitute suggestions as to how the R.E. officer can set about proper liaison; they apply equally to a knowledge of landing grounds as to the wider duties of reconnaissance, etc.

Opportunity in India is distinctly good for those officers who are in direct charge of R.A.F. work. There are, of course, the classes in Army Co-operation held by the A.C. Squadrons each training season, but the vacancies are few, and those falling to the Corps, of course, much fewer still. Nevertheless the Sapper on R.A.F. work can make a good deal of his own running without them.

Not only is he in continually close contact with the R.A.F. over his work, but the Army Co-operation Squadrons are frequently able to give lifts to Army passengers; and with other squadrons and Depots the necessary authorization to fly is easily forthcoming, so long as flying is restricted to duty trips in actual connection with work. The Royal Air Force is helpfulness itself, so long as there is a back seat vacant or a machine and Pilot free, and the job is one of genuine work.

It may, perhaps, be of use to describe the system laid down by the writer, as C.R.E. of two successive Districts, for the development of proper liaison. The object was, in the presence of the opportunities already mentioned, and in the natural absence of any cut-and-dried regulations governing a fluctuating case, to get the best out of those opportunities by systematic means, instead of leaving their exploitation to individual choice and chance. The affair being thus unofficial, no more than verbal and informal advice and approval was asked for from R.A.F. officers; but it can certainly be claimed that the system produced good results.

To begin with, every R.E. officer in actual charge of R.A.F. work had to fly. It was no difficulty to get them to do so: the difficulty lay in dealing patiently with their day and night requests for chances to fly more and more. Needless to say, such flying as was done was subject entirely to the orders and convenience of the R.A.F., who were at the same time more than kind in meeting requests. Next, officers were permitted an absolute maximum of six hours' air time in which to get "air sense" before being sent up on jobs of work. During that time, which spread naturally over some weeks or more, they had to pick up the more ordinary gambits and gadgets of the backseater's existence, such as:—

(i). Feeling absolutely at home in the air.
(ii.) Familiarity with air harness, and with working in it.
(iii). Helping to start up an engine—a vital necessity when halting at out-station landing grounds in India where there is often no one but a Pathan *chowkidar*.
(iv.) Filling up, use of the chocks, turning a plane round by hand, guiding a taxi-er by a wing tip, etc.
(v). Dropping message bags occasionally, and firing Very lights as wind indicators for the pilot.

(vi). Reading and recording any of many dials for the Pilot if desired by him, and, of course, understanding them.

(vii). Simple cross-country navigation; this was second nature to the Sapper, of course.

(viii). No stunting, but keeping one's target in sight, as well as direction-sense in the more ordinary moves, such as steep sideslip descents and stalling turns.

(ix). Practising observation all the time.

They had, furthermore, to note take-offs and landings very carefully, and to watch other machines getting off and on, so as to study the behaviour of the ground.

It will be seen that the aim was not only to produce officers with air sense and with an insight into the pilot's point of view, but also to give the pilots reason to feel that they had behind them not merely so much deadweight, but a man who could do something towards earning his passage at halts and in ordinary slight trouble.

At the end of six air-hours, it was reckoned that R.E. officers should be quite fitted to take their places in back seats for all the ordinary work likely to come their way, to the natural exclusion of purely R.A.F. duties such as photography, wireless, and expert aerial gunnery. Thereafter they were not sent up save on definite duty, by the C.R.E's orders or the R.A.F's request, for specific tasks, such as:—

(*a*). Periodical inspection of outstation landing grounds This was the commonest trip. Apart from the advantage of inspection by landing, a comparatively short ferry trip would save the Sapper one or even more whole working days in view of the slow and restricted train services of India. A longish trip, with intermediate stops, would save anything from days to weeks.

(*b*). R.E. Reconnaissances, with or without amateur photography. (A V.P.Kodak will give surprising air photos.) A lot of useful work was done in this way, in tackling big storm-drainage and river-training problems, as a supplement to ground work.

(*c*). Special trips. These might include the selection (with or without landing) of new landing grounds, such as are temporarily required for manœuvres, the inspection by night of obstruction lights provided by the R.E., and occasionally quick ferry trips by the kindness of the R.A.F., for urgently arising and distant military duty; and odd special jobs generally.

It may be added that when an R.E. officer had, as far as his own share went, passed any landing ground as fit for use, efforts were made to arrange that he should, if possible, be in the back seat of the first machine to use it. There was anything but reluctance to this.

So much for the system; it is claimed that it worked well. Its direct result was that Sappers got gradually to see all their work much more from both sides' point of view. "The basis of co-operation is an intelligent understanding of the other man's job," and the very close liaison which grew from making officers not only fly but learn to help work their passage, was of the greatest benefit to them in their own work and training, and so, one hopes, to the Royal Air Force as well.

It is this form of co-operation which the writer desires to put forward strongly. At home, of course, conditions are different; but in India, where the Sapper replaces entirely, even in peace, the Works and Buildings staff of the R.A.F., he has unrivalled opportunities of seeing the working of the Force at close quarters. It is thus urged that he should take them and use them to the utmost that his own work and the R.A.F's convenience permit.

For the efficient commanders and staffs of to-morrow, air sense will be not less than an essential; for the Sapper on R.A.F. work it can fairly be called so already, for the Sapper on his own work the future holds much of necessary R.E. aerial reconnaissance. The time to begin working towards air sense and a long start in facility for co-operation is now.

ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1926.

BY CAPTAIN G. F. HEANEY, R.E.

SUBJECT SELECTED :—" SURVEY ON ACTIVE SERVICE."

The Essay is to take the form of a Report and recommendations on the following points which arise in connection with the particular case outlined in paragraph 2 :—

(*a*) As Director of Surveys, appreciate the situation from the survey point of view and state the policy and programme that you would adopt. Is it likely that more than one scale will be necessary ? What projection would you employ and what steps would be taken to begin survey operations ?

(*b*) Do you consider the resources of the Field Survey Company adequate in personnel to undertake the programme you have outlined ? If not, what additional personnel do you consider necessary ? What reply would you make to the offer of the Colonial Survey given in paragraph 7 ? The issue of maps and photographs is to be done by you down to Brigades and Divisional Troops. What arrangements would you make ?

2. The force consists of 2 Divisions and 1 Cavalry Brigade with the normal proportion of non-divisional and L. of C. Units. These include 1 Field Survey Company *plus* Photographic Section and 1 Map Depot. All are at small war establishment. A third Division with additional non-divisional troops is to be sent out later if required.

3. The Base will be a small seaport town of about 10,000 inhabitants in a somewhat backward country. The objective will be 100 miles inland. Landing and advance will be opposed. The attitude of the civil population is uncertain. Operations are not expected to last more than six months, but are expected to include one decisive battle. The enemy is in possession of 3 Batteries of Modern Field Artillery and is plentifully supplied with modern machine guns and rifles.

4. Local topography may be divided broadly into the following zones :—

(i) The coastal part, average width about 20 miles, is heavily timbered (virgin forest) and includes large areas of mangrove swamp. Visibility poor.

(ii) The second zone, 5 miles in width, is composed of small foothills rising to the terrace edge of zone 3. The conditions are those of open English park land. Visibility fair.

(iii) Zone 3. Starting at a height of 3,000 feet the country rises progressively to 5,000 feet at the objective. There is little or no timber and the visibility is known to be good.

5. There is no railway and there would be considerable difficulty in constructing one across Zones 1 and 2. Roads are not numerous and

are all unmetalled, except the main highway to the objective. Country transport includes both carts and pack transport.

6. The Base selected and its immediate environments are fairly well mapped at the scale of 2-inches to the mile. A very bad ¼-inch map, almost blank for Zone 3, contains the only detailed topographical information.

7. The Survey Department of a neighbouring Colony has offered the services of a small volunteer geographical unit raised from its staff. The offer has been provisionally accepted and further details as to what is required have been promised.

Notes on Stores and Equipment.—1. The topographical section, armed with revolvers and issued with pantaloons, may be mounted if necessary.

2. The stores and equipment for trigonometrical and topographical surveying may be taken as adequate (for the numbers) for any method given in the *Text Book of Topographical Surveying.*

3. The printing machinery includes 1 double-demy flatbed machine (500 copies per hour in one colour) and two proving presses. The camera takes double demy negatives and both helios and vandykes can be made.

THE first duty of a Director of Surveys on being appointed to a force operating in a little known country is to obtain all possible information about the country from every source.

The information given in setting the problem is very scanty, so in Section i this is supplemented by information, which it is only reasonable to suppose would be in the possession of the Director of Surveys before the beginning of the campaign.

This essay is divided into three sections, as follows :—

Section i. A brief description of the country and of events leading up to the war, and an appreciation of the survey problems involved.

Section ii. Personnel, organisation and programme of work.

Section iii. Map production and distribution.

SECTION I.

Topoland is a small independent state, roughly rectangular in shape, covering an area of about two degrees of latitude by four degrees of longitude. On the west it is bounded by the sea and on the south and east by the large British possession, Kohara ; while to the north lie the possessions of another European power. The boundary between Topoland and Kohara runs approximately along the crest of a ridge of mountains, and transport difficulties render an invasion from this direction impracticable.

The capital town is in the middle of the state, and is connected with the only port on the coast by a metalled road, which, after crossing the forest-clad coastal zone, winds its way over the edge of the interior tableland, and then follows the course of an open valley towards the capital.

As far as is known, water and supplies are fairly plentiful, and, should the inhabitants prove friendly, small survey detachments should have no difficulty in living on the country.

A short time previously the king of Topoland was driven into exile, and sought British aid. The anti-British policy of his successor at length compelled us to take action, and it is with the object of restoring the former ruler to his throne that the present expedition is being undertaken. It is anticipated that, once the capital has been occupied, this object will be accomplished without any difficulty, and that a prolonged occupation of the country will be unnecessary.

The Kohara Survey Department has only recently been formed, and a system of triangulation has not yet been extended to the northern frontier. It is hoped that after the conclusion of peace it will be possible to connect up any triangulation carried out in Topoland during the course of the campaign, with that of Kohara on the south and east.

The War Office have already arranged for a sufficient supply of the 2″ map of the seaport to be issued to all troops likely to require it; the ¼″ map of the country contains so little information that it is not considered worth while to make a general issue of it, but a limited number of copies has been issued down to battalion headquarters, for use till more detailed maps are available.

Appreciation. In the event of the landing being strongly resisted, it may be some days before units destined for field headquarters or the Base can land, so arrangements will have to be made on board ship for any air survey work likely to be necessary during this period.

The only practicable route for advance through the coastal forest zone is along the main road, and the G.O.C. will probably content himself, at the outset, with occupying a corridor through it sufficiently wide to insure his lines of communication against molestation from a flank. The area to be mapped immediately will, therefore, probably not extend for more than 15 miles on either side of the road.

The duties of a Director of Surveys with an advancing army in an unmapped country are :—

1. To ensure that the army shall be adequately supplied with maps, however rough, of the area of operations, no matter how rapid the advance may be.
2. To undertake the systematic survey of as much of the invaded country as circumstances will permit, and to prepare and publish maps of this area.

To give effect to this policy the survey organisation under his control must be divided broadly into two sections, one of which will work in as close touch as possible with the General Staff and the Royal Artillery, and will meet all urgent calls for maps and trigonometrical data, as they may arise; and the other of which will undertake the systematic survey of the country behind the lines, making use of and supplementing the work of the forward section. This rear section will, as far as possible, carry out work according to a fixed programme, which will be independent of unimportant variations in the military situation.

The general requirements in maps in a campaign of this description are likely to be :—

(*a*) 1″ maps for ordinary tactical purposes.

(*b*) 3″ maps for a deliberate attack on a prepared position. Should a period of trench warfare set in, then 6″, or even larger, scale maps of particular areas may be required. Air photos will be largely used in compiling maps of this class.

(*c*) Maps on a scale of 1/250,000 for administrative purposes, situation maps, etc.

(*d*) Large scale maps of limited areas at the Base or on the lines of communication for laying out camps, etc. As it is not anticipated that the campaign will last for more than six months, there is likely to be only a very small demand for these.

The problem that now arises is, whether we can use methods of air survey to map the country behind the enemy's lines, and if so, what ground survey will be required to provide control for it, and afterwards to supplement and check it.

Air surveys of this kind, combined with a system of rapid map production, would clearly be of the greatest value, as it is obviously desirable that the army should be provided with maps of the country over which it is going to operate.

Behind our own lines, in open hilly country such as that of zones (ii) and (iii), air survey on a 1″ scale in its present state of development cannot compete either in accuracy or rapidity with plane-table survey.

In the coastal zone, however, the conditions are very different. To survey this area by any ground method would be extremely slow and difficult ; to carry a system of triangulation across it, without special towers from which to observe, would be practically impossible, and air survey seems to provide the only solution of the problem of mapping it with any rapidity. The country closely resembles that of the Irrawaddi delta recently surveyed so successfully in this way. There, control points were fixed by running systems of triangulation or traverse lines along the coast and up the main creeks ; but here, if the coastal forest zone is to be mapped before its occupation, some other method of control must be used. Two alternatives present themselves. The first is the method used in Palestine during the late war ; control strips of photographs forming triangles were taken from a constant height all over the area to be surveyed : these strips were considered to be all of the same scale, which was ascertained, and were rotated in azimuth till the common points at their ends coincided. The remainder of the area was then photographed with overlapping parallel strips of photographs which were adjusted to fit these control strips. The second alternative is to use the existing ¼" map to provide control. This map gives a certain amount of detail in the coastal zone, which will probably provide enough points identifiable on the photographs, to enable a controlled mosaic to be constructed. Later, after the occupation of the area, should a more accurate map be required, additional points could easily be provided by ground survey and the mosaic readjusted accordingly. This alternative seems to promise to be more satisfactory than the former one and will therefore be tried. With this end in view, the air force will be asked to take control strips at right angles to the main direction of the photography, at intervals of about 7½ miles and along the line of prominent features, such as the main road or large creeks. Later, if necessary, traverse lines will be run along these features, and additional fixed points marked on the photographs of the control strips, thus enabling the work to be re adjusted.

In giving instructions to the air force the following points should be noted :

Scale of photography to be not less than 1/20,000 (or there may be difficulty in interpreting detail).

A lens of short focal length may be used.

A 30% overlap between photographs is required in each direction.

The greatest care is to be taken to maintain a constant height during the entire photography.

On receipt of the photographs a rectified mosaic will be constructed by the method described by Prof. Melville Jones in his book, "Air Survey by Rapid Methods," and detail will be transferred from it by pentagraph to a map on the required scale.

Using the figures given in this book, the area of about 600 square miles should be photographed in about eighteen hours flying. This photography should be completed, if possible, before the landing takes place, to enable a map to be issued at the earliest opportunity.

The problem of air surveying the country behind the enemy's lines in zones (ii) and (iii), will not be so simple, as there will be distortion to contend with in most photographs, due to differences in the height of the ground, and the scale in any strip will vary for the same reason. It is not, however, impossible of solution. In 1922, very similar country on the North West Frontier of India, inaccessible to ground surveyors, was mapped on a 1" scale from air photographs ; later, when the area had been occupied, the work was checked on the ground, and was found to be quite accurate enough for ordinary military requirements, though useless as an artillery map, owing to the impossibility of contouring it accurately.

Prominent points had been fixed throughout the area, from a distance, and were identified and marked on the photographs, which were pasted together in strips. The essence of the method of compilation was then to draw in lines of latitude and longitude at one-minute intervals, by interpolating between these fixed points. The quadrilaterals so formed, which varied slightly in shape and size, were then reduced by pentagraph to the correct scale and transferred to the map, being adjusted during this latter process to fit correctly. Contours were put in approximately by examining overlapping pairs of photographs through a stereoscope and interpolating between known heights. This method is clearly not an exact one, and requires considerable skill on the part of the compiler, but has been found to give satisfactory results in practice.

The United States War Department, in their manual of *Training Regulations for Aerial Photographic Mapping*, describe a method of building up a system of control from overlapping photographs, which they call the "Radial Line Method," which will, they claim, enable them to map hilly country accurately as far as fifty miles in advance of ground control. Although possessing theoretical faults, this method, combined with that first mentioned, should be of considerable value in the present instance.

To fix the positions of points behind the enemy's lines should not present any particular difficulties, as the country slopes up towards the objective and the more prominent hills will be visible from a considerable distance.

The methods of plotting from individual photographs used in France during the late war will not, as a rule, be possible, as there is no accurate existing map from which to obtain fixed points.

Although no Director of Surveys would be justified in neglecting the possibilities of air survey, yet as its success is so largely dependent on the weather and the skill of the pilots available, and is, therefore, not assured, he will have at the same time to make arrangements for carrying forward plane-table surveys wherever possible, should air survey prove a failure.

Even should it be successful, it will not be possible to dispense entirely with plane-table surveys, as the air survey maps will require contouring, and detail will have to be checked and amplified on the ground.

During the advance through zones (*ii*) and (iii) the following will be the main duties of the advanced part of the survey organization :

1. To carry forward a system of triangulation, and to fix the position of sufficient points ahead and on either flank for plane-table surveyors to work from, for the compilation of air survey maps, and to enable the artillery survey section to fix the position of bearing pickets.
2. To compute the spherical and rectangular co-ordinates

of these points. The spherical co-ordinates will be issued to surveyors and the rectangular co-ordinates to the General Staff, who pass them on to the artillery and any other units requiring them.

3. To compile maps from air photographs.
4. To carry forward plane-table surveys. Should an air survey of the area have already been completed, the plane-tabler will work on a blue print of this, checking and amplifying detail where necessary, and inserting contours.

To enable the triangulation system to keep pace with the rate of advance, should the latter be rapid, two observers will be employed, one working on each flank. Each will be allotted one mounted trigonometrical surveyor, who will go ahead and erect marks at the stations which will be subsequently occupied. The closest liaison will be necessary between the two observers, and each day, before commencing observations, they will visit some prominent point together and decide the positions of their next stations, and which points they will intersect. On return to camp each evening all work will, as far as possible, be computed up to date.

The four topographical surveyors of the Field Survey Company will be sufficient to carry out all plane-table surveys likely to be required in the forward area, along the main line of advance, but will clearly be unable to survey the whole country up to the line of the objective, during the six months the campaign is expected to last.

To enable as much as possible to be surveyed in the time available, the services of the small geographical unit offered by the Kohara Survey Department will be required. This unit should have trigonometrical surveyors, computers, plane-table surveyors, draughtsmen, etc., in the correct proportions to render it self-contained and allow it to be independent of military assistance.

Should the General Staff decide that maps of the remainder of the coastal zone, in addition to that portion to be mapped at the outset of the campaign, are necessary, this remaining portion will also be air surveyed and the work of compilation will be entrusted to the colonial geographical unit. It is therefore desirable that some of the members of this unit should have had previous experience of work of this kind.

Projection.—The properties desirable in a projection for military maps are:

1. That sheets should fit together at the edges so as to form a continuous map.
2. That it should be suitable for the superimposition of a rectangular grid, and that the computations for the conversion of spherical to rectangular terms should be simple.
3. That it should be such that one system of rectangular co-

ordinates should cover the whole area of operations without the errors towards the extremities exceeding 1/1500, or that considered allowable for military requirements.

The other features affecting the choice of a projection are:

(*a*) The area and greatest length of the proposed survey, and the direction of the length.

(*b*) Whether there is any possibility of the extension of the survey, and in which direction this extension is likely to be.

(*c*) The existence or otherwise of an adjoining survey with which it is desirable to conform.

We will now consider how these factors affect the problem we are considering.

The greatest length of Topoland lies in an east and west direction, and there is the possibility of an extension of the survey to the west and south at some future date, to join up with those of Kohara. The Conical Orthomorphic Projection on two standard parallels fills requirements 1 and 2 above. On this projection a grid may be superimposed and extended for an indefinite distance east and west without the introduction of serious errors, over a belt of about six degrees of latitude. If we so arrange the projection that the southern border of Topoland is about midway between the two selected standard parallels, the belt of six degrees will include the whole of Topoland and as much of Kohara as is ever likely to be required on the same grid system. This projection, therefore, admirably fills all our requirements and will be adopted.

SECTION II.

PERSONNEL, ORGANISATION AND PROGRAMME OF WORK.

The Field Survey Company will be divided into two groups as under:

The Reproduction Half Company, situated at the Base.

The Forward Half Company, situated at the discretion of the Director of Surveys, in the most convenient place for keeping in touch with the General Staff and with the forward work, generally at Field Headquarters.

The Reproduction Half Company will consist of:—

1 Subaltern from Coy. H.Q.
1 Clerk do.
Photographic Section
Power Section
Litho Section } Less personnel and transport
Drawing Section } attached to the Forward Half Company.

The Forward Half Company will consist of:—

Company Headquarters (less 1 subaltern and 1 clerk at the base).

Topographical Section

1 Helio Worker 1 Machine Minder 1 Prover 2 Lithographic draughtsmen	Attached from the Litho Section.

2 Draughtsmen (attached from the drawing section).

Equipment and transport

1 Proving press

Vandyke Equipment

1 Petrol-electric lorry (from Litho Section).

1 Three-ton lorry (from M.T. Company).

Forward survey work will be organised as follows :—

2 *Triangulation Squads*, each consisting of,

1 Subaltern

1 Trigonometrical Surveyor (to go ahead and erect signals)

Men for carrying instruments and erecting beacons.

Air Survey Squad. (In abeyance unless air photographs are available.)

1 Subaltern (from triangulation squad.)

2 Draughtsmen.

The senior subaltern will be in charge of air survey work, and when required for this his place as an observer will be taken by one of the two spare trigonometrical surveyors.

Computations :

1 Computer (from topo. section).

1 Computer (from company H.Q.)

2 Observers.

4 *Plane-table Survey Squads* (two working on each flank) of :

1 Topographical Surveyor

Men for carrying instruments

These plane-table survey squads will be mounted should the O.C., survey company consider it advisable.

Spare :

2 Trigonometrical Surveyors.

These men will be kept in reserve to replace casualties, to help with computations, or for any other work that may be required.

Reply to the Kohara Survey Department.

A reply will be sent to the Kohara Survey Department, confirming the provisional acceptance of the offer of a small geographical unit, and continuing as follows :—

"The General Staff have decided that it is desirable to map as much as possible of Topoland on the 1" scale during the time available. The personnel of the survey company allotted to the force is only sufficient for carrying out surveys along the line of advance, and when the latter has penetrated some distance inland, there will be considerable areas behind the lines which the survey company will be unable to touch. It is to carry out the survey of these areas that the geographical unit from your department will be required.

"This unit should be self-contained, with its own complement of computers, etc., and be under the command of a gazetted officer, who will deal direct with the Director of Surveys, and will be exempted, as far as possible, from other military interference in his work.

"As it will be impossible for this officer to commence work till the expedition has crossed the coastal forest belt and penetrated into the hills of the interior, you will be notified by wire, the approximate date he should report for instructions to the Director of Surveys at Field Headquarters. He should be accompanied by an advance party of two triangulators, who will commence work as soon as possible; and he will then make all arrangements for the remainder of his unit, who will be required to commence work about three weeks later.

"The work required of the unit will be,

"Triangulation for a 1" survey.

"Plane-table surveys on a 1" scale.

"Fair drawing of the sheets surveyed.

"In addition to the above, should the General Staff decide that the whole of the coastal area is to be mapped, traverse lines will have to be run through it and a map produced from air photographs. A portion of this coastal zone astride the main road will be mapped from air photographs, by the survey company at the beginning of the campaign, and this may prove sufficient for military requirements.

"As it will be quite impossible for a small unit to map the whole country up to the line of the objective during the few months likely to be available, the services of as large a unit as you can raise will be very gladly accepted. It is anticipated that there will be no difficulty in obtaining all the unskilled labour required, locally."

PROGRAMME OF WORK.

Before and during landing operations.

1. Photography by air force of a belt of country thirty miles wide astride the main road, through the coastal zone.
2. Construction of a map from these photographs.

After the landing has been consolidated and an advance made from the base.

1. Observations for latitude, longitude and azimuth on which to base traverse work.
2. Commencement of traverses along the coast and up the lines of the "control strips" to provide additional control for the air survey of the coastal zone.

3. Establishment of a Reproduction Half Company at the base.
4. Drawing and reproduction of a preliminary map of the coastal zone, from air photographs.

When a footing has been established in zone (ii).

1. Observations for latitude, longitude and azimuth, and measurement of a base and base extension scheme.
2. Commencement of a system of triangulation to follow the line of advance.
3. Photography by the air force of areas behind the enemy's lines, and compilations of maps from these photographs.
4. Commencement of 1″ plane-table surveys along the line of march.
5. Drawing, printing and issue of field maps as required.

After the advance has been continued into zone (iii).

1. Continuation of forward surveys.
2. Commencement of survey of the back areas by the colonial survey unit.
3. Air survey of the remainder of the coastal zone, if required by the General Staff.
4. Fair drawing and reproduction of map sheets surveyed by the colonial survey unit.

Note on equipment.

It is not anticipated that the photographic rectification of individual photographs will be either practicable or necessary, and so no photographic rectifying apparatus will be required. It may, however, be necessaary to make simple enlargements or reductions of strips of photographs. For instance, the need for this would arise should all the strips of photographs of the coastal zone be not taken from the same height. To make these enlargements, an ordinary dry plate camera of about half-plate size is required, and a simple enlarging lantern. These should be obtained at the outset of the campaign and installed at the Base.

Section III.

Map Production and Distribution.

In any system of map production on service, time is the all-important factor, and will very largely determine the methods used.

In the campaign we are considering, generally speaking, three classes of maps will be required,

Field maps.

Regular editions of 1″ and smaller scale maps.

Maps required for special purposes, such as roads, water supply, traffic circuits, etc.

Field Maps will be prepared from forward surveys or air photographs, and are those which are required for operations actually in progress, or about to be undertaken. They will as a rule be drawn on tracing cloth, for reproduction by the Vandyke process in two colours—brown for contours, and black for the remaining detail.

Maps can be printed on a handpress at the rate of fifty copies per hour in one colour, or twenty copies per hour in two colours. Whether it will be quicker to send to the Base and have the map printed on a machine press, or to handprint it at field headquarters, will depend on the distance to the Base and the number of copies of the map required. Generally speaking, however, up to five hundred copies of a map in one colour, or two hundred copies in two colours, will be more rapidly printed on a handpress at headquarters, while larger numbers will be more rapidly printed by sending to the Base.

In order to have the latest material always immediately available at survey company headquarters, surveyors working in the forward area will, every two days, send in tracings of their work. From these a map will be drawn and kept up to date, either on tracing cloth for reproduction by the Vandyke process, or on zinc for immediate printing. Direct drawing on to zinc has obvious advantages, and will be carried out whenever possible.

Regular editions of 1" maps will be published in sheets covering fifteen minutes of latitude by twenty minutes of longitude. These will be a very convenient size to handle, and will also be very suitable for printing on the double-demy printing machine at our disposal. Maps on a scale of 1/250000 will be compiled from and cover the same area as four one-inch sheets.

These regular editions will be printed in six colours, unless otherwise ordered by the Staff, and will be fair drawn on a scale once-and-a-half times that of publication, and reproduced by the photographic process.

Maps required for special purposes will be printed as a rule in grey, and the special information will be surprinted in colours.

Distribution.—No establishment is laid down for a map depot, but the following is considered suitable for a depot at field headquarters:

1 sergeant in charge, 1 storekeeper, 2 despatch riders (mounted),
1 driver, Transport, 1 G.S. wagon and 2 horses.

Should the country permit, the G.S. wagon will be replaced by a light motor van, and the horses by motor cycles and side cars.

This map depot will distribute maps to all units in the field down to brigades and divisional troops. It will be under the orders of the O.C. Survey company.

The duties of the N.C.O. in charge of a map depot will be:

To distribute maps on the scale ordered by the General Staff.

To exchange all worn-out maps for new ones, and to keep a stock in reserve for this purpose.

The procedure for distributing photographs will be the same as for maps, but a reserve stock will not as a rule be kept. The prints will be supplied by the air force direct to the map depot, who will merely serve as distributing agents.

SHELL FIRE VERSUS PERMANENT FORTIFICATION.
LIÈGE AND NAMUR, 1914.

By CAPTAIN G. E. GRIMSDALE, *p.s.c.*, R.E.

THE *R.E. Journal* for December, 1926, contains a very interesting article by Lieutenant Harrison, R.E., on Verdun. The object of the present article is to offer a few comments about the conclusions reached by Lieutenant Harrison.

These comments are based on a visit to certain of the forts round Liège and Namur, which the present writer had the good fortune to make in the spring of 1926. The visits were made under the personal guidance of a Belgian Staff Officer, serving in the Historical Section of the Belgian General Staff. In addition, in a number of cases it was possible to discuss the experiences of men who had actually been present during the German attacks. These men are now serving as caretakers and so on in the forts. First-hand information was therefore available as to questions of fact.

The object of a fortress is to deny to the enemy the use of a certain area. Owing to the great cost, it has hitherto been impossible to construct a series of fortresses so close together as to protect the whole of an extended frontier area. The construction of fortresses has, therefore, been confined to localities of great strategic importance. As roads, rivers, and railways are essential to the movements of armies, fortresses have usually been constructed so as to protect important centres of communication. It is thus that Liège and Namur, which are situated at important centres of road, river, and railway communications, have been the sites of fortresses from the earliest times.

Lieutenant Harrison has pointed out how the increasing range of artillery necessitated the construction of a girdle of forts round the important strategic centre, at such a distance as to protect that centre from hostile artillery fire. The extent of this girdle ultimately became so great that it was found necessary to provide a mobile garrison to defend the large intervals between the forts.

This stage had been reached in the latter part of the 19th century, at which period the fortresses of Liège and Namur were rebuilt. Each of these strategic centres was protected by a girdle of some 12 forts. The forts lay at a distance from each other of 1½ to 3 miles, but, owing to difficulties of ground, were unable to afford each other mutual support. Each fort was sited on a prominent feature, from which the visibility in all directions varied from 800 yards to several miles. The garrison of a fort varied between 300 and 400 men, of whom the majority were gunners, the remainder being infantrymen. The intervals between the forts were defended by fortress troops of an inferior category. Each fort consisted of an inner keep where the main armament was mounted, a deep ditch and an outer rampart, the whole being surrounded by a belt of wire. Certain forts had also a secondary armament of light guns placed at the angles for special flanking fire. The guns were of various calibres and were mounted in revolving steel cupolas. The fort itself was built of concrete and was proof against 21-cm. shell, as also were the cupolas. Within the keep were the headquarter office of the commander, accommodation for the garrison during battle, ammunition chambers and a well. Most of the accommodation and ammunition storerooms were below ground level, ventilation being practically non-existent.

It is believed that no reinforced concrete was employed in the construction of any of the forts. Certainly, in many cases, the concrete used was very inferior, the contractors having been allowed apparently to use large boulders and brick rubbish as aggregate. Cases were noticed where a coating of cement plaster had been used as camouflage to bad work. It appeared from careful enquiries that the Belgian High Command were aware in 1914 that 30-cm. shells were likely to be used against these forts, but lack of money prevented any strengthening of the concrete or steel cupolas. The facts were therefore concealed from the garrisons, who were encouraged to, and did in fact, believe that they could remain under cover in the fort with safety from any German bombardment. The 42-cm. howitzers, which the Germans actually used, were, of course, as much a surprise to the Belgians as to the other allies.

The fortresses of Liège and Namur undoubtedly caused a certain delay to the German advance in 1914, but the rapidity with which the forts were reduced by mobile heavy artillery showed clearly that that type of fortress was a failure. The reasons for this failure may be summarised as follows:—

(a) The Germans used heavy howitzers up to 42-cm. calibre, whereas the forts were only proof against 21-cm. Thus the gun had developed while the fortress had remained the same.

(b) As the forts had been sited on the top of commanding features, observation was carried out from the gun positions. Generally, the method of obtaining observation was to fit at the highest point of the fort a kind of steel umbrella, capable of being raised vertically a few inches, so as to give all-round vision to a man standing beneath. As soon as the fort came under concentrated fire, however, observation became difficult, while in nearly every case the first direct hit on the central keep of the fort deposited such a weight of débris on top of the "umbrella" as to prevent it from being raised. If it had already been raised, apart from the dust, splinters, etc., the lumps of concrete thrown up all round made observation impossible. The result was that observation was then confined to what could be seen by looking down the barrels of the various guns. In certain cases also, buildings and trees had been allowed to grow up within a few yards of the forts, thus effectually obstructing the view over large areas of country. Thus the lack of observation at the critical moment prevented the main armament of the forts from carrying out its rôle of counter-battery work.

(c) Direct hits on the fort by even light artillery caused the inferior concrete to chip, and the broken fragments jammed the cupolas and prevented them from turning. In this way many of the guns were able to fire in one direction only.

(d) Communications were totally inadequate. The forts were connected to each other and to the commander of the fortress by air lines, which in many cases were cut in the early stages of the battle. There could thus be no effective control by the commander of the fortress.

(e) Owing to these fortresses being intended for all-round defence, the forts were designed and sited primarily to withstand attack from outside the perimeter of the fortress. The most serious defect in design was the entrance to the main ammunition store. This was in the central keep directly opposite the entrance to the fort. The latter in every case naturally lay at the back, on the side nearest the town, i.e., on the farthest side from which attack was expected. The actual passage and stairs were designed to lead straight down from the ground level to the store room, there being no corners or traverse to give protection.

Thus at Liège, Fort Loncin, situated west of the town, was attacked from the east, after the town had fallen, though it had been designed primarily to meet attack from the west. One of the first 42-cm. shells directed on the fort went straight down the passage stairway leading to the main ammunition store, the entrance to which was on the east side of the fort. This shell exploded the chief magazine, blowing up the whole fort with some 500 to 600 defenders, including the gallant commander of the fortress.

(f) The design of the forts was defective in many other ways. For example, the electric light failed under bombardment, ventilation was insufficient, particularly when the guns were firing; while the latrine accommodation was outside the keep and inaccessible to the garrison during bombardment.

The latter was apparently the immediate cause of the final surrender of at least one fort. The writer will long remember a survivor's vivid description of the stench in a large, unventilated, candle-lit, underground chamber, in which several hundred men had been rigidly confined for some days by a continuous bombardment.

(g) The intervals between the forts were held by isolated and lightly entrenched and wired infantry posts, but the wiring was not continuous. As a result, the enemy were able to pass at night between the posts.

(h) A further effect of these fortresses being designed for all-round defence was that the 20,000 elderly troops who formed the garrisons were distributed over a perimeter of some 30 miles. Thus the fortress system broke the principle of economy of force.

Again, at Liège, the fortress acted as a magnet for the 3rd Division of the Field Army, which remained within the enceinte, thus the fortress system led to the breaking of *another* principle of war—that of mobility.

(i) The principle of concentration of force was applied to the gun instead of to the shell. The guns were massed in forts and had to distribute their fire over the enemy batteries which were widely separated, while the enemy, from his scattered gun positions, could concentrate his fire upon the forts.

Some of the reasons why the frontier fortresses of Belgium failed in 1914 have now been examined, and it remains to consider in what way it is possible to replace such fortresses in the future. After studying the question on the ground, the writer has come to the following conclusions:—

(1) The conclusion of Lieutenant Harrison that "a line of isolated fortresses . . . must be replaced by a system of fortified areas . . . " is correct. These areas must form a continuous zone for the defence of the frontier.

(2) This zone should be organised in depth for the co-ordinated action of all arms, and should form part of the national defensive system.
(3) The basis for the organisation of this zone should be the artillery and machine guns, and the artillery should be mobile.
(4) The infantry trench and wire systems should be continuous.
(5) The most important work in connection with the preparation of this defensive zone will be the construction of artillery observation posts and machine gun emplacements, the selection and trigonometrical survey of battery positions, and the laying of telephone communications at such a depth below ground as to render them proof against artillery fire.

It is really with the second of the three categories, into which Lieutenant Harrison divides the defensive organization of this zone, that the present writer cannot altogether agree. It is clear that in the interests of secrecy, and also on the score of expense, it is not desirable that the whole of the work in this defensive zone should be carried out in peace time. But, on the outbreak of war, time for work will be short, and, further, it must be remembered that any newly constructed works will be clearly revealed by air photographs. If, also, the works constructed in peace are small, numerous, and widely distributed, the knowledge of their exact position by the enemy will be of little importance; for the enemy will be unable to concentrate upon all these numerous works the great number of shells which the last war showed to be necessary for their destruction.

In fact, the construction during peace time of "elaborate defensive works" should be avoided for the future and not encouraged. Instead, the following rough outline of what should be done is suggested as more likely to bring about the desired object, and as being more suited to the needs of a hard-pressed treasury.

(1) A detailed reconnaissance of the defensive zone should be made and the actual sites of all headquarters, battery positions, O.P's., machine gun posts, trench systems and wire should be decided upon and committed to a secret map.
(2) A plan of defence complete in every detail must be evolved and all arrangements made for the immediate construction on the outbreak of war of those works not previously prepared in peace time. This plan must take into account the supervision of the area, to ensure that

buildings and natural growth do not interfere with the field of fire or of view.

(3) Depots of all stores required on the outbreak of war must be prepared.

(4) The whole defensive zone must be trigonometrically surveyed and all battery positions resected.

(5) The following work should actually be carried out in peace time :—

(a) The construction of reinforced concrete artillery O.P's. and machine gun posts. These should be allowed to become overgrown with turf in such a way as to render them invisible from the air.

(b) The laying at great depth of buried telephone cables, so as to provide a complete system of communication. These cables should be laid to a large number of alternative battery positions.

(c) The construction of concrete gun platforms for heavy artillery. These platforms might be camouflaged by being constructed as floors for wooden farm outbuildings.

(d) The preparation of roads or railway lines with gun spurs, in order to permit of free movement of heavy artillery within the position. At present, railway lines are necessary for the movement of super-heavy artillery, but, in view of the fact that it is very undesirable that such lines should be constructed in peace, it is considered that experiments should be carried out to arrive at a design whereby super-heavy artillery can be moved, or even fired, on tracked carriages.

THE EFFECT OF MECHANICALIZATION OF THE ARMY ON THE ORGANIZATION AND EMPLOYMENT OF DIVISIONAL AND CORPS ENGINEERS IN THE FIELD.

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

Second Essay. Cooper's Hill Memorial 1926.

MOTTO.

"Peace, friend Sancho," answered Don Quixote: "for matters of war are, of all others, most subject to continual change."

I. THE ENGINEERS' PLACE IN MECHANICALIZATION.

ALTHOUGH " mechanicalization of the army " is an expression which has now acquired a very narrow meaning, its real meaning is a much wider one. We now generally limit it to the change which is most prominent in our own generation—the supplanting of horse-drawn transport by power-driven transport. In its broad sense it should include the adaptation to military purposes of any mechanical device which can replace or economise muscular energy.

In its broad sense, mechanicalization has been going on steadily in the armies of the world since the dawn of history. The first use of wheels, the evolution of catapults and ballistae, the invention of fire arms and the development of the modern machine gun, are some of the landmarks in a process of evolution which has been continuous since savage men first felt the need of weapons to help hands and teeth.

To-day, men still walk on their feet in our battles, and horses still strain at traces, but comparatively few of the other actions of our infantry and gunners would find their counterpart at, say, the battle of the Granicus. Yet when we turn to our sappers, we find that they have made less progress. They still heave on ropes, hoist weights and dig the earth by methods no whit in advance of those used by Alexander's engineers at the siege of Tyre.

Of course the military engineer has made use of the developments of mechanical science. Our tools, equipment, transport and methods of work prove that ; but a great deal of the " donkey work " of field engineering is still done by elementary methods—unnecessarily elementary and uneconomical methods.

In the narrower sense, too, we find that sapper units have not taken the lead in mechanicalization. We know mechanical artillery, we know the light tank and the armoured car, which may replace cavalry, and there are tanks of various design which may oust infantry ; but only now are we hearing the first rumour of a mechanicalized field company. Considering how closely akin mechanics is to engineering, it at first seems strange that sapper units have not taken the lead in replacing horse by petrol ; but the reason is not far to seek.

If engineers worked for themselves alone, we might easily have had our mechanical field company by now ; but the sapper's aim is to help towards the common object of the whole army by doing work which will assist the other arms. This consideration always did, and always will, govern their employment ; and upon their employment, and the conditions under which they are to work, must depend their organization. As the other arms take their new shape, it becomes possible to foresee the work which will be required of the sapper. As we foresee the work, so we can reorganize our units ; but our reorganization must always follow that of the infantry, cavalry and the artillery ; we cannot take the lead.

In some branches of the army mechanicalization consists chiefly of the elimination of the horse. In devising our new units we must not be content with that. The horse may have to disappear, but but that is not the end. Our object is efficiency in the work required of us, and towards that mechanics offers many a help besides mechanical traction. For us at least, mechanicalization must have its widest interpretation. We must explore all the resources of mechanical science in our search for means of raising the efficiency of our work in the field.

II. Effect of Mechanicalization on Engineer Employment.

Speed.

The foremost effect of mechanicalization must be the possibility of rapid movement. As yet the gift of speed is most unevenly bestowed, for our army is to-day, and must for many years remain, in a state of transition between the horse-drawn and the petrol-driven organizations. The foot soldier still drags along at his two-and-a-half miles an hour, while tanks and dragons can do their eight. Yet the mechanical column is already familiar, though at present it labours under all the handicaps of improvisation. The day cannot be far distant when we shall have in our army an organisation by which at least a brigade group will be able to move entirely by motor transport. Beyond that, in the future, is the day when our whole army will be able to move by similar means. The gift of speed will then have become universal.

This access of speed must react on the engineers, who are responsible for the roads and bridges. No mechanicalization as yet within sight will make armies independent of roads and bridges. Even when the vision of fleets of tracked vehicles progressing unchecked across hedges and ditches, and swimming across rivers, is realised, those same vehicles will travel more swiftly and more economically on roads and over bridges. They will still be accompanied and supplied by less highly endowed vehicles, whose dependence on roads will be greater. Certainly in the immediate future, and probably for many years to come, it will only be possible to exercise the power of rapid movement where roads and bridges exist.

There have been armies capable of rapid movement before, but, time and again, their dependence on the speed at which their engineers could work has been proved.

Suvorof was a master of rapid movement, and it was through his ability to inspire his troops with abnormal energy and determination on the march that he won many of his victories over the French in Northern Italy in 1799. Yet the impulse of even Suvorof's will could not carry his army over rivers. On June 14th, Suvorof, at Alessandria, suddenly learnt that Macdonald was advancing from the south-east, while he had expected an advance from the south-west. Ott, with a weak detachment, lay in front of Macdonald. Speed was everything if Suvorof was to reach Ott before he was overwhelmed; but the Bormida lay, unbridged, before him. Twenty-four hours of immobility were forced upon him while his engineers built a bridge. The delay would have spelt disaster for most commanders, and it was only one of the most magnificent marches in history, 53 miles in 36 hours, and a gallant attack by exhausted troops at the end of it, that made Suvorof's victory on the Trebia possible.

Bonaparte's operations against Beaulieu, in the same theatre three years earlier, prove that even his rapidity and skill in manœuvre could be nullified by the delays of bridging. Marching down the Po to cross and strike at Beaulieu's rear, he reached Placentia on May 7th, after covering 44 miles in 36 hours. " Had the army been equipped with a pontoon bridge, Bonaparte could have dealt Beaulieu a fatal blow; as he was compelled to rely on boats and rafts alone, the passage was slow and laborious."* The bridge was not completed till the 9th, and Beaulieu escaped.

If success or failure hung in the balance against the hours taken by bridging operations in those comparatively slow manœuvres of a century and more ago, how much more vital will every hour's delay become when forces can move at three times those speeds!

It will not be only bridging which must be done quickly; all work carried out for a mobile force must be speeded up. The first essential for the engineer units with the field formations of the future is that they should be able to work rapidly.

* "Napoleon," Vol. I., by Col. Dodge.

Manpower.

Manpower is closely involved with mechanicalization. In time of peace the expense of building mechanical vehicles must become a serious obstacle to development, and every economy in personnel which can possibly be justified will be made, in order that more money may be available for construction. The army will be organized on a basis of the maximum of efficiency with the minimum of personnel.

In war, the importance of the man in the workshop and the necessity for conserving national manpower, will be enough to guarantee that the same policy will be followed.

This will react in two ways on the engineers. We must expect reduction rather than increase in the strength of our engineer field units, and must therefore be prepared to undertake work without any increase in the number of available sappers. Secondly, a difficulty with which we are already familiar—that of obtaining unskilled labour to enable the sappers to be confined to skilled work—will be aggravated. To-day, in case of necessity, a working party may be grudgingly spared from an infantry battalion; but squeezing water from a stone will be easy compared with obtaining a working party from a battalion of one-man tanks.

Type of work.

Besides bringing changes in the conditions of speed and labour under which the engineers are to work, mechanicalization will also entail some changes in the actual work required in the field.

Armies will depend more and more upon roads fit to carry a large volume of quick-moving mechanical transport; and construction and maintenance of roads will form an increasing proportion of the engineers' work. Loads tend to become heavier and heavier, and the demands for bridges capable of carrying the increased weights will grow accordingly.

Demolitions will lose none of their importance, but will develop into schemes of destruction on a large scale; for the more dependent our enemy is upon his roads, the more effective will become the obstacle constituted by really efficient demolitions. At the same time, except in deliberate demolitions, the sappers will find the time available for the preparation of their charges shorter than ever. Demolitions during retreat have always been difficult: they will become even more difficult when the retreat and pursuit are carried out more quickly.

Anti-tank defence.

The whole problem of obstacles in the field will be altered when we are confronted by an enemy with tanks in really large numbers. Barbed wire may then become a relic of ancient warfare, and small mines and other anti-tank obstacles may become necessary on a scale hitherto unknown.

The mine must become the most important anti-tank obstacle for field formations. It alone, of the obstacles yet devised, can be put in position with the speed which mobile operations will often demand. But though the mine will be the primary obstacle, it would be a mistake to ignore other obstacles, such as barriers of steel rails set in concrete, or wide deep ditches. These may sometimes have their place, even in mobile operations. We must not become so obsessed with the idea of mobility as to exclude the deliberate preparation of defences from our conception of future warfare. Field formations will often have to construct defences in one area as a preparation for mobile operations in another; and whenever these defences are likely to be attacked by enemy tanks, concrete will play a large part in their construction.

Our engineer units must be able to undertake the construction of a system of defences, including numerous concrete machine gun emplacements and anti-tank obstacles, and to complete it quickly.

III. Means of Meeting the New Conditions.

Time saving.

The ability to work rapidly is the first essential for our field units; and time can be saved, not only in the execution of a job, but also in the stages of reconnaissance and preparation, which must precede execution in almost all sapper work. These first two stages both entail movement, movement of the reconnaissance party to the site, and movement of the working party with its tools and material to the same spot. So long as any of this movement is carried out on foot, time is being wasted. The future organization of the engineer field units must therefore provide for the movement of all personnel, tools and material, by some form of rapid mechanical transport.

The stage of preparation usually entails loading and unloading material of some sort. In civil work it is often possible to save time and labour by using a light crane or a mechanical grab for loading, and by providing lorries with tip bodies for unloading. It is not easy to devise a method of mechanical loading which will be applicable to every material which the sapper may have to handle; but if we can equip our units with gear which will assist in even half the loading they have to do, we shall have saved an appreciable amount of time.

The amount of work to be done in the stage of preparation can be greatly reduced whenever it is possible to use standardized material. Improvisation always means loss of time. As far as possible R.E stores were standardized in the later years of the war. As fresh forms of engineer work develop we must be on the look-out for opportunities for taking fresh standard stores into use.

In the stage of execution, civil practice shows us many ways of economising time and labour by mechanicalization, in the broader sense of that word. The navvy breaking up the streets of London no longer wields a pick; he uses a pneumatic hammer. Pneumatic drills are used in excavation in rock, mechanical grabs or shovels in looser soil. Mechanical power is used to drive winches, hoists, pile drivers, pumps and cranes.

Admittedly, the problem of the sapper differs in many respects from that of the civil engineer. The field company has not to be equipped for one type of work only, but must be prepared for a very wide range of jobs. It cannot be overburdened with heavy equipment, because it must maintain its mobility. Such machinery as it uses must not be delicate, or require careful handling, but must stand up to the roughest conditions without losing efficiency. The difficulties and limitations are many, yet engineer work will not attain that speed which future conditions will demand, until our units can be equipped with power which can be readily applied in a multitude of ways.

Every section must eventually have some sort of mobile power unit capable of accompanying it wherever it goes. This machine must be able to supply power for automatic tools, to pull on a rope or drive a crane, or work a hoist, just as the job in hand may demand. It must be able to tow a mechanical trench digger or push an Inglis bridge into position. It must be equally ready to drive a pump, a concrete mixer, a stone crusher or a pile driver.

The machine which will do all this has not yet been born; but the R.E. tank of 1918 was its crude and undeveloped ancestor. If there are those who believe this mechanical factotum to be beyond the limits of possibility, let them turn over the files of any modern engineering paper and see to what diverse ends, and by what various means, mechanical power is adapted even now; and then let them imagine the delight with which an ingenious minded sapper would tackle the problem of incorporating them into one machine.

The details of the factotum may be inaccurate, but the necessity for bringing mechanical power into more general use cannot be questioned.

Labour.

If mechanicalization is to entail some reduction in the numbers within the engineer units, the answer to this difficulty is again to be found in equipping the section with mechanical power. In the course of work ten or fifteen men would no longer have to be wasted pulling on a rope; the familiar "all together, heave" would disappear from the repertory of the sapper sergeant. Instead, the power unit or R.E. tank—call it what you will—would run its winding gear for a few seconds, and the thing would be done. The pathetic sight of two sappers slowly and laboriously working a pile driver, and dropping the monkey perhaps three times a minute, would be seen no more. Instead, the machine would do ten times as much pile driving with far less expenditure of man-power.

With these economies a slight reduction in the number of Group E sappers in a company could be survived without any serious detriment to work.

It will not be so easy to overcome the shortage of non-sapper labour. Some of the work for which working parties are now necessary might be done by mechanical means, or at least machines might be used to reduce the number of men required. Carrying parties might often be replaced by tracked vehicles able to move across country, and the number of men required for digging could be reduced by the use of mechanical trench diggers. But the unskilled party will still be necessary for many jobs.

Our present engineer organization was adopted in spite of strong arguments, put forward in favour of increasing the establishment to include Pioneers. Mechanicalization does not make these arguments any stronger, and we should be shutting our eyes to realities if we were to picture a permanent organization including additional unskilled labour. Economy will not allow it.

Our problem is to provide the labour in the cheapest manner possible.

From the engineer point of view there is no need that this labour should have other qualities than discipline and ability to work. The men need not be trained as infantry, though they must be enlisted for work under fire. They could therefore be enlisted on the outbreak of war, and yet be fit for service in a few weeks. Their cost in peace would then be limited to the cost of their mobilization stores and equipment, which would have to be held in readiness for the rapid formation of the unit.

Economy also demands that the strength of the labour units should be kept as low as possible. This can only be done if we can ensure that the labour will only be used for essential work, and will not be frittered away on the numerous desirable, but not indispensable, jobs which every subordinate commander can so easily find when labour is available. This will only be possible if the labour is under the direct control of the Chief Engineer of the Corps.

Pooling.

Mechanical transport has given us the power of pooling our resources to an extent which was quite impossible when troops or material, which were twenty miles from the battle field on the eve of battle, could hardly hope to intervene before action had been joined. Then, bridging material had to accompany the foremost units, or be wanting when the river was reached. Now, our pontoons can move far back in the rear, ready to be hurried forward by motor transport as soon as the need arises.

This pooling of resources, already being applied to bridging equipment, can be applied to labour, and to certain other equipment, with great advantage and economy. The advantage of the system is that units moving with the leading formations are relieved of equipment which is not continually necessary, and which, if with the units, would reduce their mobility. Every reduction of transport in the forward areas helps to simplify the very difficult traffic problem. The economy of the system follows from the centralised control which can be exercised over the pool. Bridging material can be allotted to divisions or brigades according to their requirements, instead of being available only on a fixed scale. Labour can be allotted for specific work, and can be recalled as soon as that work is done.

The efficiency of these pools depends on good liaison, good communications, and the possession of motor transport as an integral part of the pool. Given these, it is an economical system, the use of which may be extended as mechanical transport comes into more general use.

IV. Our Future Organization.

Summary of requirements.

We can now summarise the chief points which must be embodied in our future organization :—

(1). Men, tools and material must be carried in mechanica vehicles.

(2). Power must be available for the work in the field, and it must be possible to adapt it to the most various uses.

(3). As much unskilled labour as is indispensable must be provided.

(4). Units must not be unnecessarily encumbered with heavy equipment.

To these points must be added the principles that govern all R.E. organization; the limitation of the number of subordinates controlled by one commander in the field, the maintenance of tactical unity, and the inseparability of the sapper from his tools.

From these premises it should be possible to outline the future R.E. organization within the division and the corps.

There will be no violent change in our organization. Mechanicalization is affected by evolution rather than by abrupt revolution, and the engineer units of the future will grow out of the engineer units of to-day.

In a division to-day we have divisional engineer headquarters, three field companies, and a field park company; while the bulk of the corps engineers consists of army troops companies, E. and M. companies, and the corps pontoon bridge park. There is no reason to suppose that any of these units will disappear. Their equipment will alter, and changes may be made in their interior organization, but in name, and in the general roles they fulfil, these units will probably still be found in our mechanicalized army.

The field company.

The future field company may be slightly weaker in personnel, but we may expect the organization of headquarters and four sections, each of four subsections, to remain.

To fulfil the requirements which have been outlined, the section would consist of:—

- four mechanical vehicles for personnel, each carrying one subsection.
- one mechanical tool cart.
- one mechanical vehicle for technical stores and baggage, to replace the two L.G.S. wagons of our present organization.
- one power unit.

The power unit has been sufficiently described. The six other mechanical vehicles should all be capable of moving across country, and maintaining a speed at least equal to that of the mechanicalized units with which the field company may work. For simplicity in manufacture and maintenance, all six vehicles should have identical chassis. The bodies of the vehicles for personnel should be easy to adapt for the carriage of material, and if they can be designed to tip for unloading, so much the better.

The headquarters of the company should continue to include all the administrative vehicles—cooker, water cart, mess and medical,—but all must be able to travel at the pace of the sections, either under their own power or as trailers.

So equipped, the company would be able to move rapidly as a complete unit, to detach sub-units of varying strengths, and to carry out work quickly and efficiently. Any sapper party would also have with it invaluable transport for collecting or carrying stores or materials.

The field park company.

The field park company is already partially mechanicalized, though its personnel still marches on foot. To enable it to take its place with a mechanicalized force it must be equipped with mechanical vehicles for its men, so that it can move as a complete unit. Beyond this there need be no great change in its organization.

Corps engineers.

The work of the corps engineers will always be more deliberate than that of divisional engineers. Their movements will be less frequent, though, working in a large area, they may move long distances at a time. To equip all corps units with mechanical transport for their personnel would mean that much of this transport might spend many idle days, and would be uneconomical. It must be possible to move a proportion of the E. and M. and A.T. companies rapidly, and as complete units; but they will seldom all have to make rapid moves simultaneously.

The first line transport of all corps engineer units must be mechanical as indeed the greater part of it is already; but for personnel it will be sufficient if the C.E. has under his own control enough mechanical vehicles to move the men of fifty per cent. of his units at a time. These vehicles would only be allotted to units when rapid moves were necessary. At other times they would be pooled under the C.E's control, and could be used for moving stores and material.

Apart from the vehicles for their personnel, the organization of the A.T. companies should be identical with that of the field companies.

The responsibilities of the E. and M. companies for second line repairs to engineer plant will be considerably increased, and this will call for some expansion of the workshop equipment of these units.

The corps pontoon bridge park, now being organised, fulfils, in theory, the conditions required in a mechanical army. It keeps the pontoons in the rear, avoiding unnecessary congestion further forward, until they are required for actual service, when it takes advantage of the powers of M.T. rapidly to move the equipment to the point where it is wanted. But our mechanical army should have improved tractors and trailers for its pontoons. They should possess silence, for secrecy, and ability to move across country, to avoid the difficulties of handling them on a narrow road approach to the bridge site.

We have seen the necessity for a corps pool of labour. Making full allowance for all that mechanicalization can do to eliminate the need for unskilled labour, a corps labour unit a thousand strong is probably the least that can meet the calls which will be made upon it. This unit should be organized in detachments of, say, two hundred, each capable of remaining detached indefinitely from its parent unit, and each equipped with motor transport for its tools and administrative necessities. The C.E. would rely on his pool of vehicles for moving the personnel.

Mechanicalization will demand the formation of one other corps unit. We have seen that the " power units " with field companies and A.T. companies should be capable, among other things, of pulling trench diggers and working pile drivers, compressor plant or concrete mixers. Under certain conditions these accessories will be invaluable, but often for days and weeks at a time they will not be required with the companies. If the companies were to trail these things about with them wherever they go, their own mobility would be reduced, and unnecessary transport would be adding to the congestion on forward roads. The accessories must be available when required, but must be kept out of the way at other times. It is one more case for a pool in the C.E's hands. A unit which might be the corps workshop and park, will be wanted to hold this equipment in readiness, just as the corps pontoon bridge park holds pontoons. When it is foreseen that companies will shortly be busy with concrete work in a defensive position, the concrete mixers and stone crushers would be sent forward to them. For the preparation of extensive demolitions, compressor plant and pneumatic drills would go up to save labour in digging down through metalled roadways, and in making charge chambers in masonry.

The supply of anti-tank mines.

Though not literally part of the organization of corps or divisional engineers, the system of supply of anti-tank mines will affect the work of divisional units very closely, and reference to it must therefore be made.

Under our present organization these mines would be supplied in the same way as any other R.E. stores. In mobile operations no supply of mines would be likely to be held forward of the base engineer store depot, and, when required by a division, they would have to take their chance in the competition for accommodation on the railway. Under these circumstances there can be no guarantee that they will be available promptly. If the mines are to be used at all they will be required by the thousand, not by the hundred; and they will be wanted at short notice. The efficient supply of anti-tank mines will only be ensured when they are treated like ammunition, and are supplied through the maintenance and ammunition companies R.A.S.C. This would entail a slight expansion of these companies, based on an estimate of the scale on which the mines would be required. But it would ensure that regular echelons of supply existed, both with divisions and back from divisions to the base; and it would guarantee that sappers would be able to answer the urgent calls for anti-tank defences, which will assuredly be made upon them.

MEMORIAL TO MAJOR-GENERAL WILLIAM ROY, F.R.S

READERS of Sir Charles Close's recent articles on "The Early Years of the Ordnance Survey" will probably remember the name of Major-General Roy, who took such a prominent part in the early survey work of this country; and will be interested to know that a memorial to that distinguished officer has recently been erected.

The following brief account of Roy's survey work will explain how it led to the establishment of the Ordnance Survey, and, consequently why Royal Engineers, and particularly those engaged on survey, should feel an interest in his memory.

William Roy was born in Carluke Parish on 4th May, 1726. After the Jacobite rising of 1745, he assisted Lieut.-General Watson, Deputy Quarter-Master-General to the Duke of Cumberland, in making a map, or large military sketch, of Scotland; the first serious attempt at a continuous map of a large portion of these islands. This work was interrupted by war; but Roy always kept in view the ideal of carrying a triangulation over the country, as the basis of an accurate map. With this object he constantly noted positions suitable for trigonometrical points, and for measuring bases, and he even carried out a certain amount of triangulation privately, in the neighbourhood of London, partly for his own amusement and partly to excite interest in the subject. But, in 1783, he was called upon to supervise a geodetic operation of the first importance, namely, a triangulation for the purpose of connecting with the French geodetic work, and so determining the relative positions of the Greenwich and Paris Observatories. As the commencement of this work a base was measured, in 1784, on Hounslow Heath.

The measurement of this base was the first operation of the kind undertaken in this country, and excited great scientific and general interest. The President of the Royal Society, Sir Joseph Banks, took an active part in the measurement, and H.M. King George III paid two visits while the work was in progress.

Though the immediate object of this triangulation was that already stated, Roy always considered that the chief and ultimate object was of a "still more important nature, namely, the laying the foundation of a general survey of the British Islands."

Roy carried the triangulation which was entrusted to him to a successful conclusion, that is, to a junction with the French work across the Straits of Dover, but died soon afterwards. His project of carrying out an accurate triangulation of the whole country was put in hand after his death.

It is generally considered that the germ of the Ordnance Survey lay in the military map of the Highlands initiated by Watson, and carried out largely by Roy. The actual establishment of a paid survey staff, which developed into the Ordnance Survey, took place on 12th July, 1791, when, by order of the Master-General and Board of Ordnance, special allowances were paid to Major Williams and Captain Mudge, both of the Royal Artillery, and to the party of Artillery who assisted, for the survey work on which they were engaged. Williams, and after him Mudge, were the first Directors of the Ordnance Survey, but since their time all the Directors have been Royal Engineers.

The memorial to Roy takes the form of two bronze plates which have been fixed, one on each terminal of the Hounslow Heath base. These terminals consist of guns buried vertically in the ground. The N.W. terminal is in a field known as King's Arbour, four miles west of Hounslow. The S.E. terminal is in Cannon Field, Hampton Hill. The plates are identical, except that one bears the words, "N.W. Terminal," the other "S.E. Terminal."

The inscription on the S.E. plate is as follows:—

THIS TABLET WAS AFFIXED
IN 1926 TO COMMEMORATE
THE 200TH ANNIVERSARY OF
THE BIRTH OF

MAJOR-GENERAL WILLIAM ROY, F.R.S.

BORN 4th MAY, 1726 — DIED 1st JULY, 1790.

He conceived the idea of carrying out the triangulation of this country and of constructing a complete and accurate map, and thereby laid the foundation of the

ORDNANCE SURVEY

This gun marks the S.E. terminal of the base which was measured in 1784, under the supervision of General Roy, as part of the operations for determining the relative positions of the Greenwich and Paris Observatories—This measurement was rendered possible by the munificence of H.M. King George III, who inspected the work on 21st August, 1784—The base was measured again in 1791, by Captain Mudge, as the commencement of the principal triangulation of

GREAT BRITAIN.

The above is followed by details of the length of the base.

The unveiling ceremony was carried out at the S.E. Terminal at Hampton Hill on Tuesday, 22nd February, by the Astronomer Royal, Sir Frank Dyson, F.R.S. The following were present:

Sir Francis Floud, K.C.B. (representing the Ministry of Agriculture and Fisheries), Colonel Commandant E. M. Jack, C.M.G., D.S.O., and Lieut.-Colonel G. S. C. Cooke, D.S.O. (Ordnance Survey), Colonel H. St. J. L. Winterbotham, C.M.G., D.S.O., and Captain G. T. McCaw, O.B.E. (Geographical Section, War Office), Colonel Sir Charles Close, K.B.E., F.R.S., and Mr. A. R. Hinks, C.B.E., F.R.S. (Royal Geographical Society), Major K. Mason, M.C., R.E. (Survey of India), Mr. Stephen Mitchell, *M.P.* (Lanark), Mr. A. Miller (Carluke Parish), Professor Schlesinger (Yale University), Lieut.-Colonel O'Meara, C.M.G., late R.E., the Chairman of the Board of Trustees of theHampton Parochial Charities (Freeholders of the Site), and Mr. H. T. Mason (Leaseholder of the site).

Letters of regret were received from the following, who were unable to be present: General Sir Bindon Blood, G.C.B., Colonel R. C. Hellard, C.B. (former Director-General of the Ordnance Survey), Sir George MacDonald, C.B., LL.D., &c. (biographer of Roy), and the Officer Commanding 1st Suffolk Regiment (formerly 12th Foot, which furnished a party for work on the Base).

Colonel Jack explained the circumstances which led to the erection of the memorial, the original suggestion for which came from Sir Charles Close.

Sir Frank Dyson gave a short account of General Roy's life and work, and then unveiled the memorial.

Sir Charles Close expressed the thanks of those present to Sir Frank Dyson.

The Chairman of the Trustees stated that they fully appreciated the importance of this historic occasion, and gave his assurance that they would regard it as their duty to preserve the terminal and memorial for all time.

E.M.J.

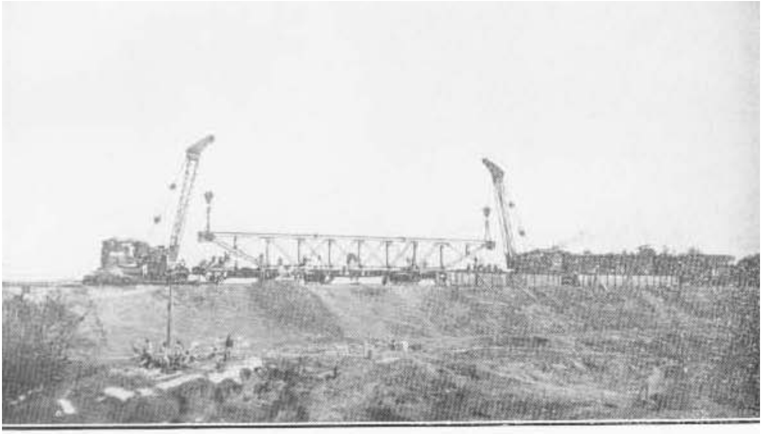


Fig. 1.

Fig. 2.

Bridge widening

Fig. 4.

Fig. 3.

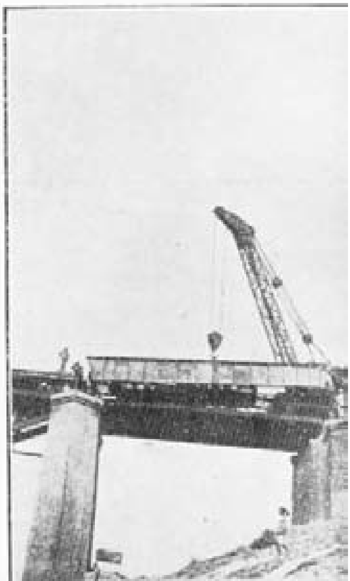


Fig. 5.

Bridge widening

WIDENING A RAILWAY BRIDGE.

By Lieut. R. Gardiner, R.E.

The following short account of a work carried out recently on the East Indian Railway may be of interest to members of the Corps.

The Grand Chord section of the E.I. Ry. has been under the process of being doubled, and amongst many other bridges was one crossing the Karamnasa River.

The bridge is a girder bridge consisting of three 100ft. spans and two 40ft. end spans. It was intended to extend the brick piers and use new girders. It was then discovered that at high flood level the water would be above the bottom boom, and it was decided to move three spans of the old bridge across the Sone River to Karamnasa and send the new girders to replace them—the Sone bridge girders being 100ft. span but shallower—rather than raise the bedstones which had already been placed. The change at Sone bridge was first carried out and then that at the Karamnasa Bridge.

As the girders were 15 feet high and weighed 32 tons each, the question of transporting them 57 miles required some thought and care.

Owing to their height it was impossible to carry the girders lying flat on their sides. The method used was as follows:

A train was made up consisting of 30 ton loco crane—flat truck—bogie platform truck—platform truck—30 ton loco crane, etc.

The girder was lifted upright on to the bogie truck and its two neighbouring trucks, and was then securely braced and strutted. 12ins. by 12ins. baulks were cut to fit under the top boom and to wedge against the edge of the truck. Baulks were also used to prevent any lateral movement of the bottom boom, and, in addition, the top boom was secured to the sides of the truck by wire ropes tightened by turnbuckles.

The train was then reassembled and the crane jibs lowered. On the journey from the Sone to Karamnasa the maximum speed allowed was 10 m.p.h., whilst through stations this was reduced to 5 m.p.h. This portion of the work was done on the day previous to that on which the actual launching took place.

The distance of the bridge from Karamnasa Station, where the train was stabled for the night, was about one mile, and the engineering department were allowed two hours in which to run out to the site, launch the girder and get clear of the main line again.

In order to save time, before leaving the station the crane jibs were lifted and attached to the girder, and the train run out in that form (See Fig. 1.), on to the existing part of the bridge until the girder was opposite its future position. (Fig 2.)

The cranes were then propped. As the first girders erected were the nearer ones and the radius of lift quite small (20ft.), it was sufficient to prop the cranes with 12in. baulks placed on the troughing of the existing bridge.

When the further girders were erected it was necessary to block up the propping girders on the inner girders of each new span, as the radius of lift was considerably greater (25ft.)

Having then removed the struts and stays from the girder it was lifted and swung out and lowered into place. (Figs. 3 and 4.).

The three inside girders were placed first, in order to allow the propping for the outer ones, as explained above.

The 40ft. end spans were placed in position by one crane lifting each about its point of balance and lowering it into position as before. (Fig. 5.).

The points in this work may be summarised as follows :—

(1). Owing to its height, each 100 ft. girder had to be transported in its most unstable position, and therefore needed great care in strutting and bracing.

(2). The train itself had to be run very slowly to prevent any undue sway being set up. (A special engine driver was chosen who could be relied upon not to cause jerks.)

(3). Owing to the limited time allowed, the crane jibs had to be raised and the tackle attached at Karamnasa station. (On the first occasion the leading jib only missed a signal by a matter of inches.)

(4). In order to be able to lift the outer girders into place the inner girders already placed had to be used to prop the cranes upon.

IMPERIAL WIRELESS.

By COL. F. A. ILES, C.B.E., D.S.O., R. OF O.

A NECESSARY introduction to the story of the development of the wireless communications of the British Empire is a brief review of the development of wireless communication generally.

The origin of wireless is the electro-magnetic theory of light propounded by Clerk-Maxwell, including his prediction, in 1864, of ether-waves, differing from those of light and radiant heat by wave-length only. This prediction of a mathematician led physicists to experiment, until Hertz, in 1887, produced and detected the waves which carry our wireless messages, and which are called by his name.

By means of the spark-discharge from his oscillator, Hertz produced wireless waves, and he detected them at a distance of a few feet by means of his resonator.

Sir Oliver Lodge, by syntony, or tuning sending and receiving circuits alike, increased the distance to sixty yards, and, in 1894, at the British Association meeting at Oxford, using Branly's coherer and a Kelvin marine galvanometer, he showed his audience how the Morse code could be used for signalling without wires.

Marconi, by means of his magnetic detector and high aerials, made wireless a commercial proposition.

"There were strong men before Agamemnon," and the Senatore Marconi would no doubt be the first to acknowledge his indebtedness to the great men named, as also to others like Faraday, Ampère, Oersted, Hughes and Righi, who was his teacher; but for the world at large wireless, as we have it to-day, means Marconi.

In 1896, Marconi came to England. He took his inventions and ideas to Sir William Preece, the Chief Engineer of the Post Office, and sent his first wireless message in England from the G.P.O., in London, and received it on a roof in Queen Victoria Street, one hundred yards away.

Experiments were then carried out on Salisbury Plain, and the range increased to $1\frac{3}{4}$ miles with success.

In May, 1897, Marconi carried out on the Bristol Channel a test over water to a distance of $3\frac{1}{2}$ miles, and the occasion was of some importance because he was trying to do, by means of the Hertzian waves, that which had already been done with perfect success by an earlier method of signalling without wires, viz., that which works by induction. In 1892, Sir William Preece, having signalled by induction between two parallel telegraph wires $4\frac{1}{2}$ miles apart, permanent communication was established by this means from Flatholm Fort, in the Bristol Channel, to Laverock Point, $3\frac{1}{2}$ miles away.

There is a still earlier method of signalling without wires to record. In 1842, Morse had accomplished wireless signalling across the Susquehanna, and in 1859 one, James Lindsay of Dundee, having in 1845 signalled successfully across the Tay, read a paper on "Telegraphy without Wires," before the British Association, and even went so far as to make all calculations necessary for signalling between England and America. In both these instances the signalling was done by means of leakage—or earth-currents, such as we used with the Power-Buzzer in France.

In this competition on the Bristol Channel with a known and successful system, Marconi tried for three days and failed, until he thought of a possible means of improving radiation, and took his transmitter from the top of the cliff to the beach below, thus incidentally inventing the high aerial. This proved a startling success. He not only got his signals $3\frac{1}{2}$ miles to Flatholm Fort, but the next day nearly nine miles across the Bristol Channel to Brean Down.

There was then no looking back: wireless henceforth meant Hertzian waves and not induction nor earth-leakage. England was the scene of the trials for the next four years, and by utilising Sir Oliver Lodge's principle of syntony, Marconi, in 1901 got a range of 200 miles over water, from the Lizard to St. Catherines, in the Isle of Wight.

In December, 1901, he went to Newfoundland, and there, by means of a kite aerial and coherer, he heard signals from his station at Poldhu. The news of this achievement caused a sudden and quite unnecessary slump in cable shares.

His experiments in Newfoundland, however, ended abruptly, for the Anglo-American Cable Company, founded in 1854 by Cyrus Field, had not only acquired the right of landing all cables in Newfoundland for fifty years, but with great forethought had worded the contract so as to exclude all other forms of signalling.

Three months later the *Philadelphia*, an American liner, received messages from Poldhu to a distance of 1,500 miles, or two-thirds of the way across the Atlantic.

In July, 1902, Marconi travelled in the *Carlo Alberto*, of the Royal Italian Navy, from Dover through the Skattegat to the Gulf of Finland, keeping communication with Poldhu all the way. The *Carlo Alberto* then took him back to Italy, still in communication with Poldhu, and then across to Nova Scotia, with similar success, arriving at Sydney at the end of October. Marconi worked at his station at Glace Bay for seven weeks, and on December 20th, 1902, sent the first transatlantic wireless telegram to the King of Italy, and another to King Edward VII.

The next few years were occupied in fitting wireless into many liners, and into ships of the Royal Navy. The Marconi Company erected a high power station at Clifden, on the West Coast of Ireland, and started a transatlantic commercial service which went on, with interruptions, but still steadily improving, until its success raised the question of an Imperial Wireless Chain.

The idea of connecting up Great Britain and its Dominions by means of wireless appears to have originated in 1910. It was a natural outgrowth of a desire for the unity of the Empire, to which it must surely contribute, and of the success by then attained by the Marconi Company, after three years' working, with their service between Clifden, in Galway, and Glace Bay, in Nova Scotia. This service, initiated by a private company, partly for experimental purposes and to gain experience in long-distance working, and partly for commercial and press-work between Europe and the United States, became, by the accident of geography, the first wireless link between Great Britain and one of the Dominions. That all the Dominions should be linked similarly, was a suggestion put before the Committee of Imperial Defence in 1910, and referred by that body to the Imperial Conference due to take place the next year.

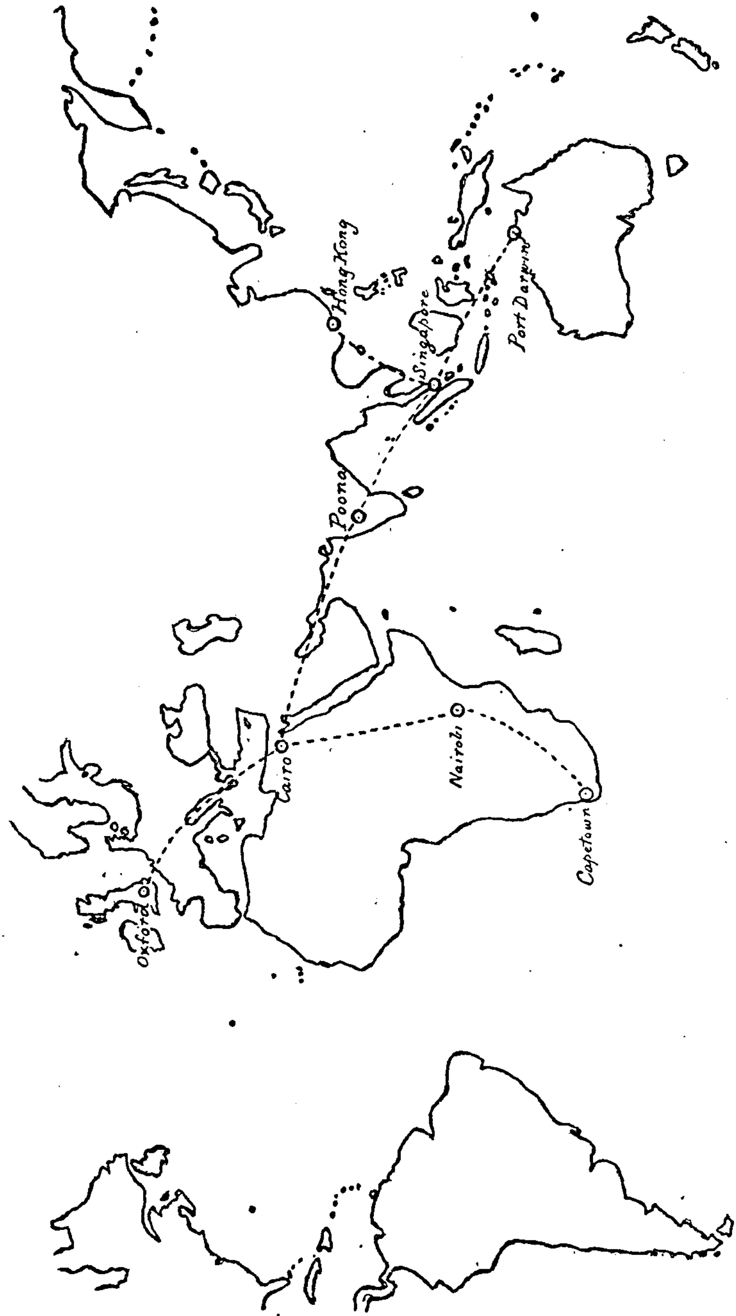
There was at that time no possibility of working wireless direct between England and the farthest outlying portions of the Empire, so that the Imperial Conference of 1911, in recognising the desirability of wireless communication between Great Britain and all the Dominions, could do no more than state their decision that a *chain* of Imperial wireless stations should be erected. They added that the Chain should be state-owned, and provided "without delay." Considering the sixteen years that have elapsed since the Imperial Conference made this latter recommendation, an element of pathos is not lacking.

In accordance with the main decision of the Imperial Conference, a contract for such a scheme connecting England, Egypt, East Africa, South Africa, India, Singapore and Hong-Kong (*v.* Scheme 1) was, in July, 1912, entered into by the Postmaster-General with the Marconi Company. Two important omissions will be noted. Neither Australia nor Canada appears in the list. The former, however, had promised to co-operate by erecting under her own arrangements a station at Port Darwin to work with Singapore, while the latter was looked upon as being already catered for by the existing Marconi stations.

Immediately the scheme was published controversy arose, and it was not until after a Select Committee of the House of Commons had sat on the subject, and the contract had been revised, that it was ratified by Parliament in August, 1913.

SCHEME 1.

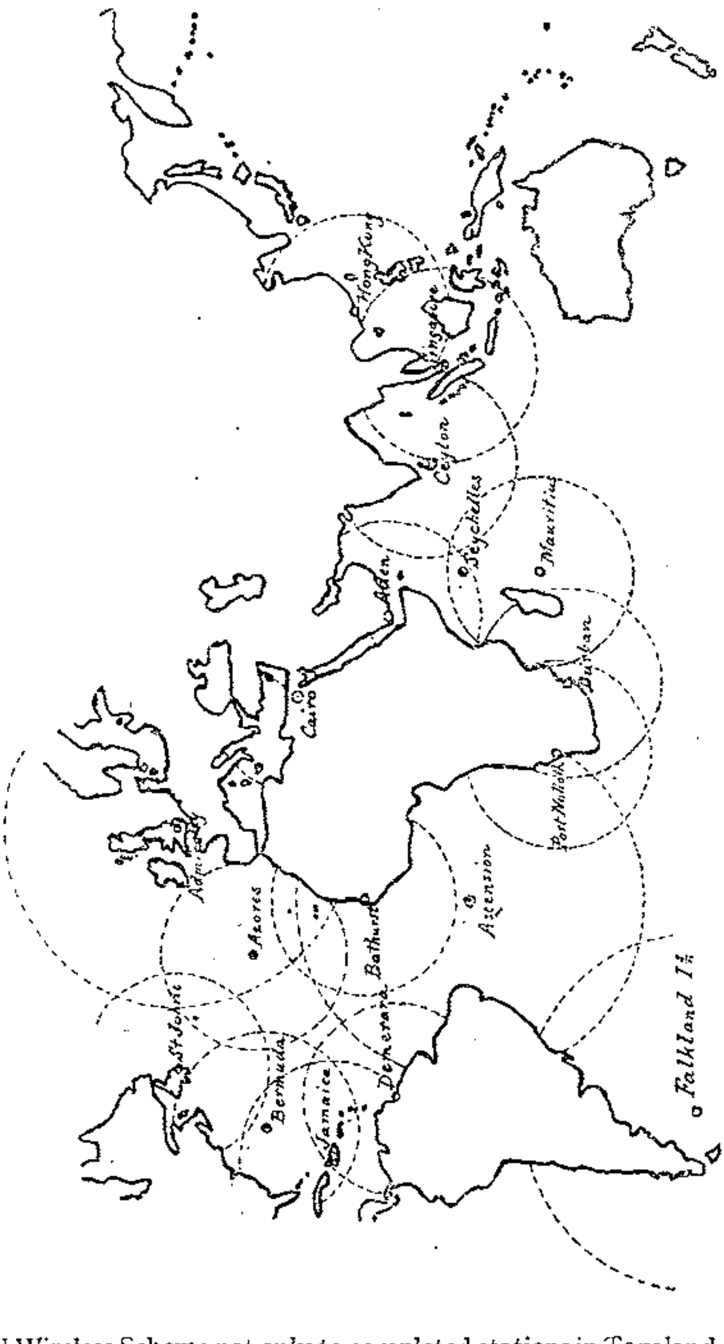
Contract given to Marconi Coy., 1913: work stopped and contract cancelled after outbreak of war.



This brought us to within twelve months of the outbreak of war, an event which occurred when the first link of our Wireless Chain, consisting of the stations at Leafield, near Oxford, and at Abu Zabal, near Cairo, was incomplete, while Germany had brought its own

SCHEME 2.

Substituted for Scheme 1 owing to War; Carried out by Marconi's and the Admiralty.



Imperial Wireless Scheme not only to completed stations in Togoland, the Cameroons, German East Africa and German South-West

Africa, but had installed in Germany a station of sufficiently high power to work to the farthest of them (Windhuk) direct. Germany was thus in a position to demonstrate as regards Imperial wireless communication the advantage of having schemes, carrying them out, and then making war at your own time, over general unpreparedness. That the advantage reaped was not greater was due to the possession by Great Britain of two things—the submarine cables of the world, and the Grand Fleet. In fact, the command of the sea was so securely in our hands that it led to the temporary abandonment of all idea of Imperial wireless communication, in favour of a scheme more suited to our needs. Government cancelled the contract with Marconi's, the Imperial Wireless Chain was relegated to an unknown date, and a scheme was drawn up which included sixteen widely-scattered wireless stations for working mainly to ships, and which was only incidentally used for imperial purposes (*v.* Scheme 2). The Admiralty Station at Horsea and a station, installed by the Royal Navy and utilizing the masts at Abu Zabal, brought the total number of stations to eighteen.

The Admiralty constructed three of the stations (Jamaica, Bermuda, and—by permission of Portugal—the Azores) and the Marconi Company thirteen (St. John's, Demerara, the Falkland Islands, Ascension, Bathurst, Port Nolloth, Aden, Seychelles, Mauritius, Durban, Ceylon, Singapore and Hong-Kong). In addition to the work of erecting these stations, the Marconi Company was awarded £590,000 as compensation for the cancelled contract.

By means of this scheme our larger ships were very seldom out of touch with the shore, and this with England was a point obviously of the greatest advantage. But, though the scheme thus forced upon us served its purpose, it was not truly Imperial wireless. It not only stopped the work of providing an Imperial Wireless Chain before the first link was formed, but it threw back the whole project of connecting Great Britain and the Dominions by wireless for five years.

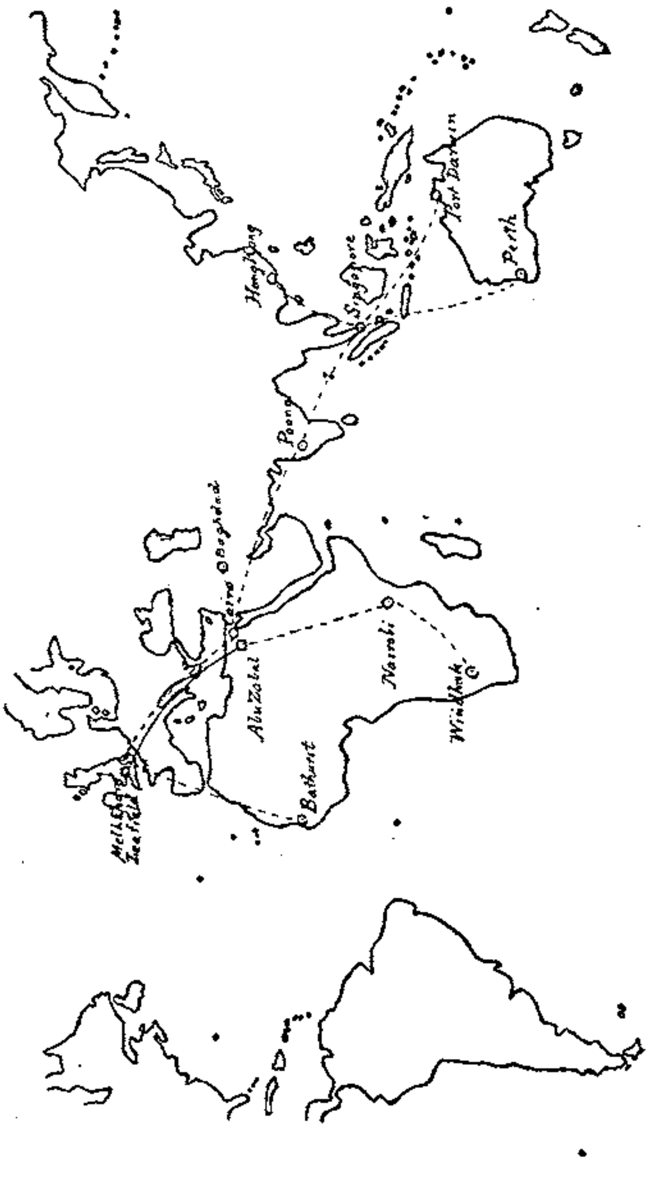
In the case of countries other than Great Britain, point-to-point communications during the war were more important than those of ship to shore, and the United States and France were, consequently, when the war ended, each in possession of a number of high-power wireless stations working to the greatest distances, while Belgium, Holland and Italy were ahead of us in their programmes for providing such stations.

Although the submarine cables had during the war saved Great Britain in the matter of Empire communications, it was soon found when peace came that they could not cope with the rush of business and press-work following on restored foreign relations and increased commercial activity. Further, since (in spite of certain peaks of activity, such as occurred in the cable-laying world in 1870-73, and

SCHEME 3.

Scheme 1 Revived and Revised by Sir Henry Norman's Committee, 1920.

Arc Station □
Valve ,, ○



again in 1899-1902) there is a steady yearly increase in the number of cables, it became evident, after four years of enforced inactivity through war, that in the matter of laying submarine cables the world had four years' leeway to make up.

Thus the demand for Imperial wireless communication became very pressing, and, in 1919, the Government again took up the project for an Imperial Wireless Chain, ordered the Post-Office to complete the two stations started by the Marconi Company, and appointed an Imperial Wireless Telegraph Committee under Sir Henry Norman to go into the whole question.

The Committee made several important recommendations (*v.* Scheme 3) :—

(1) That there should be two chains instead of one, viz.:—
  (i) Leafield—Abu Zabal—Nairobi—Windhuk.
  (ii) Melksham—Cairo—Poona—Singapore—Hongkong and Port Darwin (or Perth).
  with outlying stations at Bathurst and Baghdad.
(2) That the valve system be used throughout, except for the two Poulsen Arc Stations already nearly completed.
(3) That the Canadian Government be asked to confer with the Imperial Government as regards similar communication being provided with Canada.
(4). That the whole system be State-owned, a Wireless Commission of technical experts being appointed to design the stations and supervise them during construction, the work being carried out by the General Post Office and the corresponding Dominion and Indian authorities.

There are certain points in these recommendations which call for comment : —

(*a*) We were already committed to the Poulsen Arc for the two stations in course of erection. Since they were started, however, the valve, then in its infancy, had made such progress that the Committee decided in favour of having all the new stations equipped for valve-transmission.
(*b*) Instead of electing for high-power stations in England and in the distant Dominions, the Committee had preferred the idea of chains of stations, no link of which was longer than 3,000 miles.
(*c*) The Committee evidently had dropped the former idea that Canada was already adequately provided for.
(*d*) Although the work of providing the first wireless chain in 1913 had been given to Marconi's, that company was now to stand aside in favour of the Post Office.

There was, after this report was published in June, 1920, much furious discussion in the press, and it continued for two years. The arguments on the one side were all directed to the necessity of giving the work again to the Marconi Company.

They ran in a crude form something like this :—

(1) The Government plan being for short links, and not for stations of the highest power to maintain communication

direct with all outlying portions of the Empire, including Australia, is a bad one.

(2) The Marconi Company has spent large sums of money on research work and experiments, and is better equipped for the task than the G.P.O.

(3) The Marconi Company, by combining with the American Marconi Company, the French General Wireless Company, and the Telefunken Company of Berlin, has secured all the necessary patents.

Against these were urged :—

(1) That, in accordance with the recommendations of the W/T. Commission, appointed after the Imperial W/T Committee's report, a new English station would be erected powerful enough to work with Australia direct, except during unfavourable atmospheric conditions.

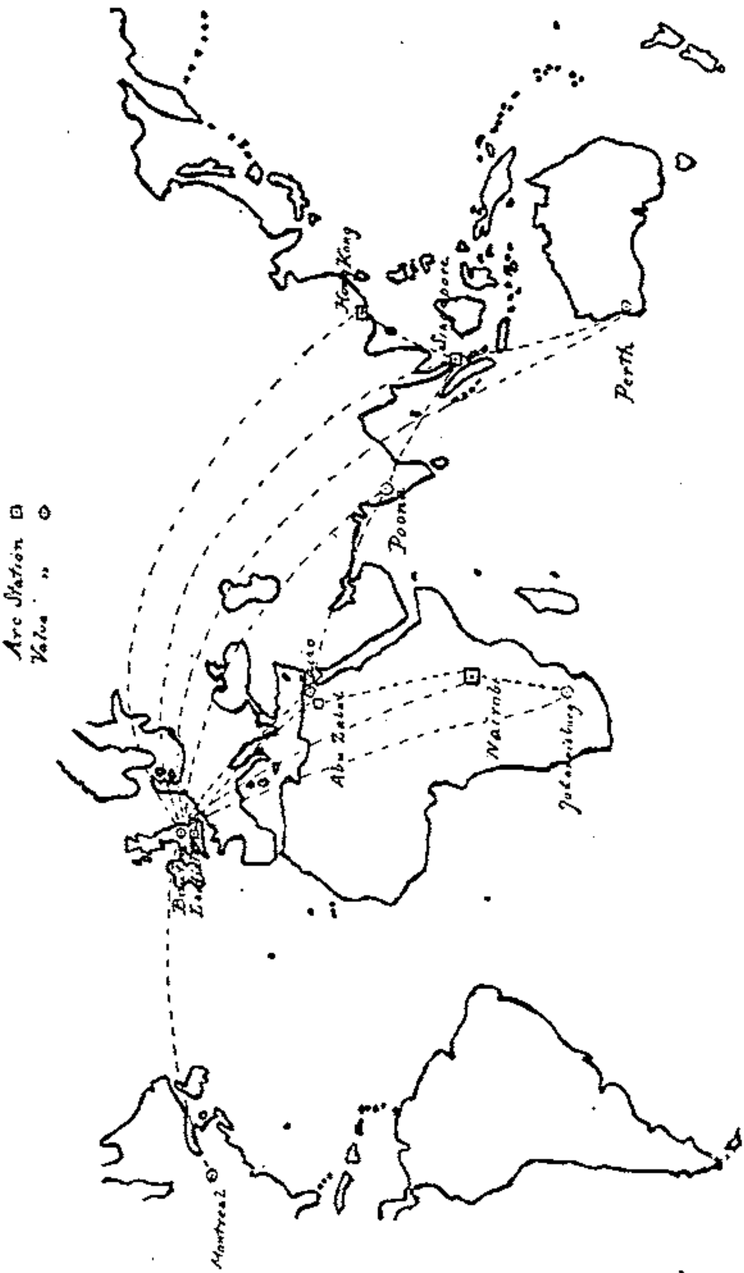
(2) That, even though this might be the case, it was not sufficiently so to warrant a monopoly being given to any one Company, which could then stifle all competition to its own benefit ; and that, as there must be a monopoly, it had better be a State one.

(3) That many important patents were about to expire, and that in the case of others there were alternatives.

The Marconi Company made some powerful allies, not only by combining with the leading wireless companies in foreign countries, but also by entering into separate contracts with certain of the Colonies. The Company also started a great agitation in the Press, which was quite ready to take up the cudgels, complaining with reason, if not with understanding, of England's undeniably backward position in the provision of really high-power wireless stations, from which the Press, of course, suffered. Moreover, Marconi, while justifiably confident that they could fill the bill, had little reason to believe that the G.P.O. would be equally successful.

In January, 1922, the Imperial W/T Commission reported on plant and sites. They also made recommendations of a general nature, of which the most important was that England, Canada, Australia, South Africa and India should have stations of sufficiently high power to work to each other direct, except during unfavourable atmospheric conditions. In other words, the Commission did not support the Imperial W/T Committee's views on the Chain question (*v.* Scheme 4).

In July, 1922, the Government, following the technical Commission rather than Sir Henry Norman's Committee, took a decided step towards dropping the idea of a Chain, in deferring the Singapore, Hong-Kong and East African stations, and also the second station in Egypt. They selected Bourn, in Lincolnshire, as the site of the English high-power station, and substituted Johannesburg for



SCHEME 4.

Proposals of Lord Milner's Commission, 1922, marks transition from Chain to Long Range.

Windhuk, the advantages of the former as regards land-line communication being sufficient to outweigh the existence of the ex-German high-power station at the latter. The Postmaster-General told the House of Commons that the erection of the high-power stations in England, South Africa and India would start at once, and that Australia had already given a contract for the erection and operation of its high-power station to an Australian Company. As South Africa and India both made similar arrangements soon afterwards, the prospect of Imperial Wireless materializing at last began to look particularly bright.

There were, however, plenty of snags ahead.

On the recommendation of the I. W/T Committee, Government had decided that the whole scheme of Wireless communication should be designed by the State, erected by the State and worked by the Post-Office for the State. This decision was made in the days of the wireless Chain. When the idea of a Chain was dropped in favour of high-power stations working direct over the greatest distances, the idea of the State doing everything was abandoned in favour of permitting private firms to design, erect and operate certain stations, while the State confined itself to control, *i.e.*, distributing traffic and determining to whom and when each station should work. This concession was really making a virtue of necessity, since, by separate agreements with Canada, S. Africa, Australia and India, either the Marconi Company or companies affiliated to it had got into their hands all the Colonial terminals of the respective wireless channels.

The Post-Office intended then to run Empire Wireless, consisting partly of Government stations, and partly of private stations, under what came to be called the system of "unified control," *i.e.*, the Post-Office would accept all traffic, and distribute it to the appropriate stations for dispatch. It would also control, *i.e.*, decide, depending on the volume of the traffic, prevalence of atmospherics and the state of ionisation of the atmosphere (*i.e.*, which part of the globe happened to be in daylight) to which station any particular station should work.

These concessions did not go far enough to satisfy. Marconi's agreed to the principle of "unified control" only on the condition that the control was left in their hands, and not in those of the Post-Office.

This was a concession the Post-Office could not make. They were obliged to make another suggestion, a system of "regional (or territorial) distribution," under which the State and Marconi's would divide the Colonies between them, each retaining sovereign control over its own system. Specifically, Government was to work England to South Africa and England to Canada, while Marconi's put up in England two new stations, in addition to their station at Carnarvon, for the rest of the Empire. This proposal was a great come-down for the Post-Office, but again Marconi's refused. With supreme confidence, they countered with a proposal for free competition, and thus produced a deadlock which lasted nine months.

In March, 1923, the Prime Minister (Mr. Bonar Law) announced :—

"In view of developments in W/T and other circumstances which have arisen since the late Government decided on a State-operated wireless chain, it is not considered necessary any longer to exclude private enterprise from participation in W/T within the Empire. Therefore, Government has decided to issue licenses for the erection of W/T stations in England for communication with the Dominions, Colonies and foreign countries, subject to conditions necessary to secure British control.

"At the same time Government has decided, in the interests of national security, that there should be a W/T station in this country capable of communicating with the Dominions, and owned and operated by the State. It will be available for commercial traffic."

In short, the Government had capitulated.

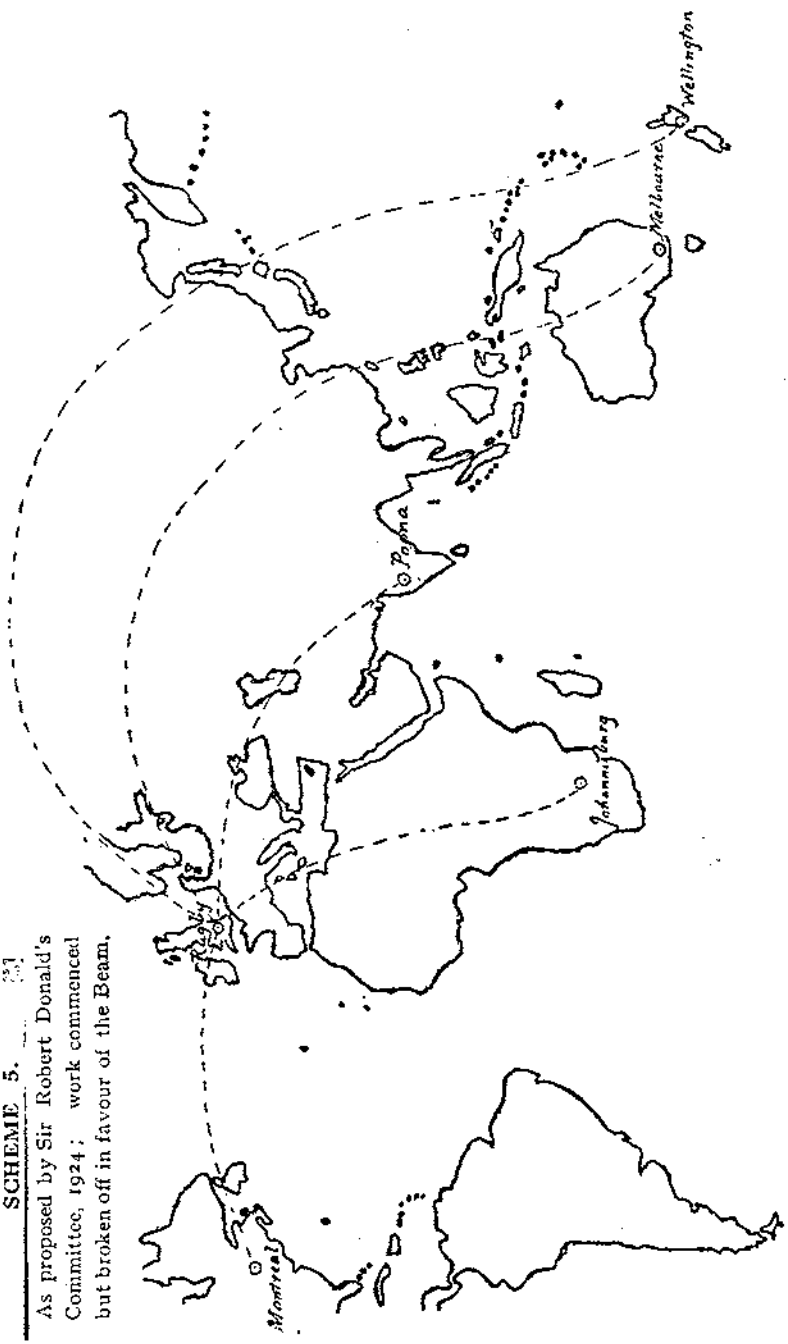
They had not only surrendered on the question of free competition, but had abandoned a policy, now eleven years old, of State-control in favour of "British" control, which, judging from the text of the announcement, must be taken as including control by a British company.

Marconi's, notwithstanding its foreign associations, was, of course, qualified under this head.

The dismay which the Prime Minister's announcement occasioned to the Post-Office, and among the supporters of the former Government policy, may be likened to the feelings of Rome on hearing of Cannae. The parallel goes further, for, as after Cannae, subsequent events quite failed to justify the apprehension felt. But this is to anticipate: the immediate result of the announcement was that Marconi's applied for a general license covering the Empire, and the Eastern Telegraph Company for one covering the wireless service between England and India.

The Postmaster-General made a number of counter-proposals, both interesting and formidable :—

(1) Marconi's to provide two high-power stations in England in addition to Carnarvon ; the Government to provide one high-power station in addition to Leafield.
(2) The whole of these stations to be worked by Government, Marconi's paying a share of the expenses.
(3) Revenue to be divided between Government and Marconi's.
(4) Unrouted traffic to be allocated to cables or to wireless, whichever would be quickest.
(5) Government to have the right to admit other companies to the pool.
(6) Government to retain its right to grant licenses to other companies outside the pool.
(7) Government to have the power of expropriation.



SCHEME 5.

As proposed by Sir Robert Donald's Committee, 1924; work commenced but broken off in favour of the Beam.

The deadlock which now resulted lasted for nine months, at the end of which time Government applied their usual last resort—a Committee. This Committee, known as the Imperial Wireless Telegraphy Committee, 1924, appointed at the end of 1923, did some swift and excellent work, and produced their report by the end of February (*v.* Scheme 5). Their chief recommendations were :—

(1) The State to erect, own and operate all wireless stations in Great Britain for communication with the Empire, except as far as Canada is concerned, the Canadian service being left in Marconi's hands.

(2) Private enterprise to be given all facilities to develop wireless communication with the rest of the world, *i.e.*, outside the British Empire.

(3) The Government wireless stations at Leafield and Rugby (for Empire communication) to be enlarged, and another high power-station erected without delay.

(4) The Government wireless station at Abu Zabal, near Cairo, to be given up when the new high-power stations in India, South Africa and Australia are working.

(5) The expert W/T Commission to report on an extension of Imperial wireless to include all the widely-scattered Colonies and Protectorates of the Empire, on the lines of the French Colonial wireless service. (NOTE :—This includes Indo-China, the West Indies, French Guiana, Réunion and Madagascar.)

The I.W.T.C., 1924, or "Donald's" Committee, "seeing no prospect of success on the lines of the policy which have been explored and discussed at much length and in great detail during the last nine months," thus felt themselves justified in recommending a reversal of Mr. Bonar Law's (March, 1923,) policy, and a reversion to the State-ownership idea.

In July, 1924, the Postmaster-General said that the recommendations of Donald's Committee were mainly accepted. We were thus back again at very much the same position as two years before, a position which led to the nine months' dead-lock that Mr. Bonar Law's proposed admission of private enterprise into Imperial Wireless failed to solve. In fact, the question of how to provide Imperial Wireless had become so knotted that cutting became the only solution. It was by the best of fortune that at this moment, when all seemed hopeless, there appeared an Alexander in the shape of Mr. Marconi. The sword with which he cut the tangled knot was his invention of Long-distance, Low-power, Short-wave Directional Wireless, better, more shortly, and more appropriately known as "the Beam."

DIRECTIONAL WIRELESS.

Before showing how the situation was thus dramatically saved, it will be necessary to say a few words about Directional Wireless. When the Beam was invented Directional Wireless was, as wireless goes, already an old story. It is almost unnecessary to say that it, also, was an invention of Marconi. It was he who discovered that a single vertical wire aerial (or a symmetrical aerial like the T-aerial) radiates energy equally in all horizontal directions, and that the converse also applies, viz., that such an aerial used for reception is affected equally by energy arriving from any horizontal direction. Further, he discovered that these properties are peculiar to symmetrical aerials, while all unsymmetrical aerials radiate waves of different intensities in different azimuths, and conversely receive greater or less amounts of energy from waves arriving from different directions.

In 1905 Marconi patented the reversed—L directional aerial, consisting of a single vertical wire (or row of such wires) with a much longer horizontal portion (or portions) pointing away from the station to which it is desired to transmit or from which it is desired to receive. Such a bent aerial radiates most strongly (and receives best) in its own plane, and in a direction opposite to that to which its horizontal portion points. Experiments appear to prove that the energy radiated or received by an inverted-L aerial thus set up is five times as great as would be the case with an aerial of the same size symmetrically arranged. It is not surprising, therefore, that, wherever the nature of their work permits, long-range wireless stations have widely adopted directional aerials for transmission as well as reception. It was so obviously uneconomic to expend energy in sending signals where they were not required, that, the directional principle having been found possible of application, much time and thought were given to the subject.

The next development of directional wireless originated, however, in a discovery of another sort.

FRAME-RECEPTION.

It was found that wireless signals, in addition to being received by means of the ordinary type of overhead aerial, either earthed or having instead of an earth a counterpoise or lower capacity, could be received upon an aerial of an entirely different type, viz., a closed coil or loop having no earth connection.

In order to understand how it is possible to receive wireless signals by means of two such widely-differing types of aerial, it is necessary to consider the nature of the wireless wave itself which carries these signals. Whatever the origin of the electro-magnetic wave, in its higher frequencies as radiant heat, light, actinic-ray, Röntgen- or Millican-ray, as wireless-message-carrier, it originates in the interaction of the two essentials of an oscillating circuit, capacity and inductance. When current is oscillating there are produced alternately a static field at the condenser or capacity-area, and a magnetic field round the inductance. As the currents oscillate in this circuit the fields (static and magnetic) are formed and die away alternately, *i.e.*, they pulsate outwards from and in towards the seat of the oscillations. It will be noticed that so far there is no question of radiation, but at a distance of about a quarter of a wave-length from the oscillating circuit, radiation actually starts through certain minute portions of energy (electric and magnetic) becoming associated to form an electro-magnetic wave. These minute portions of energy are by the inertia of the ether, so to speak, flicked off from the pulsating fields and travel together outwards with the velocity of light. The two components, electric and magnetic, of an electro-magnetic wave, are equal in energy, oscillate at the frequency of the wave, at right-angles to each other, and at right-angles to the direction of the wave. It may assist in getting a mental picture if we look upon the wireless wave as originating at the centre of a globe and as having reached the surface of it. Then, at any point on the surface the direction of travel of the wave is along the radius to that point. At right-angles to the radius, and at right-angles to each other, are the parallels of latitude and longitude. The magnetic component's oscillation is along a parallel of latitude and the electric component's oscillation is along a parallel of longitude.

The electric component is generally vertical in its oscillations. It is thus best intercepted by a lineal conductor (overhead aerial), placed horizontally, and pointing to the source of the wave. The magnetic component is generally horizontal in its oscillations. It is thus best intercepted by a coil or loop (frame-aerial) placed vertically and in the same plane as the source of the wave. The frame-aerial and the ordinary overhead aerial are thus two different means of trapping the wave in order that the receiver may discover its secret. They are alternative means, since each of them absorbs energy from one particular component of the wave, allowing the other to pass.

When the properties of the frame-aerial were noticed, signals were found to be so much weaker than with overhead aerials that the frame-aerial would have received little attention, but for the fact that it was strongly directional.

An aerial capable of rotation into the position of loudest signals was not only desirable for receiving from moving stations like ships and aircraft, but was the foundation of special departments like the wireless compass-stations which worked under the General Staff (Intelligence) in the war, locating enemy wireless-stations, and like the coastal d. f. service, which locates ships at sea and—for a small fee—gives them their bearings. An alternative to the latter is when the moving station (ship or aircraft) is itself fitted with directional apparatus. If it can then receive from two fixed stations in known positions, and if they are favourably placed for reception, the moving station can plot its own position.

The first trouble of the frame-aerial was weak signals: the second was that when it was increased in size in the interests of increased signal-strength, it soon became unwieldy. This trouble was brilliantly surmounted by the invention of the Bellini-Tosi aerial, in which two frames are mounted at right-angles, and so fixed, the necessary rotation being done not by the frames but by a small coil inductively coupled with coils in the horizontal lower portions of the two frames. When oscillations are set up locally in the movable coil, the resultant radiation of the two aerials is a maximum in the direction in which the moveable coil is pointing. Similarly for reception, the fixed frames pick up energy according to their positions relative to the direction of the incoming wave, and the movable coil by maximum (in some patterns minimum) strength of signals indicates that direction. But valuable as the Bellini-Tosi aerial was to directional wireless in general, and to reception on a loop in particular, the most valuable invention was still to come. What established loop-reception and the frame-aerial was valve-amplification, part of the phenomenal progress in wireless due to the imperative demands of war and its lavish expenditure. There is now no complaint about the frames being unwieldy, since current-amplification by means of valves has brought long-range reception (*e.g.*, Europe from America) within the scope of loops wound on frames no larger than eight feet square.

Enough has been said to show that, when Marconi invented the form of directional wireless known as the Beam, directional wireless itself was already both established and widely spread.

THE BEAM.

The Beam is often likened to the search-light. As regards the transmission-end the likeness is a good one, but it does not go far enough, since an essential part of the Beam is the collection and focussing of the rays at the reception end.

When the Beam was invented this reflection and direction of the rays at one end and collection and focussing of the rays at the other end was a novelty only as regards long-distance working. In itself, apart form this, it was the oldest form of directional wireless known, having formed part of the original experiments of Hertz, Lodge and Marconi. And, indeed, this was bound to be the case. It is barely conceivable that a scientist endeavouring to produce radiation and to detect it, should neglect such a simple means of increasing the effects he desired to obtain. The simplicity of the means lay in the fact that all good electrical conductors being opaque to wireless waves, all that was necessary to increase effects in these experiments was to place radiator and receiver in metal boxes, each box having an opening facing the other box.

Hertz, in 1887, used two zinc boxes, each with a curved side facing the open side. He showed when the open sides of the boxes did not face inwards, that by means of a metal plate, or a prism, he could reflect, or refract, the radiation from one box into the other.

For interference experiments he improved on the metal-boxes by using parabolic mirrors of zinc. A paraboloid of revolution as used with the search-light, on account of the light emanating from (approximately) a point, was not necessary. As the radiation emanated from an oscillator, say, a yard long, a parabolic cylinder was used instead, having the oscillator in the focal line.

Marconi, in his early experiments placed his Righi oscillator in the focal line of a parabolic reflector, and for reception a coherer at the focus of a second parabolic mirror.

The development of these experiments into commercial wireless telegraphy, *via* the grounded oscillator and high aerials, took place in a direction that led away from the use of reflectors. Wave-lengths were increased in order to get greater ranges, not because the longer wave-lengths were more efficient as regards the expense of energy, since the reverse is the case, but because the longer waves were more successful in surmounting obstacles and suffered less from attenuation.

With the use of longer wave-lengths the mirror ceased to be effective, since its size should, in any case, be not much less than the wave-length, and for the best results it should be larger.

The use of reflectors was thus dropped for some twenty years, until, in 1916, Marconi took the subject up again for a special purpose. Secret wireless had been demanded for war purposes, and Marconi started investigating what could be done with very short waves (2 to 3 metres). For such wave-lengths he naturally revived the reflector. He used a spark-transmitter in a closed oscillating circuit, transformer-coupled and crystal-reception, and got a range of two miles. Then, by adding cylindrical parabola reflectors of vertical wires tuned to the wave, and with apertures of 3½ wave-lengths, he increased the range from two to six miles. These trials were made in Italy. In 1917, under his instructions, the experiments were continued at Carnarvon, and the range was increased to twenty miles. It is not known whether any war use was made of these results, but, owing to their excellent directional effect, they were quickly applied to navigation in the shape of the radiophare or wireless light-house. A trial was made at Inchkeith Island, where a revolving parabolic reflector sent every two minutes a signal to every half-point of the compass, efficiently piercing fog up to a range of ten miles for any ship with a wireless eye in the form of the appropriate receiver.

When the war was over, the experiments with short waves continued, but with a new object, viz: to determine the feasibility of directional telephony, the necessary continuous wave being provided by changing to valves. With a wave-length of fifteen metres and a reflector of half a wave length aperture Marconi's assistant, Mr. Franklin, got speech sixty miles to Kingstown Harbour. This was a great success, because he was working over the horizon, in other words, the Beam, instead of being directed away into space, was behaving like undirected wireless, *i.e.*, arriving at its destination in spite of the earth's curvature.

Stations were then erected 97 miles apart, at Hendon and at Frankley, near Birmingham, and more trials were carried out, including the successful working of duplex, *i.e.*, sending and receiving simultaneously on the same aerial and the same reflector, thus not only doubling the performance, but eliminating all switching-over.

Although Marconi had proved by this time that wave-lengths of the order of twenty metres could provide a point to point directional service at a considerable range, adequate for commercial requirements,he came to the conclusion that for the longest distances, such as Imperial wireless necessitates, longer (but still short) waves were desirable.

During 1923, a series of trials were carried out on 100 metres, between a special plant at Poldhu and Marconi's yacht, the *Elettra*. The popular ideas about short waves at the time were, that they were bad travellers over land and mountains, that their range in daylight was short and unreliable, and their range in darkness, though longer, was still unreliable. It was true that there had been plenty of evidence to shake these beliefs in the U.S.A. to Great Britain amateur trials of 1921 and 1922, but there was a tendency to regard the results of these trials as "freaky" rather than to see in them a confirmation of the very sound lines upon which Marconi was working. The amateur trials certainly indicated that our ideas on the power necessary for range needed revising. High-power stations had grown from the 30 kilowatts, first used for spanning the Atlantic, to the 500 and even 1,000 kilowatts, now used for the same purpose; a growth which had proceeded mainly on the principle of smashing through at all costs—to others. The widespread successful reception in Great Britain of signals from American amateurs who were limited to 1 kilowatt, and many of whom were using less, and the results achieved by Marconi over much longer ranges with 20 kilowatts, which include telephony, incline one to wonder whether, except when required expressly for broadcasting, the 1,000 kilowatt station of the present will not join the mammoth and the megatherium.

The *Elettra* trials with Poldhu proved that all the popular ideas mentioned above regarding short waves were incorrect, at any rate as far as 100 metres was concerned. The signal-strength at 820 miles, with the whole of Spain intervening, was reported the same as in Falmouth Harbour when the yacht was only twelve miles from Poldhu. The *Elettra* was worked to on 12 kilowatts as far as the Cape Verde Islands (2,230 miles), although the yacht itself had no reflector.

Trials were continued the next year, being extended to South America and to Australia, and in June, 1924, wireless speech was received in Sydney from Poldhu by means of the Beam on 100-metre wave, using 30 kilowatts only, as compared with the 1,000 kilowatts ($12\frac{1}{2}$-mile wave) previously used for a similar performance.

THE BEAM FOR IMPERIAL WIRELESS.

But meanwhile, in 1923, the Marconi Company had gained sufficient experience of Beam-working, and was ready with a proposal to Government, which effectively cut the Gordian knot. On March 1st, at the very moment of issue of the Donald Committee's Report, they claimed in the Press the following advantages for the Beam as compared with High Power:—Marked reduction in the initial cost of stations, decreased cost of maintenance, and a far greater speed of working. Increased secrecy, owing to the Beam being dispersed over 30° instead of 360°, was also claimed, but, although this is not without value for Imperial as opposed to commercial purposes, secrecy in matters political or strategical is rather an absolute than a relative matter, and the real advantages in diminished dispersion are:—

(i) Less interference with other stations; hence an increase in the total number of stations possible. This is a most important point in view of the rapidly-increasing number of stations in the world, and the consequent congestion on the limited number of wave-lengths available.

(ii) A vast saving of energy; thus a 30° dispersion Beam would produce the same effect as non-directional wireless with 30/360 = one-twelfth of the power. A reflecting system at the receiving-station would effect the same ratio of concentration, thus making possible a further reduction to one-twelfth of the power, or to 1/144 in all.
With narrower Beams this saving rises very high.

(iii) Much reduced liability to suffer from atmospherics and from interference by other stations.

Before the Royal Society of Arts in July, Marconi claimed his discovery of the generally unsuspected fact, that short-wave wireless with lower power gives far better results than the system upon which wireless development had hitherto been concentrated, as a "revolution." Upon the results as announced to the public this claim may be conceded.

The Government, no doubt swayed by the deadlock in Imperial Wireless as regards high-power stations, and tempted by the vastly reduced cost of beam-stations (less than one-quarter that of high power stations), quickly accepted the Marconi Company's proposals, an acceptance even then anticipated by a leading newspaper in the somewhat ungracious words :—

"It would appear, therefore, that some advantage has accrued, after all, from the otherwise deplorable delay in establishing the Imperial Wireless Chain."

The Postmaster-General announced in the House of Commons only twenty days later :—

(1) Government had accepted the two main recommendations of Donald's Committee as regards the State owning all Imperial Wireless stations in England and the Post-Office working them.

(2) That the Marconi Company had put forward proposals for working by Short-wave Directive, or Beam, from England to the Dominions and India, and were willing to co-operate in whichever system might be adopted.

(3) That the Marconi Company had already entered into an agreement with the Canadian Government to build a Beam station in Canada for communication with England, and that, with the House of Commons approval, he (the P.M.G.) would enter into an agreement with Marconi's for a Beam-station in England to work with Canada. If trials were successful, such stations to be bought by the State for £58,000, and further stations to be built for communication with South Africa, India and Australia, at £36,000 each.

(4) That the Marconi Company's guarantee, included in contracts, was a speed of 100 words per minute for the following number of hours a day, based upon the sun's mean altitude :—With Canada, 18 hours ; with India, 12 ; with S. Africa, 11 ; with Australia, 7.

(5) In order to have wireless communication at all hours and for simultaneous working in all directions at all hours (considered essential for strategic and other reasons) high-power stations of the Rugby type would still be necessary, and the wireless station at Rugby would need to be extended.

There was a certain amount of grumbling in the newspapers over these announcements, and hard words were used about the "restraining shackles of a Government monopoly," but there was general satisfaction that the long struggle as to how Imperial Wireless was to be provided and how worked was at last ended. Not only the Government and the public were satisfied at the settlement, the other two parties had also grounds for satisfaction, the Post-Office, as having gained the control on which they had insisted through thick and thin, and the shareholders of Marconi's when they were informed that their Company had contracted to erect the Beam-stations in England at a profit of 10% plus 5% overhead charges, and would receive $6\frac{1}{4}$% royalty on all takings for wireless messages, an arrangement "likely to produce a substantially greater revenue" than would have been gained under the cancelled contract of 1913.

THE NEW STATIONS.

The trials between England and Canada referred to by the Postmaster-General in July, 1924, were successful. Contracts were made accordingly, and work started on all the Beam-stations in England forming part of the Imperial Wireless scheme. The Dominions and India contracted at the same time with Marconi's for their own stations for this service.

The following unofficial list gives what is believed to be the present state of affairs :—

IMPERIAL BEAM-STATIONS.

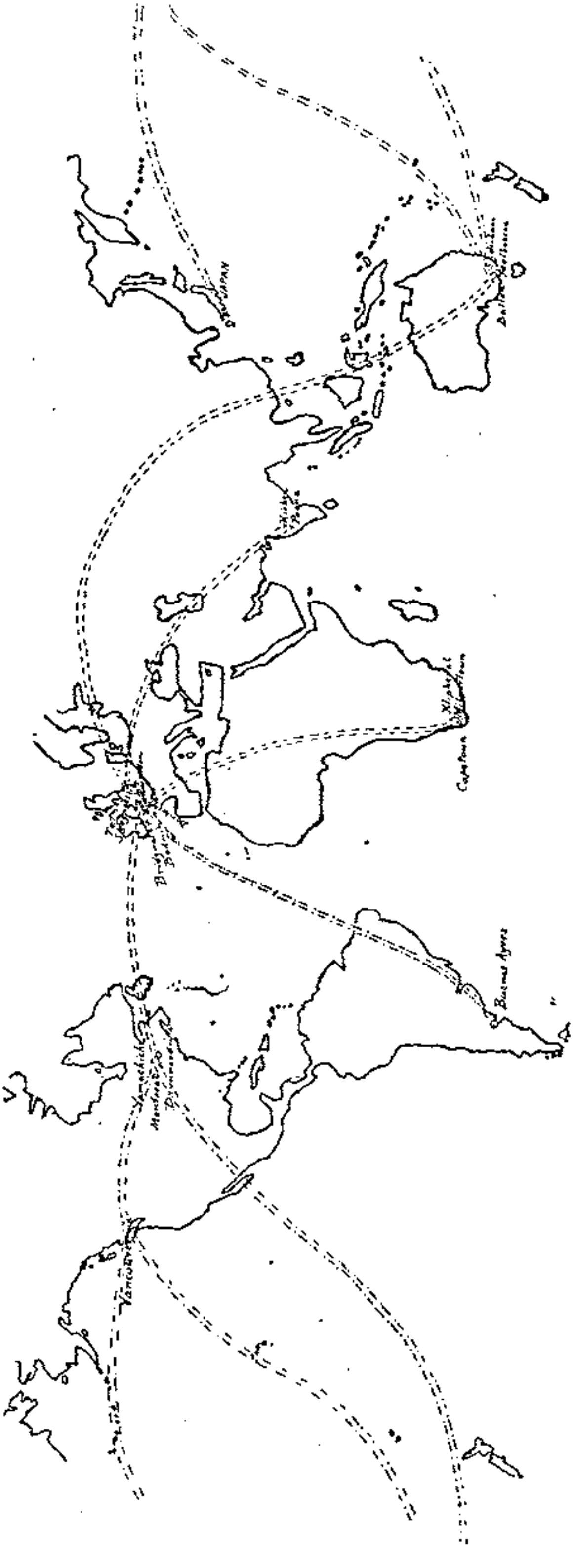
Service.	In.	For.	Transmission.	Reception.	State.
1	England	Canada	*Bodmin*	Yamachiche 25 m. N. of Drummondville	Opened 25/10/26
	Canada	England	Drummondville 35 m. E. of Montreal	Bridgwater	
2	England	S. Africa	Bodmin	Milnertown, near Capetown.	Due for opening early in 1927
	S. Africa	England	Klipheval, near Capetown	Bridgwater	
3	England	Australia	Tetney, near Grimsby	Sydenham, 15 m. from Melbourne	P.M.G. said on 9/12/26 "trials hoped to be completed in some weeks."
	Australia	England	Ballan, 50 m. W. of Melbourne	Winthorpe near Skegness	
4	England	India	Tetney, near Grimsby	Near Poona	Due for opening early in 1927
	India	England	Near Poona	Winthorpe, near Skegness	

To which should be added :—

PRIVATE BEAM-STATIONS OF IMPERIAL VALUE.

5	Australia	Canada	Ballan, 50 m. W. of Melbourne	Yamachiche, 25 m N. of Drummondville	Owned by Canadian and Australian Marconi Co.'s.
	Canada	Australia	Drummondville, 35 m. E. of Montreal	Sydenham, 15 m. from Melbourne	

This service, by relay at Montreal, provides with Service 1 an alternative to Service 3.



SCHEME 6.—The Beam System.

Between Gov't Station & Marconi Station – – – – –

Between 2 Marconi Stations – · – · –

IMPERIAL HIGH POWER STATIONS.

1. Leafield, built as part of 1913 Imperial Wireless Chain; since enlarged; works with ships; sends Press telegrams to Nova Scotia, Egypt and India, and broadcasts British official communiqués.
2. Rugby (Hillmorton), built as part of Mr. Bonar Law's 1923 scheme; since enlarged; can work to ships in every part of the world.

As regards the high-power stations which should have been erected to communicate with Rugby:—In South Africa, work had actually started on a high power station, but was stopped owing to favourable representations of the Beam system: in Australia, negociations as regards providing a high power station were broken off in favour of a Beam-station, although the Commonwealth Government had been advised by the British Government to provide stations of both kinds; in India, the company which had tendered for a high power station was allowed to withdraw its offer and to tender for a Beam-station instead.

The utility of the large Government wireless station at Rugby has thus been curtailed. It can still be of the utmost importance for communication with ships and for broadcasting, since reception of its messages can easily be arranged in all British possessions.

As regards the list of Imperial Beam Stations, certain points will be noticed. For each service there is at each end a pair of stations, one for transmission, and one for reception. This separation of transmitter and receiver, combined with directional transmission, is the usual practice for all long-range high power services, in order to obtain duplex working; thus Marconi's high power station at Carnarvon has its receiver at Towyn, thirty miles away, while the Government high power station at Leafield receives at Banbury. The grouping of transmitting stations in pairs, and of receiving stations the same, is done for administrative purposes.

In addition to being duplex, the stations all work High Speed Automatic, being operated by perforated tape previously prepared by hand, guaranteed speed=120 w.p.m., or 240 duplex, *i.e.*, 144,000 words in a ten-hour working-day. Against this the best cables to America average 25 w.p.m. (hand speed), for a 24-hour day, *i.e.*, 36,000 words per day. Hence the Postmaster General was able to announce in July, 1926, that (except for Canada) there would be a reduction of one-third on the cable rates existing in July, 1924, or 8d. a word less to South Africa, 7d. a word less to India, and proportionate reductions on Press telegrams.

In the comparison between cables and wireless, ten hours has been taken as the working-day of the latter, owing to the limitations laid down in the Marconi Company's guarantee of the Beam system in 1924, but it appears from the Press that subsequent technical improvements have allowed a 24-hour day to be substituted, even in the worst case as regards daylight interference, viz., England to Australia, for which the original guarantee was only seven hours in the twenty-four.

High Speed transmission implies High Speed reception, both being above the capabilities of the human operator. Signals on the receiver are transferred by land-line to a central office, where the message is recorded automatically by tape perforations, and the perforated tape is then passed through a printing machine which converts the message into Roman characters on strip, ready for pasting on telegraph forms.

In the case of all Beam stations in England the Central Telegraph Office in London will operate both transmission and reception by "remote control," *i.e.*, through land-line. In Canada the same system will apply at the offices of the Canadian Marconi Company in Montreal. Similarly the transmission from Ballan will be keyed at a central office in Melbourne to which the reception at Sydenham is led in by land-line.

Reflectors are of the same type at transmitting- and at receiving-stations. They are believed to consist either of a series of vertical wires suspended equally spaced along a parabola of which the aerial occupies the focal line, or the aerial itself (one wave-length high) consists of a number of vertical wires suspended between masts occupying points on a parabola, one wave-length apart, while the reflector, consisting of similar sections of vertical wires, is placed parallel to the aerial and at a distance of a quarter wave-length behind it. This distance permits both aerial and reflector to hang from 40 ft. horizontal arms carried by a single row of masts.

The dispersion from one section of such an aerial (being of a symmetrical type) is 360°. The effect of the reflector placed parallel to it and a quarter wave-length away is to make the aerial uni-directional, *i.e.*, its dispersion is reduced to 180°.

If four such sections, complete with reflecting screens, are placed along a parabola, practically all the energy radiated is confined within an angle of 30°. Twenty sections can even reduce the angle of dispersion to 6°. Equal areas of aerial at the transmitting- and receiving-stations are essential, as it is calculated that 500 times the magnification is given by having a 10 square-wave-length aerial at each end, as against having a 20 square-wave-length aerial at either end.

Where unity represents the energy received under similar conditions from a simple vertical aerial one-eighth of a wave-length high, the magnification claimed for a Beam-aerial twelve square wave-lengths in area, with reflecting-screens, at both transmitting- and receiving-station is 14,000.

FEEDER SYSTEMS.

In densely-populated England, where land-line telegrams (or at least phonograms) can be despatched from post-offices in the smallest villages, it is not always easy to get people to realize that long-distance wireless to Britain's chief possessions is only the beginning of the matter. Where different conditions prevail, where territories are vast and population is scattered, it is fortunate that the Governments are alive to this fact. Four years ago Australia, owing to the enterprise of the Commonwealth Government and of the Australian Marconi Company, had a system of over thirty wireless stations distributed over the continent, and including New Guinea, King and Flinders Islands. The whole scheme embraced the Solomon, Fiji, Gilbert and Ellice Islands. In February, 1920, the Marconi Company had brought out a pamphlet working out in great detail a proposal for a network of wireless communication to serve the needs of the whole British Empire. Under such a scheme, communications between Great Britain and a Dominion would be by a wireless trunk, the terminals being called Main Trunk Stations.

Each Main Trunk Station is connected by land-line to a Central Control Office, to which is connected also by land-line a Main Feeder Station. The M.F.S. works by wireless with Local Feeder Stations in all suitable places. The L.F.S. works to the Main Feeder Station, and is also equipped for working to Small Local Stations.

The system is duplex throughout, except between Local Feeder Stations and Small Local Stations, where simplex is considered sufficient.

These ideas were considered by Sir H. Norman's Committee, and thoroughly turned down by them on the grounds that the Feeder Systems could only duplicate existing postal and telegraphic arrangements. A possible reason for such an opinion has been indicated above. The Feeder System, so far from being unnecessary as duplicating existing arrangements, is indispensable for linking up outlying possessions. This fact was tardily recognized when, stimulated by East Africa, Singapore and Hong-Kong dropping out of the Imperial Wireless Scheme, Sir R. Donald's Committee inserted as their last recommendation, that the W/T Commission should "report on a wireless system for the Colonies to complete the Empire network."

The Feeder System is equally indispensable in the vast spaces of Australia, Canada, and South Africa, where land lines either do not exist or are difficult to maintain. It would, in Great Britain, where telegraphs abound, be of a different character, having its Local Feeding Stations at continental capitals, thus providing the Imperial Wireless Service with points of contact with the outside world. Important as this would be for Press and commercial purposes, it would be of inestimable significance for introducing to the Colonies the European atmosphere necessary for an understanding of Great Britain's position as an European power.

Whether this idea materializes or not, the Colonial Feeder Systems are being got on with by the Colonial Governments. Pretoria Post Office will operate a transmitter at Roberts' Heights, communicating with Salisbury, in Rhodesia, thus relieving a long land-line through unpopulated country in Bechuanaland. This is only the beginning of a scheme for connecting Pretoria by Beam with all the principal centres in the South African Union. Similarly, the Australian capitals, Sydney, Brisbane, Adelaide, Perth, Hobart, and probably Canberra and Darwin, will be equipped as Beam Local Feeding Stations. The Feeder Systems are thus growing *pari passu* with the Trunks.

A great step forward was taken when the England-Canada Beam Service passed the official Post-Office tests between October 7th and October 14th, 1926, sending 250 words per minute duplex for eighteen hours on end, and averaging 130 words per minute for the whole seven days. The Service was opened for public use on October 25th.

Considering how slow Great Britain was in getting off the mark in the matter of wireless communication with the rest of the Empire, and how far behind the United States and France we have been in this respect, it is interesting to record the opinion of the *Times* that the completion of the Imperial Beam Stations now imminent, taken together with the high power station at Rugby, " will give Great Britain the most complete wireless service in existence."

Sources of information:—

(*a*) The daily press, especially the *Daily Telegraph* and the *Times*.

(*b*) Government publications:—
Report of Imperial W/T Committee, 1919-20.
Report of W/T Commission, 1922.
Report of Imperial W/T Committee, 1924.

(*c*) Marconi W/T Company's publications:—
Proposal for Wireless Network for the British Empire.
The Beam System for Long-Distance Communications.

(*d*) Several articles in *Modern Wireless*, most of them by Lt.-Col. C. G. Chetwode-Crawley, R.M.A., Deputy Inspector of W/T, G.P.O.

THE SHANNON HYDRO-ELECTRIC POWER DEVELOPMENT.

By LIEUTENANT J. V. JENKINS, R.E.

The following notes were compiled after a visit to the Shannon Scheme late in 1926. By the time they appear in the *R. E. Journal* they will be in some respects out of date, as the work is making rapid progress, but they serve, nevertheless, to give an outline of a very important project, and may be found of some general interest.

I. INTRODUCTORY.

The excessive cost of coal has of recent years quickened the interest both of the general public and of engineers in the development of water power in the British Isles. The outcome of this increased interest, apart from sometimes ill-informed comment in the daily press on the subject, has been the production of numerous schemes for hydro-electric development. The majority of these, including the much-discussed Severn project, were not destined to come to fruition, but the schemes for the development of the Shannon were more fortunate. The Government of the Irish Free State, influenced partly by the fact that all coal has to be imported, decided to proceed with the most promising of the projects, the contract for the civil engineering work being given to Siemens-Bauunion in August, 1925. The electrical part of the work is being carried out by Siemens-Shuckert under a separate contract.

II. GENERAL OUTLINE OF THE SCHEME.

The Shannon, which is the largest river in Ireland, flows for the greater part of its course through country which is too flat for the economical development of water power. For some miles above Limerick, however, the fall is relatively rapid, and it is this fall which the present scheme is designed to utilise. The following brief notes may be best understood by referring to the General Sketch Plan (Fig. I).

Headworks.—A weir is being built about a mile and a half above O'Briensbridge, obstructing the river at a point where there is a bend, and the waterway is relatively narrow. The bend allows the water to flow into the Head canal leading to the power station in a natural straight line; further, owing to a fault in the strata, the rock comes very near the surface at this spot, so that little excavation is called for in making the foundations. The average depth of the river at the site is 12′, and the velocity of the current when in spate reaches 8 ft. per second.

The weir is to be constructed of Portland cement concrete, the compact sandstone which abounds in the district forming the aggregate. The concrete, which is to lie on top of the rock without any further excavation, will be placed round a steel framework, composed of tubular uprights at about 10′ interval, anchored to the rock by 18″ steel spikes cemented into bore-holes. A view of the coffer-dam, which is being constructed in three stages, and gives access to the river bed, is shown in Photo. I.

When finished, this weir will raise the water level of the Shannon to the average winter level of Lough Derg, and will be 200 yards long. This means that embankments will have to be built not only immediately above the weir, where a large area of more or less worthless country will be flooded, but also round the greater part of the Lough itself, as the district is already water-logged in winter. The fact that the river will be kept within bounds is one of the incidental advantages of the scheme.

Pondage.—In addition to the water impounded between the embankments above the weir, where a storage basin about half-a-mile wide will be formed, the contents of Loughs Allen, Ree and Derg, through which the Shannon flows, will be available as a reserve. The total present storage capacity of the three lakes is estimated by the contractors at 11,630 million cubic feet, and this could be more than doubled by increasing the height of the embankments and building additional weirs at the outlets of the two upper loughs. It is interesting to note that this storage capacity is equivalent to approximately twenty million K.W.H. at the average head available of 100 feet.

Head Canal.—The water will be taken from above the weir to the power-station at Ardnacrusha by a canal $7\frac{1}{4}$ miles long, of modified trapezoidal form, 264 feet wide at high water level. (See Type Cross Section, Fig. 4).

For the partial development at present contemplated, the canal has been designed for a flow of 8,475 cusecs, and the cross-sectional area being 5,104 sq. ft., the mean velocity will be 1.1575 ft./sec. The head available at the power-station is 100 feet, and the maximum output will therefore be about 56,500 K.W. This is half the total output obtainable from the Shannon, but provision has been made in proportioning the canal, for doubling the flow by raising the level of the water, and this will be done if and when it becomes expedient, from the commercial point of view, to instal more plant.

The small tributaries of the Shannon, which are prevented by the embankments from flowing into the river, are to be collected into a channel running parallel to the embankment, as indicated by the chain dotted line on the general plan. A reinforced concrete culvert takes the water from the channel under the head canal into the Shannon. The Blackwater River, which crosses the line of the canal about a mile above the power-station site, is provided with a similar culvert, the upstream entrance of which is shown in Photo. 2.

The canal is spanned where required by a standard type of reinforced concrete bridge, and will be available for navigation. Photo 3 gives a view of the canal under construction.

Power Station.—The Power Station, which is sited at Ardnacrusha, will be equipped with Reaction Turbines of the Francis type, operating at an average head of 100 feet, and drawing water from the forebay through reinforced concrete pipes. The turbines will discharge into the tailrace, 1⅝ miles long, which returns the water into the Shannon about a mile above Limerick. (See Fig. 1).

When the development is complete, there will be a total installed H.P. of 180,000, but, for the present, only three sets of 30,000 H.P. each are being provided for, as it is not considered that the Irish Free State will require the whole possible output in the immediate future.

An idea of the size of the excavations may be gathered from Photo. 4, which shows a steam shovel at work on the foundations. The spoil excavated, which at the time of writing is a stiff boulder clay, is removed partly in tip-waggons directly along the bed of the future tailrace, and partly by cable crane to the railway running beside the head canal; it is used in the construction of the embankments.

To give a certain amount of regulation at the power station, in addition to that provided at the weir, a channel for waste water is to be made (Fig. 2), while a series of locks will afford a means of raising ships of 150 tons from tailwater to headwater level.

Transmission of Energy.—Power will be transmitted to Dublin and Cork at 100,000 volts, and to the rest of the country at 38,500 volts. Subsidiary transmission lines will supply distant localities at 10,000 volts.

III. TEMPORARY WORKS AT ARDNACRUSHA.

The temporary works necessitated by a project of this size are naturally very extensive, and are particularly interesting to military engineers. The field headquarters of the scheme are near the site of the permanent power station at Ardnacrusha, and to facilitate supervision, distribution of power to the works, &c., the workshops, stores, and other temporary structures are concentrated at this point. (See Fig. 2, lay-out of works at Ardnacrusha).

Accommodation for Staff and Workmen.—This comprises, in addition to the usual works offices, two hutted camps, one for 750

PHOTO. 1.
Cofferdam at the Weir.

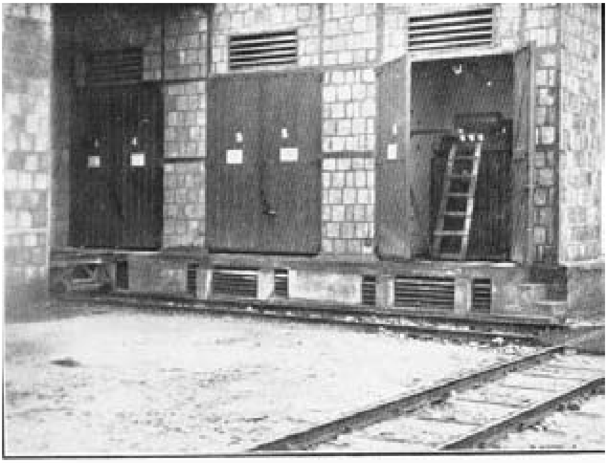
PHOTO. 2.
Entrance to Blackwater River Culvert.

BLACKWATER RIVER CULVERT

Photo. 3.
Head Canal under Construction.

Photo. 4.
Excavations at Power Station Site.

Excavations at power station



Photo, 5
Transformer House [Temporary Power Station.]

Photo, 6
Workshops.

Workshops

Photo 7. Bank Builder.

Photo 8. Bucket Electric Dredger.

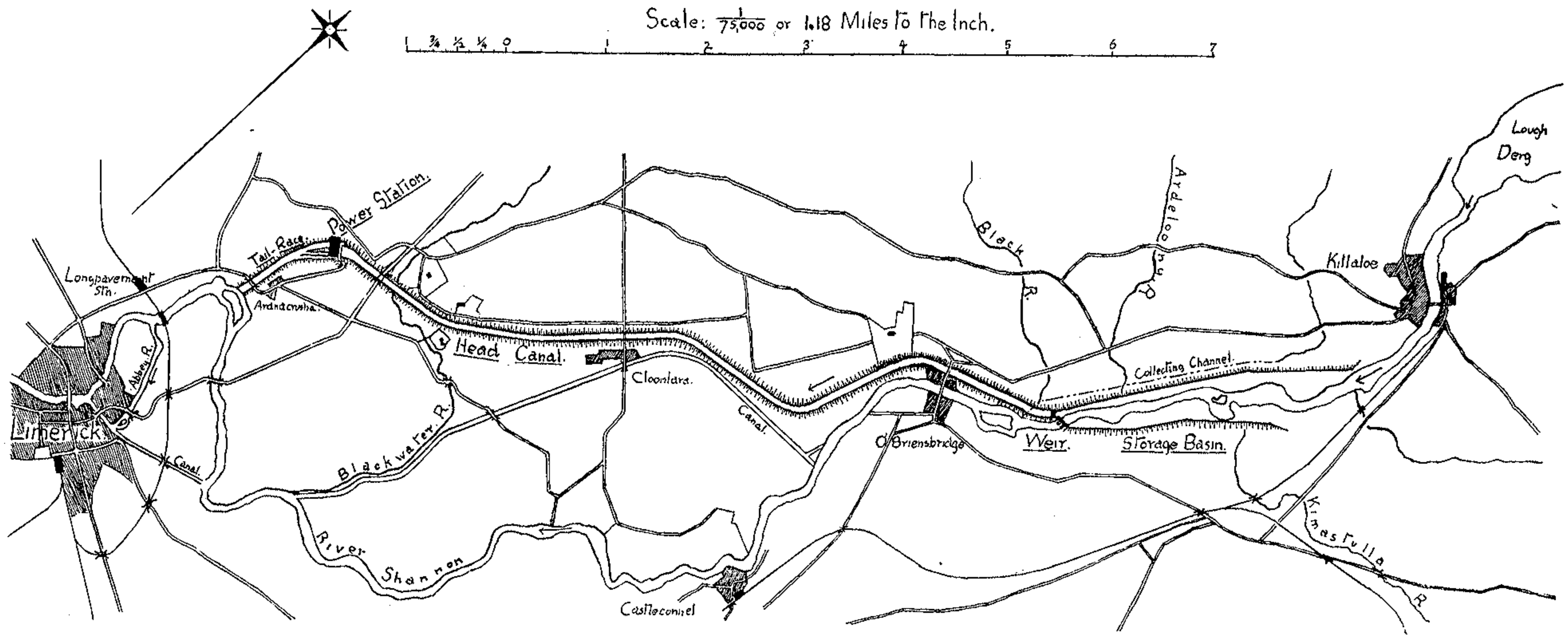
Photo 9. Crane Tripods at the Headworks.

Crane tripods

SKETCH SHOWING GENERAL PLAN OF SHANNON SCHEME.

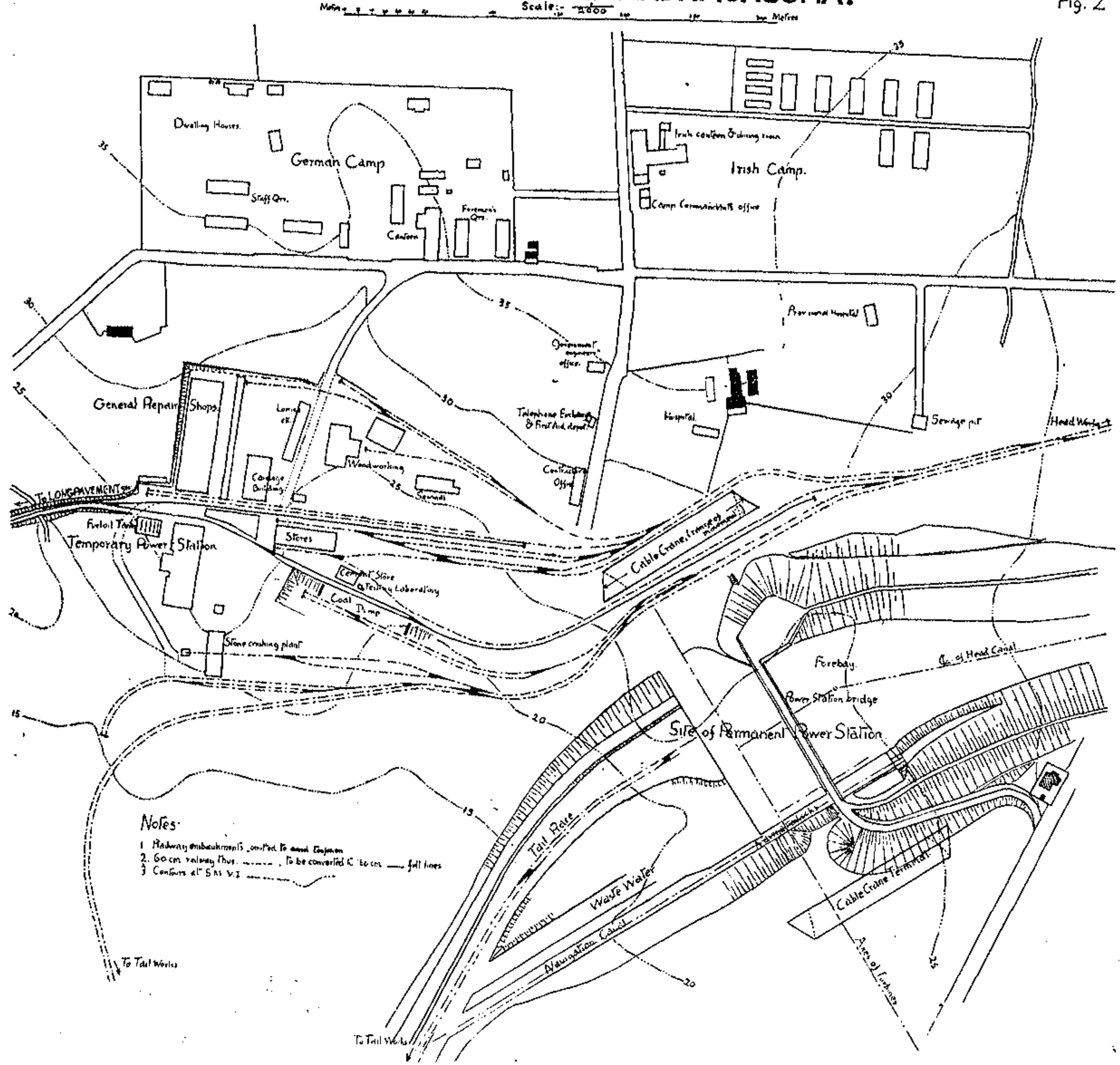
Fig. 1.

Scale: $\frac{1}{75,000}$ or 1.18 Miles to the Inch.

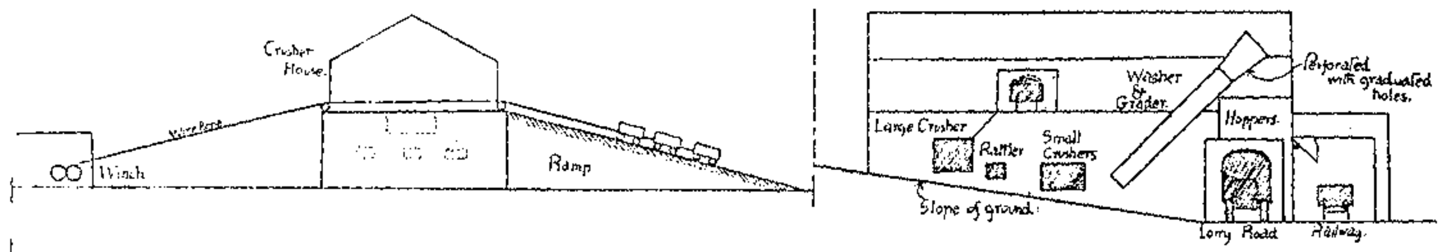


PLAN OF WORKS AT ARDNACRUSHA.

Fig. 2

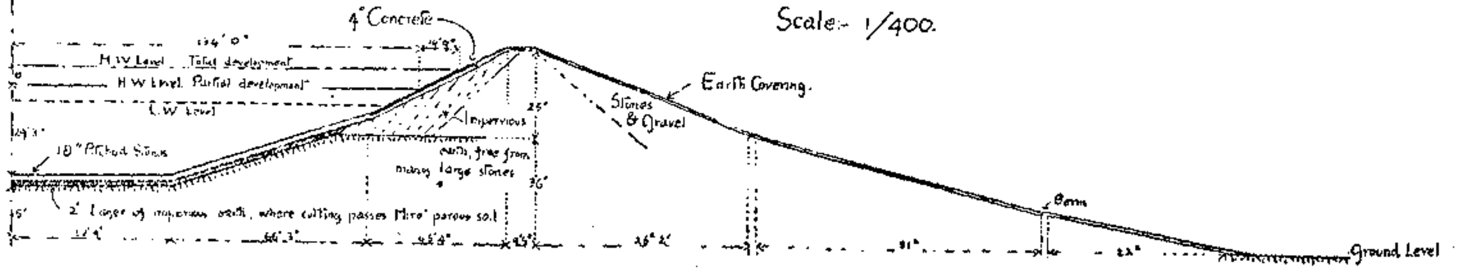


DIAGRAMMATIC SECTIONS of STONE-CRUSHING PLANT FIG. 3.



TYPICAL HALF CROSS-SECTION of HEAD CANAL. FIG. 4

Scale:- 1/400.



Irish labourers and one for 200 German specialists. The actual constructional details of these camps call for no special comment, but the very complete accommodation is worthy of note, including as it does, canteens, cook-houses, dining-rooms, bath-houses, and a separate mess for the engineering staff. The resident engineers are provided with wooden houses.

Temporary Power Station.—In order to supply electricity to the works, a power house has been erected to accommodate nine Diesel-driven alternators. The building consists of a steel skeleton, with concrete block walls and a slated wooden roof supported on steel purlins. Mention should be made of the very neat way in which principal rafters of heavy section are built up in one piece with the stanchions supporting the roof, thus obviating the use of roof trusses. The economy of the design over one using standard sections seems rather doubtful, unless a large number of similar buildings are being erected, but the elimination of tie-rods gives more headroom, and incidentally improves the appearance of the interior. The floor is of P.C. concrete and has the oil and water drains embedded in it, and the usual trench is provided for the exhaust pipework. The engine-room is well lighted and ventilated and there is ample gangway space.

Seven of the nine engines are by Krupp; each of these develops 520 H.P. at 214 R.P.M., and is coupled to an alternator of 320 K.V.A. rating. The remaining two sets, which are by Deutz, run at 250 R.P.M., and are rated at 270 H.P. and 160 K.V.A. All are of the vertical, totally enclosed, automatically lubricated type.

Though the contractors describe the engines as Diesels, no blast air is used. The Roumanian crude oil used as fuel is injected "solid" at a pressure of about 2,600 lbs. per sq. inch, a separate pump being provided for each cylinder. Fuel consumption is stated to be in the neighbourhood of the remarkably low figure of .375 lb. per B.H.P. hour.

The Krupp engines have the overhead cam-shaft which is usual in Diesel engines practice, but the valves of the Deutz engines are operated by push-rods from the crankcase, in the manner common in motor-car engineering, the design being neatly carried out. The exhaust gases are very effectually silenced by buried expansion boxes with baffles, and the whole plant runs smoothly and quietly.

The cooling water from the various jackets was originally run to waste, but as the whole supply has to be pumped, this was found to be uneconomical, and a cooling tower has since been erected to enable some of the water to be used again. The fuel oil for the engines is stored outside the buildings in five large cylindrical G.I. tanks, of 50 tons capacity each, sunk below ground-level and lying on their sides. From these the oil is pumped to the expense tanks in the engine room.

On the electrical side, 50 cycle three-phase A.C. is generated at a pressure of 400 volts, and transformed up to 17,000 volts for transmission to distant parts of the works, where it is stepped down to 3,000 or 380 volts as required. The station switchgear, which is housed in a lean-to annexe at one side of the building, does not call for much comment, as it follows standard practice, the board being arranged in panels, and the H.T. gear having mechanical remote control. The transformer house, seen in Photo. 5, is provided with large double doors for each transformer, so that in the event of fire the offending unit can be quickly pushed out on to a small truck and removed to a distance. The truck and railway can be seen in the photograph.

The exceptionally unfavourable power factor of a load composed chiefly of lightly loaded induction motors is well illustrated at this station, where Cos ϕ falls as low as .45. The plant being temporary and of ample capacity, correction is presumably regarded as not worth while.

As would be expected, in view of the claim of 25% efficiency put forward for the installation, the cost of generation compares very favourably with that of the public supply station in Limerick, and negotiations are on foot for the sale of energy to the town, pending the completion of the hydro-electric station. Town lighting would be a good proposition, as the night load on the station is small at present, and the load factor could thus be improved.

Workshops.—These include :—

1. A composite repair shop for the maintenance of the large quantities of plant and machinery used on the works. This consists of a steel-framed building 275′ by 84′, with breeze block walls containing a smithy, a metal foundry, fitting, welding and machine shops and a tool-room. A 15-ton overhead electric crane of 50′ span runs right along one-half of the building. There are three locomotive pits under the gantry of this crane, the locomotives being run in on rails at right angles to the main axis of the building. The electrically-driven machinery installed includes lathes, planing, milling, grinding, multiple drilling, and hydraulic testing machines, and in the smiths' section a pneumatic power hammer and a shearing and punching machine. These shops employ 110 hands, and are capable of undertaking any ordinary repair, including the manufacture of spare parts if required. A view of the outside of the building is shown in Photo. 6.

2. A saw-mill, equipped with a log frame and circular saws, for the reduction of timber for temporary structures, railway sleepers, form-work, etc.

3. A carpenters' and joiners' shop, built in the same block with a wood-working machine shop, for the further treatment of timber which has been dealt with by the saw-mill. These shops are less

used now that most of the temporary building and hutting has been completed.

4. A waggon building shop.

The machinery for all these shops is electrically driven from the temporary power station, the group system being extensively imployed so as to reduce the number of motors needed.

Stores.—A stock of spares is held for the plant in use, and in the large general store, 138′ by 47′, is kept the supply of poles, wire, insulators, etc., required for the erection of transmission lines, and other stores for the building sites.

The cement is kept in a special store near the railway, to facilitate the off-loading of new supplies and the dispatch of the large quantities required on the works. Close to the store is a small laboratory, where the cement and the other ingredients of concrete are tested at frequent intervals to ensure the maintenance of the correct quality.

Coal Supply.—A large supply of coal is required, the daily consumption of the locomotives and steam-shovels amounting to about 40 tons. The coal arrives in steamers at Limerick harbour, where it is unloaded into motor lorries, which convey it to Longpavement station, where the terminus of the contractor's light railway is situated. This railway takes it on to Ardnacrusha, where it is deposited in the dump provided, which is capable of holding 1,000 tons. Distribution is effected by the works light railway.

Water Supply.—The necessary water supply is obtained from the Blackwater River, nearly a mile from the works, by means of an electrically-operated pumping plant, and is distributed from a water tower built on the high ground in the German camp.

IV. Plant and Machinery.

Excavating Machinery.—For excavating the most difficult soil, in which large boulders are liable to be met with, steam shovels are used. There is a total of 13 of these machines on the works, of which some are mounted on caterpillar tracks and some on railway wheels. They vary in capacity from 2 to ½ cubic metres.

For the easier work, electric bucket excavators are employed. Photos. 2, 3 and 7 show clearly the appearance of these excavators, the method of using them for bank-building, etc., and also how they are mounted on a double line of light railway. They have a capacity of 300 cubic metres per hour.

There are also 7 smaller caterpillar bucket excavators, which are used for the removal of top soil.

Light Railway System.—The works are served by an extensive 60 cm. railway system, which connects Longpavement station with Ardnacrusha and the headworks above O'Briensbridge. The main line from Longpavement will subsequently be relaid in 1.6 metre gauge as far as Ardnacrusha. (See Fig. 2).

For the running roads, flat bottomed rails spiked to wooden sleepers are used, but lines or sidings subject to frequent alterations are laid in Decauville track.

There are 58 locomotives, the majority of which are of the usual 0-4-0 type employed by contractors for this class of work, and have two outside cylinders with a modified form of Stephenson's link valve gear, operated by reverse cranks instead of by eccentrics. The rolling stock consists mainly of tip trucks for earth, of which there are 517 of various sorts, of from 3 to 5 cubic metres capacity.

Some electric locomotives have recently arrived from the continent, but have not yet been put into service.

Stone Crushing Plant.—This is situated at Ardnacrusha and is capable of dealing with about 10 cubic yards of the local compact sandstone per minute. The crushed stone is required on the works for concrete, railroad ballast, and road metal, and will be needed at a later stage for the stone rubble lining of the canals.

The raw stone is delivered to the plant in trucks, which are drawn up a ramp by an electric winch, situated on the side of the crusher house distant from the ramp. The machinery, which is by the International Baumaschinen Gesellschaft, consists of, first, a large crusher, with jaws 3 feet wide. After going through this, the stone is conveyed to a rattler, and thence to three smaller crushers, which reduce it still further. The crushed stone is then passed on to two inclined rotary graders and washers, finally falling into hoppers, whence it can be dropped directly into either lorries or railway trucks as desired. (See diagramatic Cross Sections, Fig. 3).

The water for washing is introduced into the upper end of the grader cylinders, up which the stone is raised by Archimedes' screws.

Cable Cranes.—These are in use at the headworks and at the power station site. The position and range of movement of the crane at Ardnacrusha is shown on the plan of the works (Fig.2) ; it consists essentially of two lattice steel tripods, connected at the top by a suspension cable, along which a traveller carrying the electrically operated hoisting gear can be moved by means of a separate cable, the whole apparatus being operated from a cabin halfway up one of the supports.

The adaptability of this type of crane to almost any site, and its great utility for the rapid and precise handling of heavy loads, are self-evident. In calm weather, the accuracy of movement attainable is almost that of an ordinary crane, but it would be interesting to see the effect of a high wind when working over a long span.

Photo. 9 shows the tripods of the crane at the headworks ; it will be noted that the erection is not yet complete.

V. Administrative Arrangements.

1. *Hours of Work.*—A fifty-hour week is worked by the 1,500 men employed, and at their own request, Saturday and Sunday are whole holidays, except for such routine work as pumping. The remaining five days of the week are ten hour days. The engineers approve highly of the arrangement, as they say that the men get through very little work on a Saturday morning when the more usual system of hours is followed.

2. *Camp Organisation and Discipline.*—The organisation and discipline of the workman's camps is on almost military lines, though of course rather free and easy, especially on Saturday evenings, when Wild West scenes are not infrequently enacted, the majority of the Irish having at least "drink taken."

Each camp is governed by a Camp Commandant, elected by the men themselves, but not dismissed by them. His word is law in the Camp, and to maintain order he appoints camp policemen, who take instructions from him only. He is empowered to award punishments and fines.

The men are housed on the barrack room principle, the rooms, &c., being inspected periodically by the Camp Commandant. All the engineers are also empowered to inspect and report on rooms, the occupants of any found dirty or untidy being sent before the Commandant. Proper attention to cleanliness and sanitation is thus assured.

3. *Messing, &c.*—Messing is arranged for by a Central Mess and Canteen. Each man pays a fixed sum (*i.e.*, 2s. 1d. per day) weekly for his meals, and for this he is fed amply and well, the standard being as high as that of the best messing in the Army. A varied diet is provided, but the main item in the Irish menu is potatoes, of which huge quantities are eaten, each man having as many as six or eight with his dinner. All meals are prepared by a permanent staff in a central cookhouse, provided with one large range and four boilers. The range is 12′ long, 5′ wide, and 3′ 6″ high, and has one central fire and flue; being centrally situated in the cookhouse, it is very convenient to use. The whole top gets hot and is available for pots, frying pans, etc., while the lower part contains ovens.

The Irish mess room, which adjoins the cookhouse, consists of a large hut 100′ by 50′. Arrangements are made for using it as a chapel on Sundays, and as a cinema at other times. A separate mess room is provided for the engineers, for though the majority of these live out, they have their mid-day meal at the works.

The Germans have a separate mess in their own camp, where Teutonic tastes are specially catered for, and shops are provided where *delicatessen* may be purchased. No intercourse is allowed between the two camps for fear of international disputes arising.

Both camps are lighted electrically from the temporary power station, and every effort is made to make the inhabitants comfortable. Entertainments are also provided, as the nearest town is Limerick which is several miles off.

VI. Concluding Remarks.

In the foregoing brief notes an attempt has been made to give an outline of the works on the Shannon from the technical point of view. The commercial and other benefits conferred on the country by the scheme must largely depend upon educating the population to use electricity. Provided that the station is adequately protected from the attacks of disaffected persons, the existing electricity undertakings in the Free State would be ready, or could be compelled by statute, to buy energy in bulk, and would thus constitute a paying load for the partial development. The linking up of the country districts will provide an additional source of revenue, but if the full benefit is to be derived, the complete utilisation of the power available is essential, and this will only be attained by vigorous propaganda. When it is remembered that large towns are few in the Free State, and that the majority of the people are accustomed to live, apparently contented, in conditions of discomfort and squalor unapproached in any part of England with which the writer is acquainted, the difficulty of pushing the sale of energy at once becomes apparent. Enough apathy and suspicion are met with in districts where the convenience and cleanliness of electricity make a stronger appeal than they do among the Irish.

Judging by the appreciations of the scheme published from time to time in the newspapers, the myth that hydro-electricity is power for nothing has not yet been exploded. The very heavy fixed charges on such undertakings are apparently forgotten, and the fact that running costs are small is over-emphasised. The fundamental economics of the question are allowed to be obscured by the fact that the scheme is financed by the Government from state revenue—as though the undertaking, if not a commercial success, would be less of an incubus by being a public liability. The notorious financial difficulties of the L.C.C. tramways afford an excellent illustration of this fallacy.

The idea that cheap power means flourishing industries is also very prevalent, and this in face of the fact that some of the districts in Great Britain where industrial depression is most acute are furnished with the cheapest supply of power, *e.g.*, the Clyde. In actual fact, no substitute has yet been found for active markets and a cheap source of raw materials, and power costs are, as a rule, but a small fraction of the whole cost of production. In short, the promotors of the scheme cannot view the future with confidence unmixed with anxiety, since the population is being told to expect an Eldorado which will not improbably fail to materialise.

A RECENT DEVELOPMENT IN MECHANIZATION.

By MAJOR G. LE Q. MARTEL, D.S.O., M.C. R.E.

LONG before the Great War it was realised that as our regular army is so small and as our commitments all over the world are considerable, we should take advantage of the fact that we are one of the few highly trained regular armies in existence and develop our mobility and power of offence to the utmost to compensate for our inferiority in numbers. The same idea prevailed after the war and special attention was paid to mechanization for this reason. We started with the provision of one tank battalion per division but, with the reduced strength of the peace time army, this meant a very small number of tanks, and as the artillery had also to be very largely reduced, the Infantry were not much better off than in 1914 as regards attacking a defensive position. In connection with what may be called administrative mechanization we made great progress. Certain artillery brigades have been mechanized, giving them greatly increased mobility, and much has been done towards mechanizing army transport generally. In addition to increasing mobility, these changes have produced certain financial savings in maintenance and a reduction in tonnage necessary in sea transport, owing to the replacement of fodder by petrol and oil. This work however gives no direct tactical assistance to the infantryman; the tactical basis in battle is still the infantryman and he is only assisted on the battlefield by the very small number of tanks that we can afford in peace time.

It was with the above points in mind that I started, in January, 1925, to evolve a small cheap tank, which was to be made mainly of commercial motor components. There would then be a chance of having very much larger numbers of tanks in peace time and the possibility of expanding these numbers rapidly in the event of war. A further point which influenced me was that the existing types of tanks were being seriously threatened by anti-tank guns, and just as infantry had had to use dispersion to avoid casualties from machine guns, in the same way it seemed reasonable to suppose that, at any rate, a proportion of the large expensive tanks would have to "disperse" into a larger number of small tanks to avoid casualties from anti-tank weapons.

The first model of this tank was constructed from second-hand motor components to avoid expense, and many demonstrations were given in August and September, 1925. These demonstrations raised considerable interest and it was decided to order two of these tanks. I had in the meantime shewn the model to the managing director of Morris Commercial Cars and later he agreed to accept the order for the first two tanks to be made mainly of standard Morris components. The first experimental model had been a one-man tank and no difficulty was experienced in firing an automatic rifle while driving the tank at the same time. My object in keeping to a one-man tank was that a greater number (at least 50 per cent. greater) of one-man tanks could be constructed, manned and maintained for a given sum of money compared with two-man tanks ; the difference being due to the cost of training and upkeep of the second man. There was however no difficulty in providing room for a second man in the tank and this did not materially affect the cost or performance of the tank. Of the first two Morris tanks to be ordered, one was a one-man and the other a two-man tank. Opinion is now strongly in favour of two men and the remainder of this article will refer to two-man tanks except where otherwise stated.

The main points in the mechanical design of the Morris tank were as follows :—

The engine was the 16 h.p. Morris Commercial engine, driving through a gear box with an emergency low speed on to a commercial type differential back axle, and sprockets at the ends of the axle to drive the tracks. So far, we have a very small compact Morris 1-ton van with tracks each side instead of wheels. A very small track machine of this nature would however be very bumpy on rough ground and the trench crossing capacity would be small ; in addition, there would be a danger of the tank overturning backwards when rushing up a very steep bank. To obviate these difficulties a tail was added, carrying a pair of wheels which followed in rear of the tracks. A single wheel in rear would have had advantages, but by using a pair of wheels it was possible to employ a standard front axle and no special parts had to be manufactured. This afterwards proved to be a mistake and a single wheel should have been employed. These wheels could be controlled from the tank and they served to steer the machine ; in addition they steadied the tank considerably over rough ground and they served as a precaution against overturning backwards. The body was in the normal position behind the bonnet and in the two-man tank it was wider and accommodated two men side by side. The body and all vital parts were armoured. In addition to the tail, another novelty was introduced in the body ; the seats were made so that they could slide up and down very quickly and the top of the cab was left open. Normally, when not in close contact with the enemy, the men sit with their heads above the armour, so that they can see all round and be controlled by signals or word of mouth. When coming under fire, the men lower their seats and fight through a loophole in the armour plate. A movable top made of light armour would be necessary in mountainous districts and might be an advantage under all conditions.

Shortly after the appearance of my first experimental model another type, known as the Carden Lloyd, was produced. This was an unarmoured one-man tank and the whole machine was very small, low and inconspicuous: the idea was that the men should be carried very rapidly forward, and by speed and inconspicuousness they should be able to avoid casualties. These ideas were soon found to be impracticable and after the appearance of the Morris Tank, the Carden Lloyd was reconstructed to serve a similar purpose with an armoured body. The tank had a short track and no tail and possessed the disadvantages already referred to of a short track machine without a tail.

The Carden Lloyd tank was rapidly developed by Carden who was both the designer and the manufacturer, and successiv models were produced. A single wheel tail was added, and a very clever system of wheel-cum-track transmission was introduced, so that the tank could carry out a long approach march on wheels and so save the wear and tear on the tracks. It will thus be seen that the two types are becoming similar; but they are both still comparatively undeveloped and many mechanical troubles will appear during the field tests. Whether the tank in its final form is more like the Carden or the Morris is a matter of no importance. What does matter is the fact that as a result of this work a tank could now be developed which would fill the following specification:—

Crew: Two men.
Armament: One machine gun.
Armour: Proof against S.A.A. at any range.
Speed: 30 Miles an hour on roads.
15 Miles an hour on tracks.
Transmission; Wheels for approach march, tracks in action.
Circuit of action: 100 Miles.
Weight: About two tons.

The tank to be capable of climbing very steep banks and cross any natural road ditches and a clear span 4 feet wide. The tank to be narrow and easy to handle, so that it can pass along narrow tracks and negotiate woods by passing between the trees. The cost in production should not exceed £500.

The tank to be reliable and cheap to maintain and the maintenance, including a proportion of the capital cost, not to exceed the annual cost of two infantrymen, i.e., one of these tanks with the crew of two men to be provided and maintained at the same cost as four infantrymen.

Having arrived at the type of tank that can be constructed from a mechanical point of view, we can now consider the tactical side. To do so it is first necessary to produce a picture of what the position might be in 10 or 15 years if we constructed large numbers of these small tanks. The picture will no doubt be very inaccurate—pictures of the future always turn out to be wrong in many ways—but unless we form a picture of some sort, we have nothing to aim at and the tactical trials stray in every direction. The picture that we will take is that of the whole of the infantry of the regular army being mounted like cavalry, but on bullet-proof horses (small tanks). Thus a battalion of infantry will become 500 men mounted in 250 small tanks. It is not suggested that 250 tanks would necessarily form the best tactical unit, but the figures can be used to compare the type of army that can be obtained for the same cost as the army in its present form. Thus the infantry would become mechanical infantry and they would be supported by artillery in much the same way as ordinary infantry, and under suitable circumstances they would be backed up by larger tanks. The mechanical infantry would be the tactical basis; they would set the pace on the march and in battle and all other arms would be required to assist them in every possible way. We will now try to see how an army of this nature could fill the requirements demanded of the British regular army.

Let us for a start take a typical case abroad, and assume that one infantry battalion is charged with the duty of the protection of the island of Singapore from invasion. The perimeter of the island is too long to establish anything in the nature of a linear defence, and the battalion would have to remain concentrated in one or two places. If the enemy effected a landing, the battalion, or a portion of the battalion, would at once be sent to attack the landing party and drive them back to the sea. With infantry it would be several hours before they could reach the place where the enemy had landed, and they would then probably encounter machine guns, which would cause further delays, and by that time the situation would be critical. If we change the infantry battalion into mechanical infantry, i.e. 500 men in 250 small tanks, the position is very different. They would be on the site in half an hour or less and could attack the enemy landing party at once, regardless of a defensive screen of machine guns, and the fear of an attack of this nature would do much to reduce the risk of the enemy attempting a landing at all. It is not suggested for a moment that no infantry would be wanted for the defence of the island; for instance, there would be many places, such as oil fuel depots, where a permanent infantry defence in trenches or block-houses would be essential. This type of work can however be quite well carried out by local volunteers. The expensive and highly trained regular soldiers should be kept as far as possible for offensive operations which need years of experience and practice and it is for this work that the small tanks would prove so useful.

Much the same arguments apply to most foreign stations. In countries like Egypt a larger proportion of armoured cars would no doubt be necessary. It is in India however that the greatest difficulties are met. A proportion of the British battalions in India are used on the North-West Frontier, where tanks are of little use. Under these circumstances, the mechanical infantry would have to dismount and fight on foot. This would not however offer an insuperable difficulty. Cavalry are trained to fight mounted and dismounted and well trained mechanical infantry would soon pick up the mountain warfare methods of the North-West Frontier. There is also the question of police work, which is important in India and, as the mechanical infantry would only possess half the numbers of men compared with existing battalions, police work would be more difficult. It is not however unreasonable to suppose that if half the existing garrison cannot keep order by the police work on foot, then the position is serious enough to call out the troops and for this purpose men in tanks would have every advantage over infantry.

Turning now to the question of a European war, the advantages of mechanical infantry appear to be very marked. The employment of a British Expeditionary Force of four divisions is not a very serious factor in the early phases of a Great War, but if we change this to mechanical force based on mechanical infantry we get a very different picture. The organization of the force would be very simple. The R.A.F. and armoured cars would carry out long distance reconnaissance. The mechanical infantry would carry out their own close reconnaissance and lead the assault, assisted by aeroplanes. In an attack against a defensive position they would be supported by heavier tanks and a full complement of mechanised artillery. The Royal Engineers would have as their main duty the construction of bridges and provision of communications for the force and the destruction of enemy communications. We would thus have a simple organization compared to the complex army which we possess at present, and the whole force could move 100 miles in 24 hours and exist for several days without communications. Such a force would be a tremendous threat to a large continental army. By moving rapidly round a flank and carrying out extensive demolitions behind the enemy, the latter would be rendered immobile without being attacked at all. It might be assumed that large continental armies would follow suit and adopt a similar type of army, but this would place them in a very difficult position. With conscript armies the men are practically unpaid and very large reductions in numbers would be necessary to provide funds wherewith to buy large numbers of tanks. Hence the change would be from a large conscript army to a small mechanical striking force. Now France and Germany are mainly concerned with the defence of a frontier 300 miles long, and even if the military advisers were agreed, it would be some time before the civilians would be satisfied with a small mechanical striking force instead of a large conscript army, for the defence of their frontier. As we have no continental frontier to defend, our position is quite different and we should make full use ofthis by having an army which is pre-eminently suitable as a striking force.

The above statements are an attempt to visualize a possible picture which might exist in the near future. An obvious criticism is that the whole of the infantry have been mechanised. This however is not quite a correct statement. Infantry will naturally be needed in battles of the future, but their work may be of a much simpler and easier nature than it is to-day. The above proposals suggested mechanizing the whole of the regular infantry, and this gives us such striking advantages that we may well be able to depend on volunteers, territorials or hastily raised troops for the policing and passive defence which would become the role of the infantry under these circumstances. The change from infantry to mechanical infantry would of course have to come slowly. Certain units at home and abroad would have to be mechanised first and these would relieve each other to provide the foreign service tours. These and many other difficulties would have to be faced, and certain weak points would have to be accepted, because no change to produce advantages can ever be introduced without facing certain disadvantages. The possible advantages however appear to far outweigh the disadvantages.

Finally, if we believe in some picture of this nature as a possibility in the near future, we should take certain steps now to lead us in this direction, and the following appear to be the four most important. Firstly we must concentrate on the design of the tank that we require. There is no reason why this tank should not become as reliable and fool-proof as the motor car of to-day, but it will require a concentrated effort for a couple of years on the part of the technical branches concerned to achieve this result. Secondly, we need an experimental unit equipped with these tanks, for tactical trials and to demonstrate what they can and cannot do. Thirdly, we shall need a travelling committee of officers who know exactly what this unit can do, to visit foreign stations and see how and where the mechanical infantry can meet our commitments. And lastly, if we are to become a first class mechanical power, we will need a first-class technical organization to design, produce, inspect and repair the great fleet of mechanical vehicles which will be required for the army.

BATTLE HONOURS OF ROYAL ENGINEER UNITS (continued).

AMIENS, 8TH-11TH AUGUST, 1918.

Unit.	Formation.		Remarks.
FOURTH ARMY.			
ARMY TROOPS.			
D. Special (Cylinder) Co.	III Corps	N.E.	
H. ,,	III ,,	E.	
Z. ,,	III ,,	,,	
No. 1 Special (Mortar) Co.	III ,,	,,	
No. 2 ,,	Can. ,,	,,	
648th (H.C.) Field Co.	Aust. ,,	N.E.	No diary.
144th Army Troops Co.	Can. ,,	,,	
146th ,,	Cavy. ,,	E.	
213th ,,	4th Army	N.E.	
216th ,,	Aust. Corps	,,	Arrived in area 11th Aug.
221st ,,	III Corps	,,	
238th ,,	Aust. ,,	E.	
283rd ,,	III ,,	,,	
288th ,,	III ,,	N.E.	
567th ,,	Aust. ,,	E.	
574th ,,	Aust. ,,	N.E.	No diary.
1st Aust. ,,	Aust. ,,	E.	
No. 1 Siege Co. R. Anglesey	III ,,	,,	
No. 4 ,,	Can. ,,	,,	
180th Tunnelling Co.	III ,,	D.	
182nd ,,	Can. ,,	E.	
253rd ,,	III ,,	,,	
254th ,,	4th Army	N.E.	
256th ,,	III Corps	E.	
1st Aust. ,,	Aust. ,,	,,	
2nd Aust. ,,	Aust. ,,	,,	
No. 6 Foreway Co.	III & Can. Corps	N.E.	
1st Tramways Co. C.E.	Can. Corps	,,	
CAVALRY CORPS.			
1st Field. Sqn.	1st Cavy. Div.	E.	
2nd ,,	2nd ,,	,,	
3rd ,,	3rd ,,	,,	
III CORPS.			
69th Field Co.	12th Div.	,,	
70th ,,	,,	,,	
87th ,,	,,	,,	
79th ,,	18th Div.	,,	
80th ,,	,,	,,	
92nd ,,	,,	,,	
517th Field Co.	47th Div.	N.E.	
518th ,,	,,	D.	Within area on 11th Aug., but not employed.
520th ,,	,,	,,	Within area on 11th Aug., but not employed.
503rd ,,	58th Div.	E.	
504th ,,	,,	,,	
511th ,,	,,	,,	

AMIENS, 8th-11th August, 1918.

Unit	Formation.		Remarks.
Canadian Corps.			
206th Field Co.	32nd Div.	E.	
218th "	"	"	
219th "	"	"	
1st Bn. Can. Eng.	1st Can. Div.	"	
2nd "	"	"	
3rd "	"	"	
1st P.B.T. Unit	"	"	
4th Bn. C.E.	2nd Can. Div.	"	
5th "	"	"	
6th "	"	"	
2nd P.B.T. Unit.	"	"	
7th Bn. C.E.	3rd Can. Div.	"	
8th "	"	"	
9th "	"	"	
3rd P.B.T. Unit	"	"	
10th Bn. C.E.	4th Can. Div.	"	
11th "	"	"	
12th "	"	"	
4th P.B.T. Unit	"	"	
Australian Corps.			
77th Field Co.	17th Div.	D.	Within area, but not employed.
78th "	"	"	Within area, but not employed.
93rd "	"	"	Within area, but not employed.
1st Aust. Field Co.	1st Aust. Div.	E.	
2nd "	"	"	
3rd "	"	"	
5th "	2nd Aust. Div.	"	
6th "	"	"	
7th "	"	"	
9th "	3rd Aust. Div.	"	
10th "	"	"	
11th "	"	"	
4th "	4th Aust. Div.	"	
12th "	"	"	
13th "	"	"	
8th "	5th Aust. Div.	"	
14th "	"	"	
15th "	"	"	

SIGNALS.

AMIENS, 8th-11th August, 1918.

Unit.	Formation.		Remarks.
Fourth Army Signal Co.		D	
Cavy. Corps Signal Co.	Cav. Corps	E.	
1st Signal Sqn.	1st Cav. Div.	"	
2nd "	2nd "	"	
3rd "	3rd "	"	
C. Corps Signal Co.	III Corps	D.	
12th Divl. Signal Co.	"	E.	
18th "	"	"	
47th "	"	N.E.	
58th "	"	E.	
Can. Corps Signal Co.	Can. Corps	"	
32nd Divl. Signal Co.	"	"	
1st Can. "	"	"	
2nd Can. "	"	"	
3rd Can. "	"	"	
4th Can. "	"	"	

SIGNALS.

AMIENS, 8TH-11TH AUGUST, 1918.

Units.	Formation.	Remarks.
Aust. Corps Signal Co.	Aust. Corps.	D.
17th Divl. Signal Co.	,,	E.
1st Aust. ,,	,,	,,
2nd Aust. ,,	,,	,,
3rd Aust. ,,	,,	,,
4th Aust. ,,	,,	,,
5th Aust. ,,	,,	,,

N.B.—"SOMME, 1918," COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN THE BATTLES OF ALBERT, 1918, AND BAPAUME, 1918.

ALBERT, 1918, 21ST-23RD AUGUST, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
"J" Special (Cylinder) Co.	VI Corps	N.E.	
"K" ,,	IV ,,	,,	
"N" ,,	V ,,	E.	
"Q" ,,	IV ,,	N.E.	
No. 3 Special (Mortar) Co.	IV ,,	,,	
546th Field Co. (73rd Div.)	VI ,,	,,	
547th ,, ,,	VI ,,	,,	
132nd Army Troops Co.	VI ,,	,,	
142nd ,,	IV ,,	,,	
147th ,,	V ,,	E.	
149th ,,	IV ,,	,,	
232nd ,,	VI ,,	,,	
280th ,,	V ,,	,,	
559th ,,	V ,,	,,	
565th ,,	VI ,,	,,	
577th ,,		N.E.	
7th R. Mon. Troops Co.	IV ,,	E.	
No. 2 Siege Co. R. Anglesey	VI ,,	N.E.	
174th Tunnelling Co.	VI ,,	E.	
175th ,,	V ,,	,,	With 21st Div. No diary.
177th ,,	VI ,,	,,	
178th ,,	V ,,	,,	With 38th Div.
179th ,,	IV ,,	,,	
181st ,,	VI ,,	N.E.	
183rd ,,	V ,,	E.	
252nd ,,	IV ,,	,,	
258th ,,	3rd Army	N.E.	
N.Z. ,,	IV Corps	E.	
No. 3 Pontoon Park	V & VI Corps	D.	
No. 1 Foreway Co.		N.E.	
No. 8 ,,		,,	No diary.
IV CORPS.			
59th Field Co.	5th Div.	E.	
491st ,,	,,	,,	
527th ,,	,,	,,	
152nd ,,	37th Div.	,,	
153rd ,,	,,	,,	
154th ,,	,,	,,	
427th ,,	42nd Div.	,,	
428th ,,	,,	,,	
429th ,,	,,	,,	
247th ,,	63rd Div.	,,	
248th ,,	,,	,,	
249th ,,	,,	,,	
1st N.Z. Field Co.	N.Z. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	

ALBERT, 1918, 21ST-23RD AUGUST, 1918.

Unit.	Formation.		Remarks.
V CORPS.			
77th Field Co.	17th Div.	D.	Within area, but not employed.
78th ,,	,,	,,	
93rd ,,	,,	N.E.	
97th ,,	21st Div.	E.	
98th ,,	,,	,,	
126th ,,	,,	,,	
123rd ,,	38th Div.	,,	
124th ,,	,,	,,	
151st ,,	,,	,,	
VI CORPS.			
55th Field Co.	Guards Div.	,,	
75th ,,	,,	,,	
76th ,,	,,	,,	
5th ,,	2nd Div.	,,	
226th ,,	,,	,,	
483rd ,,	,,	,,	
56th ,,	3rd Div.	,,	
438th ,,	,,	,,	
529th ,,	,,	,,	
410th ,,	52nd Div.	N.E.	
412th ,,	,,	E.	
413th ,,	,,	N.E.	
416th ,,	56th Div.	E.	
512th ,,	,,	,,	
513th ,,	,,	N.E.	
467th ,,	59th Div.	E.	
469th ,,	,,	,,	
470th ,,	,,	,,	
FOURTH ARMY.			
ARMY TROOPS.			
"D" Special (Cyl) Co.	III Corps	E.	
"Z" ,,	Aust. ,,	N.E.	
No. 1 Special (Mortar) Co.	III ,,	E.	
648th (H.C.) Field Co.	Aust. ,,	N.E.	No diary.
144th Army Troops Co.	III ,,	E.	
146th ,,	Aust. ,,	,,	
213th ,,	4th Army	N.E.	
216th ,,	Aust. Corps	E.	
221st ,,	III ,,	N.E.	
238th ,,	Aust. ,,	D.	
283rd ,,	III ,,	E.	
288th ,,	III ,,	N.E.	
567th ,,	Aust. ,,	,,	
574th ,,	Aust. ,,	,,	No diary.
1st Aust. Troops Co.	Aust. ,,	E.	
No. 1 Siege Co. R. Anglesey	III ,,	,,	
No. 4 ,,	III ,,	,,	
180th Tunnelling Co.	III ,,	D.	
182nd ,,	III ,,	E.	
253rd ,,	III ,,	,,	
254th ,,	Aust. ,,	D.	
256th ,,	III ,,	E.	
1st Aust. Tunnelling Co.	Aust. ,,	D.	
2nd Aust ,,	Aust. ,,	,,	
No. 6 Foreway Co.		N.E.	
III CORPS.			
69th Field Co.	12th Div.	E.	
70th ,,	,,	,,	
87th ,,	,,	,,	

ALBERT, 1918, 21ST-23RD AUGUST, 1918.

Unit.	Formation.		Remarks.
79th Field Co.	18th Div.	E.	
80th ,,	,,	,,	
92nd ,,	,,	,,	
517th ,,	47th Div.	,,	
518th ,,	,,	,,	
520th ,,	,,	,,	
503rd ,,	58th Div.	N.E.	
504th ,,	,,	,,	
511th ,,	,,	,,	
AUSTRALIAN CORPS.			
206th Field Co.	32nd Div.	E.	
218th ,,	,,	,,	
219th ,,	,,	,,	
1st Aust. Field Co.	1st Aust. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
9th ,,	3rd Aust. Div.	,,	
10th ,,	,,	,,	
11th ,,	,,	,,	
4th ,,	4th Aust. Div.	N.E.	
12th ,,	,,	,,	
13th ,,	,,	,,	
8th ,,	5th Aust. Div.	D.	Within area, but not employed.
14th ,,	,,	E.	
15th ,,	,,	D.	Within area, but not employed.

SIGNALS.
ALBERT, 1918, 21ST-23RD AUGUST, 1918.

Unit.	Formation.		Remarks.
Third Army Signal Co.		N.E.	
"D" Corps Signal Co.	IV Corps	D.	
5th Divl. Signal Co.	IV ,,	E.	
37th ,,	IV ,,	,,	
42nd ,,	IV ,,	,,	
63rd ,,	IV ,,	,,	
N.Z. ,,	IV ,,	,,	
"O" Corps Signal Co.	V ,,	D.	
17th Divl. Signal Co.	,,	,,	
21st ,,	V ,,	E.	
38th ,,	,,	,,	
"F" Corps Signal Co.	VI ,,	D.	
Guards Divl. Signal Co.	VI ,,	E.	
2nd ,,	VI ,,	,,	
3rd ,,	VI ,,	,,	
52nd ,,	VI ,,	,,	
56th ,,	VI ,,	,,	
59th ,,	VI ,,	D.	
Fourth Army Signal Co.		N.E.	
"C" Corps Signal Co.	III ,,	D.	
12th Divl. Signal Co.	III ,,	E.	
18th ,,	III ,,	,,	
47th ,,	III ,,	,,	
58th ,,	III ,,	D.	
Aust. Corps Signal Co.	Aust. Corps.	,,	
32nd Divl. Signal Co.	Aust. ,,	E.	
1st Aust. ,,	Aust. ,,	,,	
3rd Aust. ,,	Aust. ,,	,,	
4th Aust. ,,	Aust. ,,	N.E.	
5th Aust. ,,	Aust. ,,	E.	

BAPAUME, 1918, 31ST AUGUST-3RD SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
"J" Special (Cyl.) Co.	VI Corps	N.E.	
"K" ,,	IV ,,	,,	
"N" ,,	V ,,	,,	
"Q" ,,	IV ,,	,,	
No. 3 Special (Mortar) Co.	IV ,,	,,	
546th Field Co. (73rd Div.)	VI ,,	E.	
547th ,, ,,	V ,,	N.E.	
549th ,, ,,	VI ,,	E.	
132nd Army Troops Co.	VI ,,	D.	
142nd ,,	IV ,,	E.	
147th ,,	V ,,	N.E.	
149th ,,	IV ,,	,,	
232nd ,,	XVII Corps	,,	
280th ,,	V Corps	,,	
559th ,,	V ,,	D.	
565th ,,	VI ,,	E.	
577th ,,	IV ,,	N.E.	
7th R. Mon. Army Troops Co.	IV ,,	D.	
4th Siege Co. R.M.R.E.	VI ,,	..	Employed under C.R.E. 73rd Div.
174th Tunnelling Co.	VI ,,	E.	
175th ,,	V ,,	D.	No diary.
178th ,,	V ,,	N.E.	
179th ,,	IV ,,	E.	
181st ,,	VI ,,	N.E.	
183rd ,,	V ,,	D.	
252nd ,,	IV ,,	E.	
258th ,,	3rd Army	,,	
N.Z. ,,	IV Corps	N.E.	
No. 1 Foreway Co.		D.	
No. 2 ,,		,,	
No. 8 ,,		,,	
IV CORPS.			
59th Field Co.	5th Div.	E.	
491st ,,	,,	,,	
527th ,,	,,	,,	
152nd ,,	37th Div.	,,	
153rd ,,	,,	,,	
154th ,,	,,	,,	
427th ,,	42nd Div.	,,	
428th ,,	,,	,,	
429th ,,	,,	,,	
1st N.Z. Field Co.	N.Z. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
V CORPS			
77th Field Co.	17th Div.	,,	
78th ,,	,,	N.E.	
93rd ,,	,,	E.	
97th ,,	21st Div.	,,	
98th ,,	,,	,,	
126th ,,	,,	,,	
123rd ,,	38th Div.	,,	
124th ,,	,,	,,	
151st ,,	,,	N.E.	
VI CORPS.			
55th Field Co.	Guards Div.	E.	
75th ,,	,,	D.	
76th ,,	,,	E.	

BAPAUME, 1918, 31ST AUGUST-3RD SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
5th Field Co.	2nd Div.	E.	
226th ,,	,,	,,	
483rd ,,	,,	,,	
56th ,,	3rd Div.	D.	
438th ,,	,,	E.	
529th ,,	,,	,,	
457th ,,	62nd Div.	,,	
460th ,,	,,	,,	
461st ,,	,,	,,	
FOURTH ARMY.			
ARMY TROOPS.			
"D" Special (Cyl.) Co.	III Corps	N.E.	
"Z" ,,	Aust. ,,	,,	
No. 1 Special (Mortar) Co.	III ,,	,,	
648th Field Co.	Aust. ,,	,,	
144th Army Troops Co.	III ,,	D.	
146th ,,	Aust. ,,	N.E.	
213th ,,	4th Army	,,	
216th ,,	Aust. Corps	E.	
221st ,,	III ,,	N.E.	
238th ,,	Aust. ,,	E.	
283rd ,,	III ,,	N.E.	
288th ,,	III ,,	E.	
567th ,,	Aust. ,,	,,	
574th ,,	Aust. ,,	N.E.	No diary
1st Aust. Army Troops Co.	Aust. ,,	E.	
No. 1 Siege Co. R.A. R.E.	III ,,	,,	
No. 4 ,,	III ,,	,,	
180th Tunnelling Co.	III ,,	,,	
182nd ,,	III ,,	,,	
253rd ,,	III ,,	,,	
254th ,,	Aust. ,,	N.E.	
256th ,,	III ,,	E.	
1st Aust. Tunnelling Co.	Aust. ,,	,,	
2nd Aust. ,,	Aust. ,,	,,	
No. 6 Foreway Co.		NE..	
III CORPS.			
69th Field Co.	12th Div.	N.E.	
70th ,,	,,	D.	
87th ,,	,,	N.E.	
79th ,,	18th Div.	E.	
80th ,,	,,	,,	
92nd ,,	,,	,,	
517th ,,	47th Div.	,,	
518th ,,	,,	,,	
520th ,,	,,	,,	
503rd ,,	58th Div.	,,	
504th ,,	,,	,,	
511th ,,	,,	,,	
No. 5 Field Co. R.A. R.E.	74th Div.	,,	
No. 5 Field Co. R.M. R.E.	,,	,,	
439th Field Co.	,,	,,	
AUSTRALIAN CORPS.			
206th Field Co.	32nd Div.	,,	
218th ,,	,,	,,	
219th ,,	,,	,,	
5th Aust. Field Co.	2nd Aust. Div.	,,	
6th ,,	,,	,,	
7th ,,	,,	,,	
9th ,,	3rd Aust. Div.	,,	
10th ,,	,,	,,	
11th ,,	,,	,,	

BAPAUME, 1918, 31ST AUGUST-3RD SEPTEMBER, 1918.

Unit.		Formation.		Remarks.
8th	,,	5th Aust. Div.	,,	
14th	,,	,,	,,	
15th	,,	,,	,,	

SIGNALS.

BAPAUME, 1918, 31ST AUGUST-3RD SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
Third Army Signal Co.		N.E.	
"D" Corps Signal Co.	IV Corps	D.	
5th Divl. Signal Co.	,,	E.	
37th ,,	,,	,,	
42nd ,,	,,	,,	
N.Z. ,,	,,	,,	
"O" Corps Signal Co.	V Corps	D.	
17th Divl. Signal Co.	,,	E.	
21st ,,	,,	,,	
38th ,,	,,	,,	
"F" Corps Signal Co.	VI Corps	D.	
Guards Divl. Signal Co.	,,	E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
62nd ,,	,,	,,	
Fourth Army Signal Co.		N.E.	
"C" Corps Signal Co.	III Corps	D.	
12th Divl. Signal Co.	,,	,,	
18th ,,	,,	E.	
47th ,,	,,	,,	
58th ,,	,,	,,	
74th ,,	,,	,,	
Aust. Corps Signal Co.	Aust. Corps	D.	
32nd Divl. Signal Co.	,,	E.	
2nd Aust. ,,	,,	,,	
3rd Aust. ,,	,,	,,	
5th Aust. ,,	,,	,,	

N.B. "ARRAS, 1918," COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN THE BATTLES SCARPE, 1918, AND DROCOURT-QUEANT.

SCARPE, 1918. 26TH-30TH AUGUST, 1918.

Unit.	Formation.		Remarks.
FIRST ARMY.			
ARMY TROOPS.			
Special Cos.	First Army	N.E.	
106th Field Co. (25th Div.)	XXII Corps	,,	
25th Army Troops Co.	First Army	,,	
217th ,,	XXII Corps	,,	
230th ,,	First Army	,,	
282nd ,,	VIII Corps	,,	
290th ,,		,,	
560th ,,		,,	
568th ,,	XXII Corps	,,	
1st Can. ,,	Can. Corps	,,	
2nd Can ,,	,,	E.	
3rd Can. ,,	,,	,,	
4th Can. ,,	,,	,,	
5th Can. ,,	,,	,,	
1st Siege Co. R.M.R.E.	VIII Corps	N.E.	

SCARPE, 1918. 26TH-30TH AUGUST, 1918.

Unit.	Formaiton.		Remarks.
172nd Tunnelling Co.	VIII & XXII Corps	,,	
176th ,,		,,	
185th ,,	VIII Corps	,,	
1st Tramway Co. Can Eng.	Can. Corps	E.	
2nd ,,	,,	,,	
VIII CORPS.			
2nd Field Co.	8th Div.	E.	
15th ,,	,,	D.	
400th ,,	,,	N.E.	
XXII CORPS			
67th Field Co.	11th Div.	D.	Within area on 30th August "standing by."
68th ,,	,,	,,	
86th ,,	,,	,,	
400th ,,	51st Div.	E.	
401st ,,	,,	,,	
404th ,,	,,	,,	
CANADIAN CORPS.			
9th Field Co.	4th Div.	E.	
406th ,,	,,	,,	
526th ,,	,,	,,	
1st Bn. Can. Eng.	1st Can. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
1st P.B.T. Unit	,,	,,	
4th Bn. C.E.	2nd Can. Div.	,,	
5th ,,	,,	,,	
6th ,,	,,	,,	
2nd P.B.T. Unit	,,	,,	
7th Bn. C.E.	3rd Can. Div.	,,	
8th ,,	,,	,,	
9th ,,	,,	,,	
3rd P.B.T.	,,	,,	
10th Bn. C.E.	4th Can. Div.	,,	
11th ,,	,,	,,	
12th ,,	,,	,,	
4th P.B.T. Unit	,,	N.E.	
THIRD ARMY.			
ARMY TROOPS.			
232nd Army Troops Co.	XVII Corps	E.	
No. 2 Siege Co. R.A. R.E.	,,	,,	
177th Tunnelling Co.	,,	,,	
XVII CORPS.			
410th Field Co.	52nd Div.	E.	
412th ,,	,,	,,	
413th ,,	,,	,,	
416th ,,	56th Div.	,,	
512th ,,	,,	,,	
513th ,,	,,	,,	
421st ,,	57th Div.	,,	
502nd ,,	,,	,,	
505th ,,	,,	,,	

SIGNALS.

SCARPE, 1918. 26TH-30TH AUGUST, 1918.

Unit.	Formation.		Remarks.
First Army Signal Co.		N.E.	
8 Corps Signal Co.	VIII Corps	,,	
8th Div. Signal Co.	,,	D.	

SIGNALS.

SCARPE, 1918. 25th-30th August, 1918.

Unit.	Formation.		Remarks.
Y Corps Signal Co.	XXII Corps	N.E.	
11th Div. Signal Co.	,,	E.	
51st ,,	,,	,,	
Can. Corps Signal Co.	Can. Corps	D.	
4th Div. Signal Co.	,,	E.	
1st Can. ,,	,,	,,	
2nd Can. ,,	,,	,,	
3rd Can. ,,	,,	,,	
4th Can. ,,	,,	N.E.	
Third Army Signal Co.		,,	
R Corps Signal Co.	XVII Corps	D.	
52nd Div. Signal Co.	,,	E.	
56th ,,	,,	,,	
57th ,,	,,	,,	

DROCOURT-QUEANT. 2nd-3rd September, 1918.

Unit.	Formation.		Remarks.
First Army.			
Army Troops.			
106th Field Co. (25th Div.)	XXII Corps	N.E.	
217th Army Troops Co.	XXII ,,	,,	
568th ,,	XXII ,,	,,	
1st Can. ,,	Can. ,,	,,	
2nd Can. ,,	Can. ,,	,,	
3rd Can. ,,	Can. ,,	,,	
4th Can. ,,	Can. ,,	D.	
5th Can. ,,	Can. ,,	N.E.	
172nd Tunnelling Co.	XXII ,,	,,	
179th ,,	XXII ,,	,,	
1st Tramway Co. C.E.	Can. ,,	D.	
2nd ,,	Can. ,,	,,	
No. 7 Foreway Co.	XXII ,,	,,	No diary.
XXII Corps.			
67th Field Co.	11th Div.	E.	
68th ,,	,,	N.E.	
86th ,,	,,	E.	
Canadian Corps.			
23rd Field Co.	1st Div.	E.	
26th ,,	,,	,,	
409th ,,	,,	,,	
9th Field Co.	4th Div.	,,	
406th ,,	,,	,,	
526th ,,	,,	,,	
1st Bn. C.E. 1st Bde. C.E.	1st Can. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
1st P.B.T. Unit	,,	,,	
4th Bn. C.E. 2nd Bde. C.E.	2nd Can. Div.	,,	
5th ,,	,,	,,	
6th ,,	,,	D.	
2nd P.B.T. Unit	,,	,,	
7th Bn. C.E. 3rd Bde. C.E.	3rd Can. Div.	N.E.	
8th ,,	,,	E	
9th ,,	,,	,,	
3rd P.B.T. Unit	,,	N.E.	
10th Bn. C.E. 4th Bde. C.E.	4th Can. Div.	E.	
11th ,,	,,	,,	
12th ,,	,,	,,	
4th P.B.T. Unit	,,	,,	

DROCOURT-QUEANT. 2ND-3RD SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
232nd Army Troops Co.	XVII Corps	D.	
No. 2 Siege Co. R.A.R.E.	XVIII ,,	,,	
177th Tunnelling Co.	XVIII ,,	E.	
XVII CORPS.			
410th Field Co.	52nd Div.	E.	
412th ,,	,,	,,	
413th ,,	,,	,,	
416th ,,	56th Div.	,,	
512th ,,	,,	N.E.	
513th ,,	,,	,,	
421st ,,	57th Div.	E.	
502nd ,,	,,	,,	
505th ,,	,,	,,	
247th ,,	63rd Div.	,,	
248th ,,	,,	,,	
249th ,,	,,	,,	

SIGNALS.

DROCOURT-QUEANT. 2ND-3RD SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
First Army Signal Co.		N.E.	
Y Corps Signal Co.	XXII Corps	,,	
11th Div. Signal Co.	,,	D.	
Can. Corps Signal Co.	Can. Corps	N.E.	
1st Div. Signal Co.	,,	E.	
4th ,,	,,	,,	
1st Can. ,,	,,	,,	
4th Can. ,,	,,	,,	
Third Army Signal Co.		N.E.	
R Corps Signal Co.	XVII Corps	D.	
52nd Div. Signal Co.	,,	E.	
57th ,,	,,	,,	
63rd ,,	,,	,,	

N.B.—"HINDENBURG LINE" COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN ANY OF THE BATTLES FROM HAVRINCOURT TO CAMBRAI, 1918.

HAVRINCOURT. 12TH SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
J Special (Cyl.) Co.	VI Corps	N.E.	
K ,,	IV ,,	,,	
N ,,	V ,,	,,	
Q ,,	IV ,,	,,	
No. 3 Special (Mortar) Co.	IV ,,	,,	
546th Field Co. (73rd Div.)	VI ,,	,,	
547th ,,	V ,,	,,	
549th ,,	VI ,,	,,	
132nd Army Troops Co.	VI ,,	,,	
142nd ,,	IV ,,	D.	
147th ,,	V ,,	N.E.	
149th ,,	IV ,,	D.	
180th ,,	V ,,	N.E.	
559th ,,	V ,,	,,	

HAVRINCOURT. 12TH SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
565th ,,	VI ,,	E.	
577th ,,	IV ,,	N.E.	
7th R. Mon. ,,	IV ,,	,,	
4th Siege Co. R.M. R.E.	V ,,	,,	
174th Tunnelling Co.	VI ,,	D.	
175th ,,	V ,,	,,	No diary.
178th ,,	V ,,	N.E.	
181st ,,	VI ,,	D.	
183rd ,,	V ,,	N.E.	
252nd ,,	IV ,,	D.	
258th ,,	Third Army	,,	
N.Z. ,,	IV Corps	,,	
No. 1 Foreway Co.		N.E.	
IV CORPS.			
152nd Field Co.	37th Div.	E.	
153rd ,,	,,	N.E.	
154th ,,	,,	E.	
1st N.Z. Field Co.	N.Z. Div.	N.E.	
2nd ,,	,,	,,	Within area but not employed.
3rd ,,	,,	,,	
V. CORPS.			
77th Field Co.	17th Div.	N.E.	
78th ,,	,,	,,	
93rd ,,	,,	,,	
97th ,,	21st Div.	,,	
98th ,,	,,	,,	
126th ,,	,,	,,	
123rd ,,	38th Div.	,,	
124th ,,	,,	D.	
151st ,,	,,	N.E.	
VI CORPS.			
55th Field Co.	Guards Div.	N.E.	
75th ,,	,,	D.	
76th ,,	,,	,,	
5th ,,	2nd Div.	N.E.	
226th ,,	,,	,,	
483rd ,,	,,	,,	
457th ,,	62nd Div.	E.	
460th ,,	,,	,,	
461st ,,	,,	,,	

SIGNALS.

HAVRINCOURT. 12TH SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
Third Army Signal Co.		N.E.	
D Corps Signal Co.	IV Corps	,,	
37th Div. Signal Co.	,,	D.	
N.Z. ,,	,,	,,	
O Corps Signal Co.	V Corps	N.E.	
17th Div. Signal Co.	,,	,,	
38th ,,	,,	D.	
F Corps Signal Co.	VI Corps	N.E.	
Guards Div. Signal Co.	,,	,,	
2nd ,,	,,	,,	
62nd ,,	,,	E.	

EPEHY. 18TH SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
Special Co's.	Third Army	N.E.	
142nd Army Troops Co.	IV Corps	,,	
147th ,,	V ,,	E.	
149th ,,	IV ,,	N.E.	
280th ,,	V ,,	D.	
559th ,,	V ,,	E.	
577th ,,	IV ,,	N.E.	
7th R. Mon. ,,	IV ,,	,,	
4th Siege Co. R. Mon.	V ,,	E.	
175th Tunnelling Co.	V ,,	,,	
178th ,,	V ,,	N.E.	
183rd ,,	V ,,	E.	
252nd ,,	IV ,,	,,	
258th ,,	3rd Army	N.E.	
N.Z. ,,	IV Corps	,,	
IV CORPS.			
59th Field Co.	5th Div.	N.E.	
491st ,,	,,	D.	
527th ,,	,,	E.	
V CORPS.			
77th Field Co.	17th Div.	E.	
78th ,,	,,	,,	
93rd ,,	,,	D.	
97th ,,	21st Div.	E.	
98th ,,	,,	,,	
126th ,,	,,	,,	
11th ,,	33rd Div.	D.	Within area, but not employed.
212th ,,	,,	N.E.	
222nd ,,	,,	,,	
123rd ,,	38th Div.	E.	
124th ,,	,,	D. }	"Standing to" just outside area.
151st ,,	,,	,, }	
FOURTH ARMY.			
ARMY TROOPS.			
Special Cos.	4th Army	N.E.	
648th (H.C.) Field Co.	Aust. Corps	,,	
144th Army Troops Co.	III ,,	E.	
146th ,,	Aust. ,,	N.E.	
213th ,,	4th Army	,,	
216th ,,	IX Corps	,,	
221st ,,	IX ,,	,,	
238th ,,	Aust. ,,	D.	
283rd ,,	III ,,	,,	
288th ,,	III ,,	,,	
567th ,,	IX ,,	N.E.	
574th ,,	Aust. ,,	,,	
1st Siege Co., R.A.R.E.	III ,,	D.	
4th ,,	IX ,,	,,	
224th Transportation Works Co. R.E.	III ,,	,,	
1st Aust. Army Troops Co.	Aust. ,,	E.	
180th Tunnelling Co.	III ,,	E.	
182nd ,,	III ,,	,,	
253rd ,,	IX ,,	N.E.	
254th ,,	IX ,,	,,	
256th ,,	III ,,	,,	
1st Aust. ,,	Aust. ,,	D.	
2nd ,,	Aust. ,,	,,	

EPEHY. 18th September, 1918.

Unit.	Formation.		Remarks.
III Corps.			
69th Field Co.	12th Div.	E.	
70th "	"	"	
87th "	"	"	
79th "	18th Div.	"	
80th "	"	"	
92nd "	"	"	
503rd "	58th Div.	"	
504th "	"	"	
511th "	"	"	
5th Field Co. R.A.R.E.	74th Div.	"	
5th Field Co. R.M.R.E.	"	"	
439th "	"	"	
IX Corps.			
23rd Field Co.	1st Div.	E.	
26th "	"	"	
469th "	"	"	
12th "	6th Div.	"	
459th "	"	"	
509th "	"	"	
Aust. Corps.			
1st Aust. Field Co.	1st Aust. Div.	E.	
2nd "	"	"	
3rd "	"	"	
4th "	4th Aust. Div.	D.	In Reserve.
12th "	"	E.	
13th "	"	"	

SIGNALS.

EPEHY. 18th September, 1918.

Unit.	Formation.		Remarks.
Third Army Signal Co.		N.E.	
D Corps Signal Co.	IV Corps	"	
5th Div. Signal Co.	"	D.	
O Corps Signal Co.	V Corps	N.E.	
17th Div. Signal Co.	"	E.	
21st "	"	"	
33rd "	"	N.E.	
38th "	"	E.	
Fourth Army Signal Co.		N.E.	
C Corps Signal Co.	III Corps	D.	
12th Div. Signal Co.	"	E.	
18th "	"	"	
58th "	"	"	
74th "	"	"	
E Corps Signal Co.	IX Corps	N.E.	
1st Div. Signal Co.	"	E.	
6th "	"	"	
Aust. Corps Signal Co.	Aust. Corps	N.E.	
1st Aust. Div. Signal Co.	"	E.	
4th "	"	"	

WATER DIVINING.

By LT.-COLONEL HUGH ROSE of Kilravock, C.M.G., late 1st Bn. The Black Watch (42nd).

THE writer had the honour to be asked a month ago to pen an article for the *R.E. Journal* with reference to a critique by "H. B.-W." in its March number (p. 171, etc.) on a book entitled *The Divining Rod*, by (the late) Sir William Barrett, F.R.S., and Theodore Besterman.

In his summing up the reviewer says, "The conclusion to which the military reader of this interesting, but rather heavy, work must come, is that an experienced dowser should be available at headquarters of any force in the field to assist the engineer officers responsible for water supply. The want of such an expert was severely felt in the South African War. Many lives would have been saved, and much fruitless labour avoided, if an experienced dowser had been available, for instance, during the long halt at Modder River. Amateur dowsers did their best, but the results were almost nil. Geological data can generally be obtained of a possible theatre of war, but a dowser with experience of local conditions is a *rara avis*."

In the instances given in *The Divining Rod* of my having helped two R.E. Water Supply officers of the III Corps Headquarters in the Great War near Albert, the first case certainly exemplified the fact that weeks of labour were fruitlessly spent in digging and boring for a comparatively small supply. Moreover, worry and anxiety were affecting the officer's health, and it was the fact of his being in my mess, and my happening to ask him one morning what made him look so ill, that led to the water finding described on page 194 of the above-mentioned book.

This article, therefore, aims at suggesting how the excellent conclusion of "H.B.W." may perhaps be attained. But, first of all, a few general remarks on dowsing may not be out of place. My experience, which extends over a period of some twenty-two years, is that a very large number of people have never been aware that such a faculty as dowsing exists. Others who have heard of it, and perhaps seen it, are profound sceptics, and look upon the whole matter as "in some cases as a 'conscious commercial fraud,' (to quote a letter in a well known newspaper last year,) and in others a semi-conscious desire to achieve what is sincerely be ieved possible." Being an amateur, I presumably am included in the latter category of poor deluded mortals, honest maybe, but dotty. This view, as often as not, arises through their having seen some expert demonstrate, and tried to do the same thing, but, through lack of the necessary sensitiveness, have entirely failed to get a pull. They then reason inwardly somewhat in this manner: Why should a forked rod turn in this fellow's hands, while with me, a person of obviously superior intellect, nothing whatever happens? A murrain on the varlet!

All such people should read carefully through the evidence and facts collected in the Barrett-Besterman book. And I am sure that an afternoon's outing with a very gifted professional water diviner of Oxford, whom I had the pleasure of meeting and working with for four days this month (April), would convince the most hardened unbeliever that dowsing is not only a genuine, but a truly marvellous faculty. This is how I first got track of Mr. John Timms, who, by the way, does not happen to be mentioned in *The Divining Rod*, though unquestionably in the front rank of professional water finders. A little over a year ago we were returning from a trip through Corsica, by a Bibby liner from Marseilles. On the promenade deck of our vessel, in Marseilles harbour, a French bookseller had rigged upa bookstall, containing all sorts of British newspapers and magazines. Glancing at the contents on the front cover of each magazine, my eye caught the words on the April *Cornhill*, "Water Divining, Scientific and Commercial." It was the joint production of John Timms and Hyacinthe Daly. The *Cornhill* was at once added to a growing collection of books on dowsing. And, following upon a correspondence with Mr. Timms, a meeting was arranged at Oxford, and proved to be a most interesting and instructive one for both of us. One thing that our investigations and experiences proved was, what I have for a number of years maintained. namely, that hardly any two dowsers work alike, because their supersensitive organisms are different, sometimes in a very marked degree. For instance, Timms's rod turns in the same direction for water, oil and metals. Mine turns the same way as his for water and oil, yet there is quite an unmistakeable difference between the two; water affording a steady pull and turning of the rod, while oil gives a curious quick jerk, which touches up the solar plexus, and either muscles or nerves, on the inner side of my elbows. And for me metals and minerals turn the rod in exactly the opposite way to water. If Timms puts some gold on the ground and holds gold in his hand, his rod remains quite immobile, and I have come across other one or two famous dowsers who have the same happening. If I hold, say, a gold chain in my hand, and approach gold lying on the ground, or floor, the rod turns very much more readily and sooner to the latter, than it would without this affinity assistance. Moreover, it will not turn to any other metal on the floor but its like.

This peculiarity led to an amusing incident a few years ago. A wealthy young friend threw a gold matchbox on the ground while we were having lunch out fishing, and said, "Just try that." Gold chain in hand, I went to it, but there was no response. "Hullo," I said, "this is not gold at all." "What, not gold? Do you know what I gave for it?—a tenner." "Well, all I can say is that you have been done down; and I'll lay you an even ten pound note that there is no gold in it at all." He wisely did not bet, or he would, as he found out later, have lost.

One more instance may be given of diversity. At Aldershot, shortly before the Great War, I came across a Brigadier-General generally known as "New Zealand Davies," quite a good hand at divining. His rod turned in exactly the opposite ways to mine. From these three examples of variation it can be realised how important, it is that not only the general public, but dowsers themselves, should be aware of it. Some dowsers are apt to dogmatise on what they believe to be the one and only method, namely, their own. Some, too, have in the past attributed to the rod itself powers which it most certainly does not possess. The rod, watch spring, or whatsoever instrument the dowser elects to work with, is purely an indicator, comparable to the hands of a clock. Whether the rod be whipped round the junction of the V with string, or anything else, so as to prevent, or lessen, the chance of its splitting at the fork, does not impair its efficiency in the slightest degree.

Both Mr. Timms and I concur that there is no better rod than a good symmetrical hazel, that is, one having both sides of equal thickness and strength. It is a tough wood, pleasant to handle, and in spite of being held for long spells in a state of tension, its tendency is to regain its normal V-shape at once when released. But when used for some hours' work it is very tiring to the muscles of the arms and may thereby, if overdone, affect the nervous system. Personally, I find that a good deal of searching for water can be done with a finely tempered watch spring, $\frac{1}{8}$ of an inch in width, without incurring any fatigue to speak of, and it was by this means that I dowsed the water near Albert in 1916-17. But to roughly get at whether there was likely to be a sufficient supply or not, I made use of a pretty stout hazel rod. How to gauge the depth down of the water and the amount per hour in gallons, I had no idea, and made no attempt to predict it. But now Mr. Timms has shown me his method of arriving at these. All the same, I fully realise that much practice and experimenting will be necessary for me, or any dowsing tyro, before we can hope to attain the amazing accuracy of him, and of other first-class professionals of the day. There is assuredly no royal road to it.

Few, if any, dowsers feel any reaction over stagnant water; it has to be running.

But I can get a pull for water in a finger bowl or even a tea cup placed on the ground.

This supersensitiveness may be useful for indoor demonstrations, but entails disadvantages out in the field.

Mr. Timms and an Oxford University lecturer, A. H. Church, M.A., D.SC., F.R.S., have almost finished a prodigious task, that of mapping out all the underground streams and rivers of Oxford in and around and for some miles outside the city; in all about thirty square miles in area!

In a most careful and painstaking way they have respectively traced them with the rod, and draw them forthwith on the Ordnance maps, nothing being taken for granted or guessed at.

From the positions of the older colleges, several old wells in the city, ancient farms and sites of old monasteries in the mapped area, all placed on natural though unseen streams, they have no doubt but that the monks of old were well acquainted with the faculty of dowsing, and employed those who had the gift before commencing to build.

Mr. Timms took me one day up to a hill where a year ago he traced three or four streams, through a tangle of brambles and undergrowth, driving in at that time a long wooden peg here and there to mark the general line of each, and I saw evidence of this in the shape of five good new wells which I examined while on the site. We came to a depression where some ugly blackish water was oozing down the brae face, and he was impressing upon me the huge mistake which an inexperienced dowser may make in going by surface indications, such as this, instead of trying in some quite unlikely area for a pure supply at a reasonable depth, free from all surface contaminations. The hill had recently been cleared of its scrub, as it is now being built over. He said that from his recollection of the previous year's work, a small stream should be flowing below, and not far from where we were standing. He took out his rod, made a few steps forward and up she went, and at the same moment his toe was actually stubbed by one of his pegs, concealed under a tangle of red bracken. As he remarked, it was a pretty good object lesson in dowsing accuracy.

He and I, working quite separately at metals, found that the rod reacts more readily to nickel than to gold.

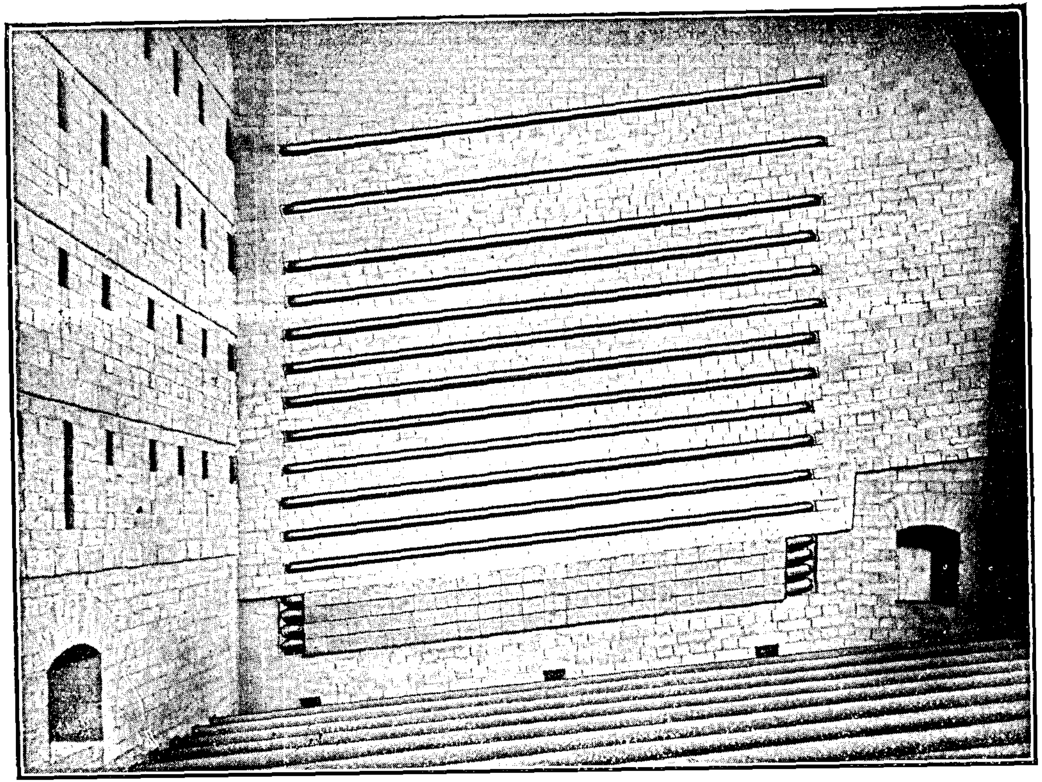
What perhaps astonished me more than anything was that when we were sitting on the top of a motor 'bus holding our rods in tension, while crossing a river, they both continued to revolve as long as we were over the water He has found similar action while in an aeroplane 1,000 feet up.

He also showed me how to differentiate between ordinary and brackish (saline) water, and, under his instructions, I felt an underground river flowing two hundred and fifty feet below us, there being no indication of any sort of its existence.

And now for our suggestions.

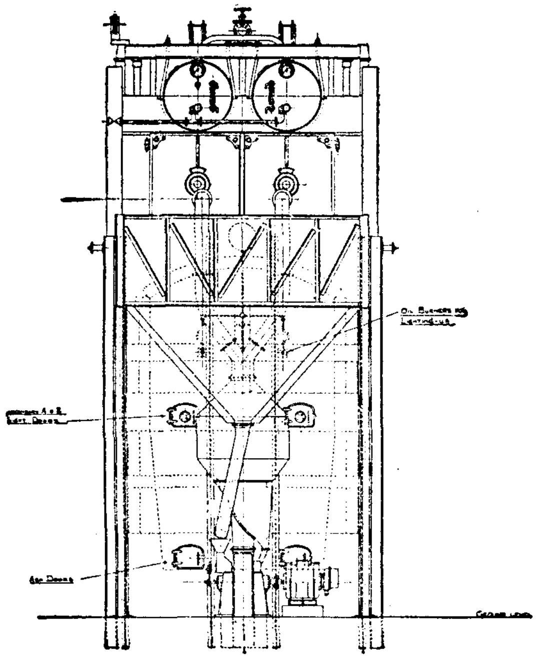
Mr. Timms is of opinion that about one in a thousand may be found to possess the faculty of dowsing. Being of a sanguine nature, I am inclined to estimate the proportion as nearer one per hundred. It would be very greatly to the advantage of Great Britain if there was a far better supply of good water to villages and farms than exists at present. In Scotland, many farm wells, foolishly placed in the past and quite unprotected at the top from pollution, become fouled by the drainage from stables and cattle byres. And in many counties in the kingdom a dowser is unknown. We suggest that, just as a small trickle of water becomes a rivulet, a rivulet a stream, and a stream a river, there should be a quite small beginning, working up gradually to a large scheme. Start, say, with one county in England—perhaps the smallest, Rutland—and try out, parish by parish, to see who may possess the gift of dowsing and be likely to devote time and energy in thoroughly mastering the art of predicting depths and quantities of water in gallons per hour. It takes very little time to test individuals over running water. The names and addresses of all likely dowsers should be taken, and a class formed in a market town handy to several parishes. My experience of dowsers is that they are, in general, a very open-minded type of men, ready to help others along. At the same time, they are a busy class, and have, as a rule, little spare time so would naturally require recompense for work which took them away from their daily living. Pupils should be taught a knowledge of geology, but at the same time in their instruction it could not be too strongly instilled into them that they must be guided by the rod and let the geological knowledge prove useful after the water has been located. They should be tested at the end of a course and given a diploma if passed as capable. Were a moderate sum granted by the War Office or Government to start a trial scheme of this sort, it would be a good beginning towards a solution of obtaining reliable dowsers in war time. And the mere fact of the much-maligned dowser co-operating with the geologist ought to tend to remove the strange prejudice which still strongly exists, even among highly educated people. Without the least exaggeration, had I been given a five pound note for every time since 1904 that the following phrase has been said to me, I could have purchased quite a nice small motor car costing over one hundred and fifty pounds. I know now too well the look that precedes the utterance of the saying, and positively dread it. It goes like this (and the speaker seems to think that it is entirely an original one): Do you know, if you had lived two hundred years ago, you would have been burnt as a witch ?" Two or three—more brainy than the others—have added, after a pause, "perhaps I ought to say, Wizard ?" Quite recently I was treated to a novel variation of this formula. "If you were to do that in India, the natives would call it *Jadoo.*" Talking of India reminds me that the Bombay Government is employing an European dowser, a Major Pogson, at a considerable salary, and that he has been doing excellent work in his Presidency for several months past.

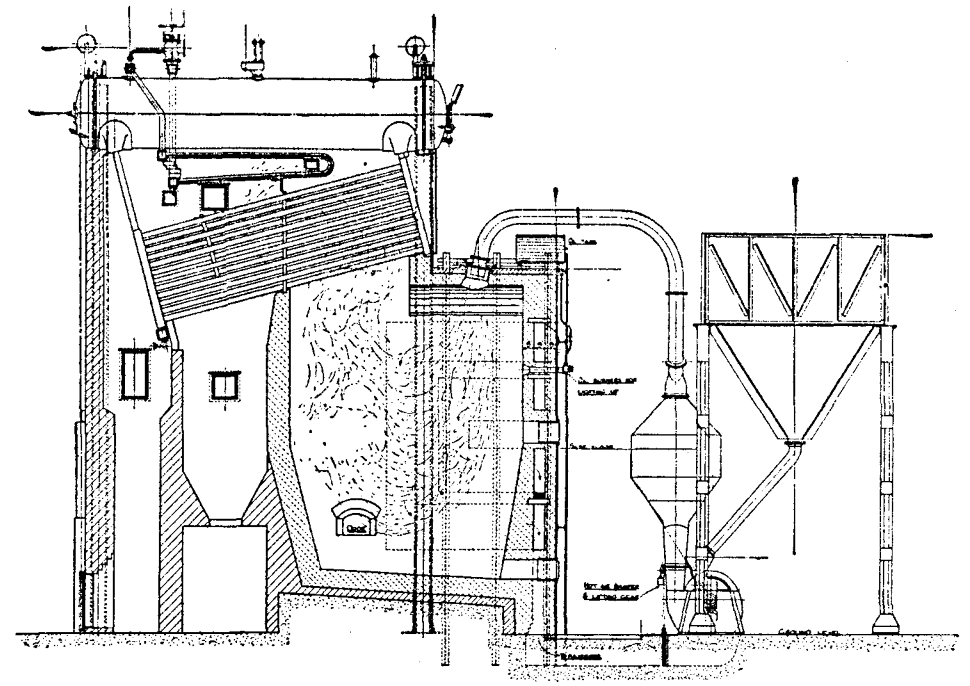
In conclusion, I may remark that I am at present engaged in trying to solve the problem, "What force turns the rod ?" and hope to have arrived at the answer before the end of the year.

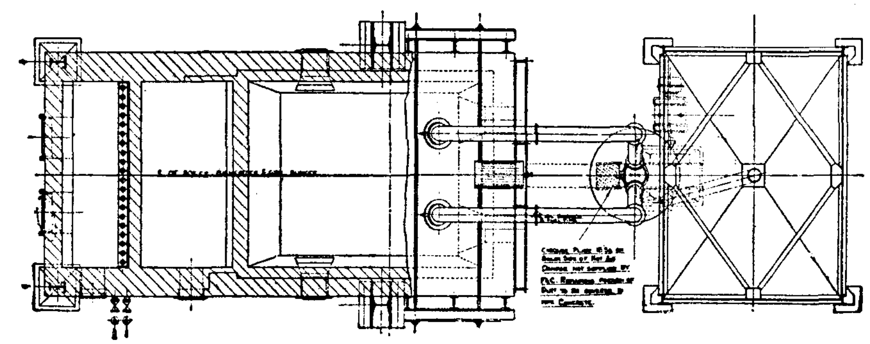


Inside View of Combustion Chamber, showing Water Screen and Water-cooled Walls.

By kind permission of The International Combustion Company.







Layout of Typical Unit Installation.

By kind permission of Messrs. Fraser and Chalmers.

PULVERISED FUEL FOR BOILER FIRING.

By LIEUTENANT K. H. TUSON, R.E.

IN some branches of industry, notably in the heating of rotary cement kilns, coal has been burnt in the pulverised form for nearly twenty-five years. Since the war this method of firing has been coming into use for steam raising, both for process work and in power stations. So far it has been used to a greater extent in the United States than in this country, but it has now been installed in several of the latest "super" power stations, among others Nechells, Birmingham.

The advocates of this system of firing claim that the following advantages result from its use :—

(1) A much lower grade, and consequently cheaper, fuel can be burnt than with chain grate stokers.

(2) Owing to the very large surface area of coal in a finely divided state, an intimate mixture of coal and air can be obtained. As a result of this and of the absence of a moving grate, much less excess air is used than with stoker firing, and partly owing to this:

(3) The boiler thermal efficiency is high, 86 to 88 per cent.

(4) Riddling losses through the bars of the grate are eliminated, also losses occasioned through coal traversing the entire grate and dropping into the ashpit without being entirely consumed.

(5) Boilers can readily be forced in emergency.

(6) Plant can be started up and put on the range very quickly and easily.

(7) Banking losses are almost entirely eliminated.

(8) Coal in its pulversied form can be transported easily in pipe-lines with little loss.

The plant can be arranged in two principal ways, each of which has its own particular application. For large installations the central system is more usual, and pulverising plant is installed with bunkers for both the raw and the pulverised coal. The pulverising plant may be in a separate building apart from the boiler house, and the coal dust is delivered to the boilers by mechanical means if the distance is short, or more usually, pneumatically, through pipes. In this case fans have to be provided. Drying apparatus must also be installed.

The pulverised coal bunker enables the pulverising plant to be shut down when required for cleaning, renewals, etc., and also ensures that, in the event of a breakdown, the supply to the boilers will not be interrupted.

For small installations of one or two boilers only, the expense of, and space taken up by, a central system preclude its use. Each boiler is regarded as a separate unit, and is complete with its own pulveriser, driving motor, etc. The pulveriser feeds direct to the burners (usually two) in the boiler combustion chamber. A small fan is incorporated in the pulveriser. Naturally, with this system, any breakdown of the pulverising plant puts the whole boiler unit out of action. The power absorbed per ton and running costs are also greater than with a central system.

One advantage of the unit system is that the danger of spontaneous combustion of the coal dust is removed. At the same time, totally enclosed and, if necessary, pipe-ventilated motors should be used for driving pulverisers.

BETTINGTON PULVERISERS.

The working of a plant will best be understood if a typical installation is described in detail. The particular plant chosen is known as the Bettington, and is manufactured by Messrs. Fraser and Chalmers (G.E.C.), but the main outlines are common to all makes. So far, Bettington pulverisers are manufactured in sizes suitable for unit systems only. Plate 1 shows the general arrangement of an installation.

The plant consists of :—

(a) The pulveriser A. The raw coal is fed from overhead bunkers or by belt into the receiving hopper, from which a friction-driven screw takes it into the pulverising chamber. There, revolving beaters mounted on a steel rotor hammer it against mild steel liner bars, and the coal is broken up until 85 per cent. of it will pass through a 200-mesh screen (200 to the inch). Previous to being fed on to the screw, the coal passes over the poles of a magnet to remove all tramp iron. Hot air is drawn into the pulveriser, sometimes from the combustion chamber walls, made hollow for the purpose. This helps to dry the coal.

The boiler output is regulated by adjusting the rate of rotation of the feeding screw.

(b) A double inlet fan, intergral with the pulveriser. This has three functions :—

(1) To draw in the air mentioned above.
(2) To direct the coal on to the beaters.
(3) To deliver the pulverised fuel to the burners.

The coal is not actually delivered under pressure; there is a point of balanced pressure half-way along the pipe line and thence the coal is drawn into the combustion chamber by suction.

(c) A mechanical separator B, mounted above the pulveriser. As the beaters and liners wear, the average size of particles delivered from the machine increases. It is essential to deliver particles of a uniform size to the burners, and consequently in any pulverising plant provision must be made for rejecting all oversize particles.

In the Bettington this takes the shape shown in the accompanying plate. The particles on their passage to the burners strike a cone-shaped baffle, which flings them outwards. The large particles are too heavy to be thrown out, and fall down, being fed back into the pulveriser.

(d) The Burners C. These consist of a set of small spiral channels, which split up the fuel and cause it to enter the combustion chamber with a rotary motion. Most of the air necessary for combustion has been drawn into the pulveriser, but arrangements for introducing extra air into the burners are usually made.

(e) The Combustion Chamber D. This is one of the most important features of a pulverised fuel plant, and will be gone into in more detail later in this article. It is essential that the fuel should be completely burnt out before the flame strikes the water tubes.

A vertical tube boiler is better than one with horizontal tubes, as it has a much larger tube surface to receive the radiant heat.

In most plants the burners are placed on top of the combustion chamber and deliver downwards as shown in the figure.

(f) Lighting up arrangements. A small oil tank is mounted above the boiler, and oil delivered through a separate burner lighted with a torch. The consumption of oil is very small.

Other Systems.

Various other pulverised fuel plants are on the market; the only important differences are in the pulveriser and in the design of combustion chamber to avoid the troubles mentioned hereafter.

In the *Fuller Pulveriser* (sold by Babcock and Willcox) and in that marketed by *Simon Carves* for central plant, loose hard steel balls are free to roll around inside the machine. Wear is taken up by inserting fresh balls as the old ones are worn away.

The *Herbert* attritor pulveriser has a revolving element consisting of a disc, on the side of which about thirty cast-iron pegs are fixed. These rotate among a similar set of fixed pegs on the side of the casing, and the coal (after a preliminary breaking up with revolving hammers) is reduced to the required degree of fineness by attrition (i.e., rubbing of particles against one another). As a consequence the power used and running cost are low (figures are given subsequently).

The separation of tramp metal is not done magnetically. The coal is air-borne into the machine and the stream of air is so regulated that it has not sufficient velocity to support the metal with its high density.

The uniformity of particle size is also not ensured by a distinct separator, but by vanes on the rotating element, which throw into the pipe-line by centrifugal force all particles which have attained the requisite degree of fineness.

The low power consumption and cheap maintenance (referred to later) appear to be distinct advantages of the Herbert system. In 1926, none of these plants were running in Great Britain in *power stations*, though stations in Melbourne, Australia, and Holland and industrial plants in this country are equipped with it.

WORKING RESULTS.

Efficiency. Overall boiler efficiencies based on gross calorific value of fuel, of 87-89 per cent., are claimed, but these take no account of power required to drive pulverising plant or anything outside the boiler and economiser.

One plant inspected had been converted from stoker firing, and consequently the above efficiencies were not obtained, but 82 per cent. was obtained consistently over long periods—a great improvement on its previous performance.

Running Cost. In estimating the cost of a pulverising plant the cost of driving the pulveriser is an important item. An average figure for several systems is 25 K.W. hrs. per ton of fuel, but the attritor machine is claimed to absorb only 18 units per ton of fairly dry coal pulverised—a tremendous saving in operating costs. Steam turbines are sometimes employed instead of electric motors for this drive.

Moisture. Coal containing a fairly large moisture content is apt to clog the machine and cause a stoppage. This is a serious drawback to the unit system, where there is usually no dryer. The practicable limit of free moisture is about 10 per cent., though higher figures are claimed by manufacturers.

Renewals. The beaters in the Bettington and other pulverisers of the same type require renewal every thousand hours, and the liners every two thousand. The operation is very simple, a spare rotor being always kept, but the cost of replacements is high, in the neighbourhood of £70 for 2,500 hours running. For the same period £15 will cover replacements to an attritor machine, but the operation takes longer, as all the rotating pegs require replacing every thousand hours, and the stationary pegs and hammers every two thousand hours.

Combustion Chamber. The factor at present retarding the spread of this form of boiler firing in Great Britain is that the maintenance of the combustion chamber, owing to the high temperatures attained, is thought to be very high. Hollow walls are used, with water or air circulation in the hollow space, and the designer has to be very careful to allow for expansion.

It is found in some stations that if an attempt is made to run with a high CO_2 percentage (16 or 17) the ash slags badly and refractories melt, and in some plants the figure is kept down to 11. This of course prevents the system giving its best results. The solution to the difficulty is to have a relatively cool zone where the ashes are deposited. This can be partially achieved by a very deep combustion chamber. Messrs. Fraser and Chalmers are experimenting with introducing flue gases into the bottom of the chamber.

The International Combustion Co. (Lopulco and Rayco systems) Herberts, and Simon Carves, insert a water screen, forming part of the boiler circulating system, to cool the bottom of the chamber. This seems to be a satisfactory arrangement, though the cost of upkeep tends to be high. The recent burst of one of these screens was found to be due to lack of water; the low water alarm had gone off, but the attendant had failed to notice it.

REVIEW.

It is now proposed to discuss in turn each of the advantages of pulverised fuel firing mentioned at the beginning of this article. Any advantage mentioned there which is not referred to here may be considered as generally admitted.

(1) In the past few years the ability of mechanical stokers to deal with low grade fuels has greatly increased. This ability is of immense advantage at power stations near pitheads where large waste dumps are available, but at stations a long way from collieries the price difference (in B. Th. U.) in favour of low grade fuel becomes less. It must also be remembered that if pulverised fuel firing becomes widespread, the demand for, and consequently cost of, this fuel will increase, and the price of coal for stoker firing will decrease as the demand for it falls off.

(3) The difference in efficiency over long periods may be taken as about 5 per cent. better than with stoker plant.

(5) Boilers are usually run with rates of evaporation up to ten pounds per square foot of heating surface.

(6) After a boiler has been banked, it can usually take full load within fifteen minutes of being started up.

(8) This advantage, of course, is only gained with the central system. Plants are running in the tropics where coal dust is transported for long distances by pipe-lines through forest.

One great disadvantage of using pulverised fuel is the difficulty of keeping the boiler alight at low loads. At anything under $33\frac{1}{3}$ per cent. of normal load, the flame usually goes out, as the temperature of the combustion chamber is too low to maintain combustion.

Conclusion.

In any instance where the firing of new boiler plant is under consideration, a balance sheet, including all items concerned, should be prepared. The table below shows some of the entries, though it is not suggested that it is exhaustive for every individual case.

Comparison of Pulverised Fuel and Mechanical Stokers.
Annual Balance Sheet.

In favour of Pulverised Fuel firing.	In favour of Mechanical Stokers.
1. Annual saving in fuel bill, due to cheaper coal and higher thermal efficiency.	3. Interest and depreciation on difference in capital cost of alternatives.
2. Annual saving in wages.	4. Annual cost of energy required for pulveriser motors, fans, dryers, etc.
	5. Maintenance and renewals for pulveriser.
	6. Extra maintenance of combustion chambers over stokers.

Item 4. If electric drive be used it is considered that the energy be charged at the actual cost per unit generated at the station busbars *exclusive* of all standing charges, as these are unaffected by the few extra units required, but some engineers may prefer to charge it at the total cost of production.

Item 5. This is best obtained from actual figures of the cost of spare parts, etc. Figures of from 1d. to 2d. per ton of coal pulverised are advanced.

Item 6. This is at present the indeterminate factor of which many engineers are afraid. Neglecting it, the balance sheet will usually show a balance of a few hundred pounds in favour of pulverising (the makers may possibly be induced to guarantee the maintenance costs for a short period).

In general, the conversion of existing plant is not advantageous, as the requisite depth of combustion chamber can only be obtained either by digging or raising the boiler drums, both costly processes, even if they are feasible.

At present, too, the consensus of opinion seems to be that pulverised fuel firing is not a commercial proposition with boilers evaporating less that 20,000 lbs. of water an hour, though undoubtedly this is only a passing stage in its development.

DEMOLITION OF A MASONRY BRIDGE.

By CAPTAIN C. G. MARTIN, V.C., D.S.O., R.E.

THE following account of a demolition recently carried out at Chatham may be of interest and value to officers of the Corps as exemplifying the use of small charges in boreholes.

The bridge consisted of a single span brick arch over a sunken road which was to be widened and deepened to take motor lorries. The bridge itself had long been disused, and its removal by breaking up by hand had been attempted, but owing to the hardness of the masonry the only results obtained at the end of two weeks' work were the removal of the roadway and parapet walls and cutting a small hole in the arch ring.

As the removal of the bridge was urgently required, the R.E. were asked to carry out its demolition with explosives, the only conditions being that the abutment wall "A" on the east side be left standing undamaged and that the debris be broken up to such a size that it could be removed by hand. (See sketch A.)

Dimensions of bridge :—

Span	10′
Width of abutment	11′
Thickness of arch ring	18″
,, abutment piers	3′
Height of arch above ground	13′

Material of construction :—

Burnt brick in Portland cement mortar.

Owing to the situation of the bridge, in a populated area, within 60 yards of a row of cottages, 200 yards of a public road, and 500 yards of an acre of greenhouses, only small charges could be fired, and contact cutting charges on the arch ring and abutment pier, amounting to 19lbs. and 90lbs. respectively, were out of the question. It was therefore, decided to experiment with bore-hole charges

Three distinct operations were involved :—

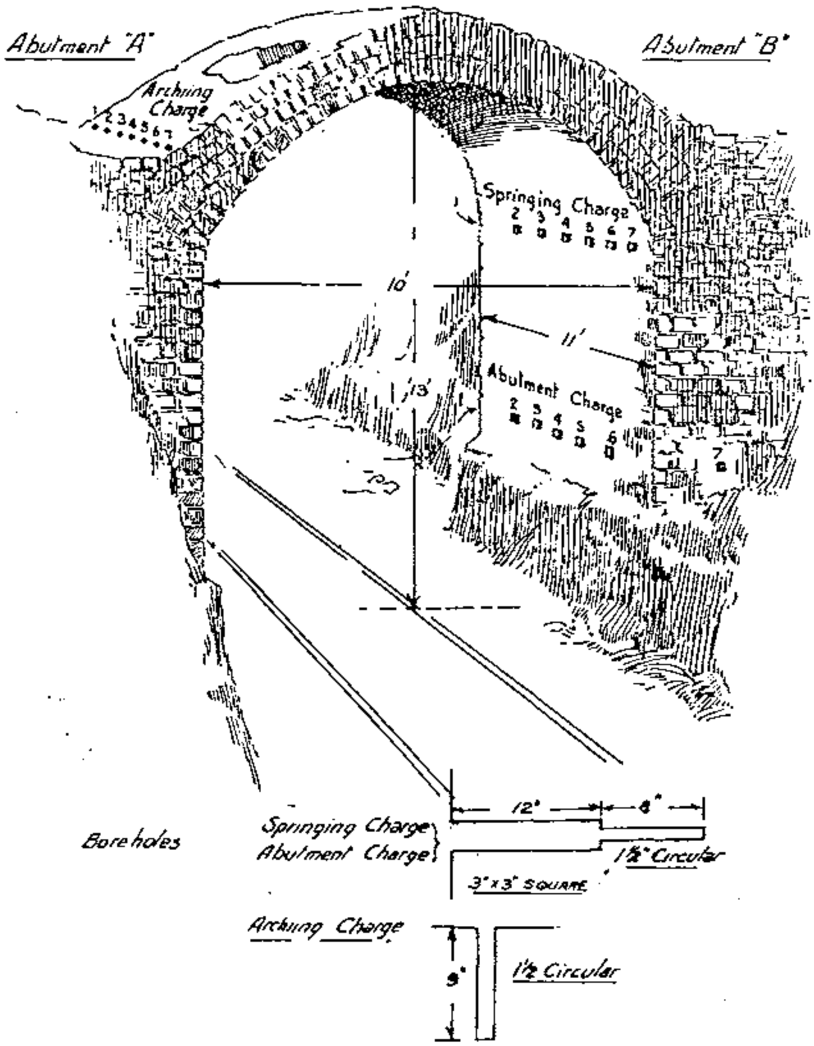
(1) Demolition of arch ring and its springing by charges below and behind the springing course in abutment "B."

(2) Demolition of a pier abutment "B" by charges in the centre of the lower portion of the pier.

(3) Demolition of the arch ring where it joined the abutment "A" to cut any portion remaining after operation (1) had been carried out.

SKETCH "A"

Position of Boreholes.



Calculations for charges.

(1) *Springing charge.*

Depth to centre of charge=1′ 6″.

$$C=\frac{L^3}{6} \text{ where } L=3/2'. \quad \text{(Page 60 } \textit{M.M.E.} \text{ Vol. IV.)}$$

$$=9 \text{ ozs.}$$

Fig. 1.

Fig. 2.

Bridge demolition 1 & 2

Fig. 3.

Fig. 4.

Bridge demolition 3 & 4

Bridge demolition 5

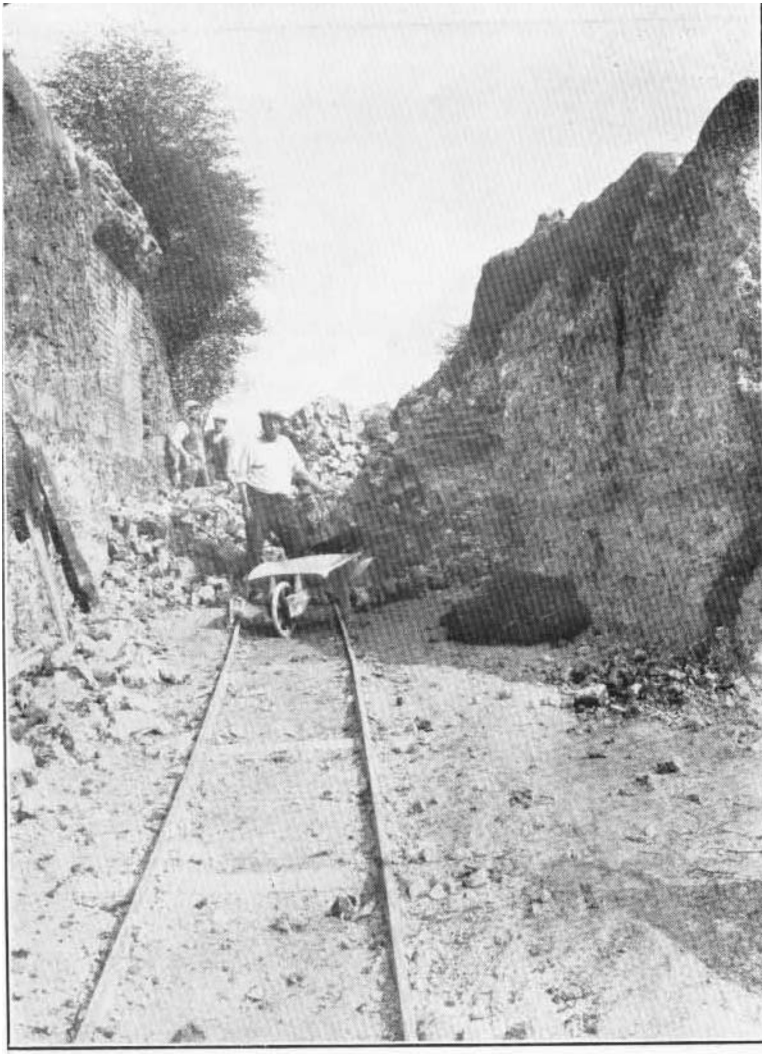


Fig. 6.

Bridge demolition

Spacing of charges $=\frac{4}{3}$ L $=24''$

(2) *Pier abutment charge.*
Thickness of pier $=3'$

$\therefore$ L $=3/2'$.

$\therefore$ Charge as for springing charge $=9$ ozs.
spacing of charge $=24''$.

(3) *Arch ring charge.*
Thickness of arch ring $=18''$

$\therefore$ L $=3/4'$.

$C=\frac{L^3}{6}=1\frac{1}{8}$ oz.

Spacing of charges $=\frac{4}{3}\times$ L $=12''$

Total Charges from calculations.

(1) Springing.	5 charges of	9 ozs. at 22″ interval	=3lbs. 7 ozs.
(2) Pier.	5 ,,	9 ozs. at 22″ interval	=3 lbs. 7 ozs.
(3) Arch ring.	9 ,,	$1\frac{1}{8}$ ozs. at 12″ interval	= 10 ozs.
		Total	=7 lbs. 8 ozs.

For convenience, to suit the working party reliefs and available tools, the following bore-holes were driven for charges :—

(1) Springing. 7 bore-holes at $16\frac{1}{2}''$ interval.
(2) Pier. 7 ,, ,, $16\frac{1}{2}''$,,
(3) Arch ring. 7 ,, ,, $15''$,, Sketch A.)

Bore Holes.

The bore-holes for the springing and the pier charges were made from a slung platform (Photo 1); the first 12 inches were made with a $18''\times1\frac{1}{4}''$ chisel and a $4\frac{1}{4}$lb. hammer, mason, cutting a $3''\times3''$ square hole.

The average time taken for the 12″ hole was 45 mins.

The last 8″ consisted of a $1\frac{1}{2}''$ round bore-hole, made with a $4'\times1\frac{1}{2}''$ boring bar No. 3 and a 7-lb. hammer.

The holes were bored dry.

The time taken for the last 8″ in the springing series, where the hammer was used above the head, was 135 mins., and in the pier series 75 mins.

With the bore-holes $16\frac{1}{2}$in. apart, it was necessary to work in two shifts, the total time taken being 6 hours for the springing and 4 hours for the pier.

For the arch ring bore-holes, the No. 3 boring bar and 7-lb. hammer were again used, but the hole bored wet.

The time taken for 9" depth was 45 mins.

Working in two shifts, the total time was 90 mins.

The above figures were with recruits who had no previous experience in the use of these tools.

Charges Used.

Test Charge (see Photo 1).—Bore-hole No. 7 in abutment "B" was charged with fou 1-oz. gun-cotton primers and fired by F.I.D.

The charge was less than half the calculated charge of 9 oz.

Result is shewn in Photo 2.

The corner of the pier was blown out, and the pier was cracked down to the foundations on the inner face.

Springing Charge.—It was decided to charge bore-holes 1 to 7 of the springing charge with four 1-oz. guncotton primers each and to fire electrically, covering the top of the pier with torpedo netting.

After individual test, the seven No. 13 detonators were inserted in the charges and the bore-holes tamped with clay.

On testing for continuity before firing, it was found that the No. 13 detonator in bore-hole No. 1 was defective; this was disconnected from the circuit and bore-holes No. 2 to 7 were fired.

Result is shown in Photo 3.

Larger portion of the arch ring was blown away.

Charges 3 to 7 successfully blew out the springing, but charge 2 blew out on top of the abutment. The portion of springing above charge 1, which was not fired, and above charge 2, which blew out the other side of the pier, remained in position though badly cracked.

Abutment Charge.—The abutment bore-holes No. 1 to 6 were charged with three 1-oz. guncotton primers each and fired by F.I.D. branches, which passed through the primers after taking off from the main F.I.D. by hammered twisted joints.

The main F.I.D. was fired by one No. 8 detonator, attached to it by a brass union. (See Sketch "B.")

Result is shown in Photo 4.

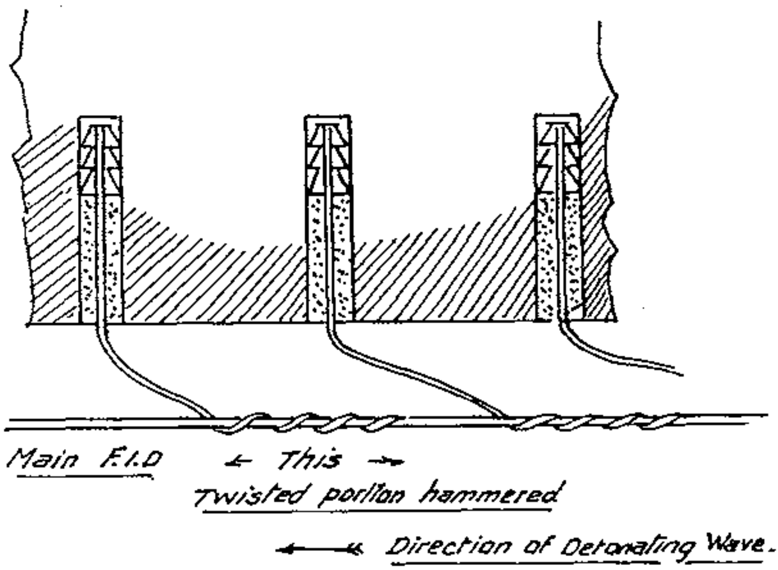
A wedge was cut out of the abutment for full length, the whole pier was cracked and was only kept standing by the earth bank behind.

The remaining portion of the arch ring was cut from the pier, but kept in position by its own weight.

Arch Ring Charge.—Bore holes Nos. 1-7 were charged with two 8-oz guncotton primers and fired by F.I.D. as for the pier.

SKETCH 'B'

Method of firing Borehole Charges with F.I.D.



Initial detonation of F.I.D.

Result as in Photo 5.

The arch ring was cut off and dropped, with the pier abutment, on to the roadway.

Breaking up.

Seven bore-holes, 9in. deep, were made in the larger blocks of masonry, charged with two 1-oz. guncotton primers and fired electrically.

Result as in Photo 6.

Total Charges Used:—

Springing	=	24 ozs.
Pier	=	22 ,,
Arch ring	=	14 ,,
Breaking up	=	14 ,,
		74 ozs=$4\frac{5}{8}$ lbs.

POINTS BROUGHT OUT BY THE DEMOLITION.

1. *Demolition of Pier.*

The formula $\frac{L^3}{6}$ is ample and the spacing of charges $\frac{4L}{3}$ is suitable for working where both sides of the pier can be got at, holes being driven from the opposite sides alternately.

2. *Demolition of Brick Arch by Bore-hole Charges under and behind Springing.*

(*a*) The bore-hole should be bored to a depth so as to bring the centre of the charge at a distance from the face at least equal to thickness of the arch ring.

(*b*) To enable work to be carried out at all bore-holes simultaneously, the spacing of bore-holes must not be less than 3′; this will necessitate a larger charge. For an arch ring 2′ in thickness the charge required, spaced at 3′ intervals, using $C=\frac{S}{\sqrt{10e}}L^3(\sqrt{1+n^2}-0.41)^3$ formula (*M.M.E.*IV, page 152)

taking $S=4$

$e=3$

works out at 2 lbs.

3. *Bore-holes.*

For untrained men, a square or rectangular hole in masonry is more rapidly cut than a circular bored hole. From tests carried out, a square hole 9″×9″ can be cut with brick chisels to a depth of 3′ at the average rate of 1′ an hour, so long as the direction of the hole coincides with the courses of brick work.

If boring bars or jumping bars are employed, holes should, where possible, be bored wet, thus reducing the time taken.

TRADE TESTING AND TRADE TRAINING.

By Capt. R. P. A. D. Lithgow, R.E.

While it is neither possible nor desirable to deal exhaustively with the subject of Trades Organization generally in an article such as this, it is thought that there is, perhaps, especially among junior officers, some lack of understanding of the methods of trade education employed in the Corps and of the qualifications which are to be expected of a tradesman.

As a basis upon which to work it is essential that the general classification of Trade Groups and Rates should be known.

The detailed composition of the trade groups, together with the authorised trade tests for each class, is laid down in "Regulations Governing the issue of Tradesmen's Rates of Pay, 1923," originally issued with *Army Orders* for December, 1923, and considerably amended subsequently. A rough classification may, however, be of value, to enable officers to understand more readily the broad principle or framework on which Corps trades are organised.

Composition of Trade Groups.

The Trade Groups are arranged by letter, ranging from A to E, the higher group trades carrying the greater rates of pay for men of similar standard, or class, in their respective trades.

Each trade in groups A, B, and C, is subdivided into three Classes, I, II and III; Groups D and E contain Classes II and III only, Class II for certain Group E trades being authorised by *A.O.* 213 of 1925.

Group A trades are, broadly speaking, those requiring considerable theoretical knowledge and/or practical experience over a period of years.

As typical examples, more commonly met with in the Corps, may be instanced *Draughtsman* (*Architectural* or *Mechanical*); *Fitter*; *Patternmaker*; and *Surveyor* (of various kinds).

Group B trades contain the majority of the normal Building and Workshop trades, such as *Blacksmith, Bricklayer, Carpenter and Joiner*, and so on.

Group C comprises normal trades requiring less training and experience, or less skill, than those in Group B, some of the commoner examples being *Painter and Decorator, Riveter* and *Tinsmith and Whitesmith*.

Group D consists of rather lower category trades and, as previously mentioned, these trades are divided into two classes only, there being no Class I rate.

Examples are *Concretor*, *Driller* (*Machine and Hand*), and *Sawyer*.

Group E is composed of semi-skilled trades, such as *Blacksmith's Striker* or *Hammerman*, and also contains men who are classified as semi-skilled at a Corps trade of higher category. The latter are enlisted as Pioneers in their trades, e.g., *Pioneer* (*Carpenter and Joiner*) or *Pioneer* (*Bricklayer*).

Men who show more than ordinary semi-skilled knowledge of a trade but who cannot be classified as Class III tradesmen, owing, perhaps, to their experience being limited to certain branches of the trade only, may be passed as Pioneers F. and recommended for six months' trade training on completion of their Recruits course.

Further details are given below under the head of "Trade Training."

It should be noted that men, whether tradesmen or Pioneers, can only be enlisted into the Corps when they have trade qualifications in a recognised Corps trade, and that all the trades listed in the Regulations referred to are not applicable to R.E.

Men are also enlisted on normal rates of pay (as for infantry) if they have no useful knowledge of a recognised trade, but can subsequently be mustered as *Pioneers R.E.*, without knowledge of a Corps trade, provided that they obtain a certificate from their C.O. that :—

(i) They are above the average in intelligence, with a fair amount of education, equivalent to the standard of a third class school certificate.

(ii) They have satisfactorily passed through a course of fieldworks.

Qualifications for Trade Rates.

The detailed qualifications and tests for the different classes of all trades are laid down in the Regulations referred to above, and it is not proposed to go into any further detail here. As a rough guide to the method of classification, however, the following may be found of some use.

The Pioneer is a semi-skilled man only and more or less corresponds to a Learner or Mate in civil life.

The Class III tradesman is a skilled man as far as manual dexterity is concerned, but is only expected to work under supervision.

Broadly speaking, he should be able to carry out the actual work on any but complicated jobs, but cannot be made responsible for the setting out of the work, nor must he necessarily, except in certain specified trades, be expected to work from a sketch or drawing. His qualifications correspond roughly to those possessed (in theory) by a Journeyman in civil life.

The Class II tradesman should possess considerable manual skill and should be able to carry out the work on quite complicated jobs. He should also be able to work to a sketch or drawing and to make simple sketches, and to set out work such as is normally met with in his trade.

The Class I man corresponds to the foreman in civil life.

He should possess manual skill to the same, or possibly to a slightly greater, degree then the Class II tradesman, but it should be backed by considerable experience, enabling him to undertake work of any kind within his trade, to supervise men of lower categories, to read and make drawings and set out any class of work, and to estimate quantities. In fact, given a sketch or verbal instructions, he should be able to start the work, draw the requisite stores and materials, and supervise, or himself perform, the whole job from start to finish as far as his own trade is concerned.

These remarks are necessarily brief and very general in character, but any officer should, with the assistance of the Regulations concerning Trade Rates, be able to assess fairly accurately a man's qualifications if the above rough guide is kept in mind.

Trade Testing.

As regards the method of carrying out the actual trade test, it is difficult to lay down any definite procedure. Full details of the standard tests are laid down in the Regulations, but there are a few points which must always be borne in mind by officers to whom Trade-testing duties are delegated or who wish to recommend a man in their unit for a further test, with a view to increase of Trade Rate, by the Trade-Testing Board.

Trade testing is, of course, almost entirely a matter for experience, and an officer who has had no practice, and who probably has only a somewhat superficial knowledge of the actual manual work, must be largely guided by an N.C.O. or Sapper who is himself a good tradesman and has a knowledge of the standard to be expected.

A few words of warning and advice may not, however, be out of place here.

Firstly, then, a trade-testing officer must be fair to the recruit or sapper under test. It must always be remembered that local practice, especially in the building trades, varies in different parts of the country. It is not, therefore, reasonable to fail a man merely because his *method* of obtaining a result differs slightly from that of standard practice in the Corps (or possibly only from that of the tradesman expert whose advice is being sought). It is really the result which matters.

The way in which a man handles his tools and the way he starts to work on his job are usually very sound indications as to his capabilities.

Secondly, it is equally, if not more, important, to be fair to the man's future Company Commander and to the tradesmen already in the Corps. *Too much lenience in testing is an evil which cannot be too strongly deprecated.*

A man who is not worth his trade rate is a nuisance and may even be a danger. This point appears quite obvious without further elaboration, but the possible case of a man who was, for the sake of example, barely up to Class III standard on enlistment and has not worked at his trade since, but is "given" his Class II rate on service because he is, let us say, a very good Officers' Mess cook, has been met with in practice. It should not be lost sight of that the same individual may perchance subsequently be posted as an instructor in his trade. Unfortunately, the irony of fate rarely ensures that the "testing" officer in his case shall also be in charge of the Trade School concerned!

It must not be thought, in consequence of this, that the standard trade tests must be rigidly adhered to in all their details. In the first place, a man's capabilities should always be tested by questioning as well as by his practical work. The length of his experience; the class of work on which he has been employed; his knowledge of practical details of normal jobs within his trade not brought out by the practical test-job given; his general knowledge of constructional or workshop methods which affect his trade and those others with whom some liaison may be necessary or desirable; all these points should be taken into consideration and may turn the scale in either direction.

Further, it should always be remembered that the trades approved and laid down for enlistment into the Corps do not exactly correspond to the trades recognised in civil life.

One example should serve amply to illustrate this point.

Under what one may broadly classify as Plumbers trades there are in the Corps but two approved trades, namely *Plumber and Gasfitter*, Group B, and *Tinsmith and Whitesmith*, Group C.

These two trades, in the higher rates, embrace a knowledge of several entirely distinct civil trades, such as Plumber, Gasfitter, Tinsmith, Whitesmith, Coppersmith and Panel Beater, to say nothing of "Hot Water Engineers" and "Sanitary Experts."

Thus, although the Class III trade tests are usually so arranged as to admit a man skilled in one civil branch only, it will be found that in many cases he has to combine two or more such branches before he can qualify for a higher rate.

In some trades the supply of men of the required standard of skill cannot adequately be maintained by direct enlistment and therefore recourse has to be had to training, the methods of which are further discussed below.

Trade Training.

Trade Training, to supplement the supply of tradesmen obtainable by direct enlistment, may most conveniently be divided into three categories, namely :—

(i) The training of Pioneers.
(ii) The training of Normal Rates men.
(iii) The training of boys.

The training of men who are already tradesmen with a view to their qualifying for a higher trade rate is considered to be beyond the scope of this article and must in any case depend upon local conditions and facilities.

In the ordinary course of events, both boys and Pioneers F. are given their trade-training before being posted to a unit, but in some cases this devolves upon the company, and it is of great importance that the fullest possible use should be made of such facilities as do exist locally for the training of buglers and men, whether already classified as Tradesmen or not.

(i) *The training of Pioneers.* The ordinary Pioneer and the normal rates man, of course, receive no trade training at Government expense before proceeding to their units. There is, however, a distinct class of man known as the Pioneer F., who, provided there are sufficient vacancies in establishment in his trade, receives a six months' course of instruction in his trade. This course is given at the S.M.E. on conclusion of the man's recruit training and before he proceeds to a unit.

Men who fail to reach the Class III standard in some particular, but who have a good knowledge of the use of the tools, are worth considering for six months' training. Here again the difference between Corps trades and trades in civil life has a definite bearing. For instance, a man who has had fair experience of outside carpenters' work, such as roofing, flooring and fixing and hanging generally, but has done little work on the bench, will probably be worth classifying as a Pioneer (Carpenter and Joiner) F., provided that his method of using the tools and the neatness of his work are promising enough to warrant the belief that after his training he will be well up to the Class III standard.

Similarly, a "brush-hand," with a good knowledge of ordinary painters' methods and plain painting, who has perhaps done a little glazing or paperhanging, but has not sufficient skill at either to pass Class III, and has had no opportunity of practising colour-mixing, is probably worth passing as a Pioneer F, although, of course, no guarantee can be given that there will be sufficient vacancies in his trade to allow of his being trained further at Government expense.

As regards the actual method of training adopted at the S.M.E. in the case of such men, the requirements of each individual are kept in view as far as possible, but in general the men are put to work in the shops concerned, where they take a considerable part in the ordinary work which is being turned out.

In this way, in addition to special and definite instruction, they obtain, during their six months, a very fair experience of different classes of jobs such as are met with in Army shops, which, of course, include repair work as well as original construction. In many cases, where the man has had a fair grounding in his trade before coming up as a recruit, he may, if he works hard, come near the Class II standard on completion of his course, though the passing of the Class II test immediately after the period of training is an extremely rare occurrence, owing to the lack of general experience. In the majority of cases the Pioneer F, on passing Class III at the end of his course, will be a more useful tradesman than the recruit who has just managed to qualify as Class III on enlistment.

(ii) *The training of Normal Rates men.* Courses of instruction in certain trades, most of which are peculiar to the Corps, are held at the S.M.E., at the S.E.L. Gosport., and elsewhere—particulars may be found in *Corps Memo.* No. 634, Part II.

For certain trades, e.g., *Engine Hand (I.C.)*, *Stoker (Stationary Engines)*, and *Well Borer*, definite courses are held as required and at fairly regular intervals.

In other trades, in which the available supply of tradesmen from normal sources is insufficient to maintain the authorised establishment in the Corps, classes may occasionally be held in order to make up deficiencies from selected Normal Rates men, such classes being formed at the request of O i/c R.E. Records. For example, three classes were held at the S.M.E. for the training of Bricklayers during 1925 and 1926.

It must, of course, be realised that it is impossible to transform a Normal Rates man, however keen and willing he may be, into a tradesman in any desired trade during a comparatively short course, up to about six months in duration.

Even in the case of trades such as that of bricklayer, in which the knowledge required is more or less stereotyped, it is impossible to do more than produce a good degree of manual dexterity, the gaining of the experience which must mean so much to any tradesman being left to subsequent general employment.

The only reason for the possibility of turning out reasonably good tradesmen in so short a time, as compared with that required in civil life, is that, in the Army, men on such courses receive continuous, definite and individual instruction with one end in view, whereas in civil life the embryo tradesman has too often to pick up what he can while labouring for others.

(iii) *The Training of Boys.* Two distinct classes of boys receive trade instruction :—

(a) Apprentice Tradesmen.
(b) Buglers.

The former have now to pass a competitive educational entrance examination before enlistment, and on the whole, the class of boy now coming up for training is distinctly good.

Until 1st January, 1927, the majority of Apprentice Tradesmen for the Corps were trained at the S.M.E. but, except in the case of certain trades, these boys are now to receive their training at the Boys' Technical School at Chepstow.

The Bugler, of course, is primarily enlisted as such, but, on qualifying in bugle calls, is sent in for trade training in a selected trade at the S.M.E. The greater proportion of them are found to be keen and, although they put in less time in the shops than the Apprentice Tradesman, some very good tradesmen are turned out from amongst them.

In the normal course of events the boy starts his training at the age of about 15 to 15½ and continues until his 18th birthday, when he becomes due to join the ranks as a sapper. During this period he is put through a progressive course of training, essentially practical in character but containing some theoretical instruction in the form of lectures on building or workshop practice, which is punctuated every six months by graduated Regulating Tests.

The passing of these regulating tests affects the rate of pay received, but is by no means a foregone conclusion, though comparatively few boys fail to pass at the end of the minumm period, except in cases where much time has been lost through sickness or similar causes.

The number who definitely fail and are put back for a further six months is very small.

The trade standard reached by most boys on joining the ranks is high, in fact much higher than that of the average recruit.

The principle adopted, as far as possible, is that a boy, on completion of his trade-training, should attain the Class II standard, as as far "manual dexterity" is concerned, though he can only be rated as Class III, owing to his lack of general experience. He has, however, been thoroughly grounded, and the average boy should find little difficulty in obtaining his Class II rate within a reasonable period after joining his unit.

In conclusion, it is hoped that the foregoing may perhaps help towards "a better understanding on the part of all concerned of the 'trade problem' to be solved in the Corps and the method adopted for its solution." [*Corps Memo.* No. 634 Part II. Sec. 1. (2).]

MAJOR-GENERAL A. EMMETT AND NAPOLEON.

By F. E. G. S.

ANTHONY EMMETT was born in 1789, and received his first commission in the Corps of Royal Engineers in 1808. Early in 1809 he joined the Army in the Peninsula, and remained with it to the end of the war, except for the period from April, 1812, to October, 1813, which he spent in England recovering from a wound received in the capture of Badajos. His experiences of active operations are given by him in the following list :—

"1st. At Abrantes, and skirmished near it whilst the French were in front of the lines of Lisbon.

"2nd. In 1811, at both the sieges of Badajos. At the cavalry affair at El Bodon, and occasionally in the trenches before Ciudad Rodrigo, though sickness prevented him taking duty. Prior to the siege he was occupied in improving the navigation of the Upper Douro, to facilitate the transport of supplies for that operation.

"3rd. At the siege of Badajos, in 1812, and at the assault, he led on one Portuguese column of the 4th Division to the breach of the curtain. Severely wounded in the covered way, he was conveyed to the hospital tent, and eventually sent to England for the restoration of health. He believes he was the only subaltern Royal Engineer with a column who was not killed on that perilous night. . . .

"He joined the Army as Captain in November, 1813, and was employed in the examination of the fords of the Nive—held by the enemy's posts—prior to the successful passage of the river, reporting thereon direct to Headquarters and also to Lord Hill. In every instance his report proved correct.

"During the following campaign he was attached to the 2nd Division, and was present :

"1st. At the battle of St. Pierre, near Bayonne, on the 13th December ;

"2nd. At the attack on the Heights of Garris, St. Palais, at Tarbes, and other minor affairs ;

"3rd. At the battle of Orthes ;

"4th. At the battle of Toulouse."

Besides his wound at Badajos, he was twice slightly wounded.

"Soon after his return to England he was sent with General Keane on the Expedition to New Orleans, landed with the advance and was present in the attack of the Americans on that night, at the assault on the enemy's lines and siege of Fort Bower."

On his return to England in 1815, he received the appointment of C.R.E. at St. Helena, and sailed on the *Phaeton*, frigate, in January, 1816, with Sir Hudsón Lowe and his staff and the 7th Company, 4th Battalion, Royal Sappers and Miners. They landed at St. Helena on the 14th April, and among some papers recently presented to the Corps by Mr. A. H. Emmett, son of the General, are the original " Memoranda for the Guidance of the Officer in command of the Engineers at St. Helena," in Sir Hudson's handwriting, and signed by him at James Town on the 3rd May. It is a formal document dealing with works and working parties and accounts, but twice mentions works in connection with " General Bonaparte's establishment." It is characteristic of Lowe that he wrote : " No works of any kind to be undertaken without the written approbation of the Governor."

Emmett kept a diary, and though he unfortunately destroyed most of it in his old age, as he considered that the horrors of war were best left unrecorded, he preserved the portion of it dealing with his experiences in St. Helena, and a copy of this is among the papers and has been placed in the Corps Museum. (It has already been published in America, in the January, 1912, issue of *The Century Magazine*).

He had one, and only one, interview with Napoleon. As he had to make a report on the defences of the island, it was not until the 20th July that he was able to pay his respects to the Emperor. He was accompanied by Lieut. Jackson, a sort of attaché to Sir Hudson, and Counts Bertrand and Montholon were in attendance on the Emperor. He was received graciously, and, in reply to Napoleon, said that he was the Chief Officer o fEngineers, and that he had served both in the Peninsula and in France, under both Wellington and Beresford. When asked if he was in the lines at Lisbon, he said " no," but in those of Almada, on the opposite side of the Tagus, but that he knew the lines well. Napoleon said, " Masséna made a great mistake. He ought to have attacked them immediately on coming before them." Emmett expressed his doubts as to the success of this action ; the lines had been long in preparation—were well armed with artillery—and our Army had retired on them in good order. He replied : " That might be, but it was Masséna's only chance of success—by pushing *tête baissée* into them he might have carried them. At all events, it would have been better than rotting before them. Turenne and Montecuculi both said, ' give no time to your enemy to entrench.' " Emmett here remarks that General Sir George Murray, in a later conversation, agreed that Masséna would have had a fair chance of success, as our Army entered the lines in a very disorderly state.

Napoleon mentioned Masséna's defeat at Busaco, and exclaimed with wrath and indignation, "Why did he not acknowledge it? We must all be beaten at one time or another." After some discussion about the siege of Badajos, Napoleon mentioned Burgos, which he said he remembered well, and asked if a strong redoubt, which he had ordered, had been made there. Emmett answered, "Yes, a horn-work had been constructed, which was carried at once by assault." This rather startled him, but Emmett explained that while columns attacked the fronts unsuccessfully, another attacked the gorge and forced the palisades, but that the losses were heavy.

After that they discussed the battle of Toulouse, and Emmett criticised Soult for allowing an army to file across the front of his position and between it and the difficult little stream, the Ers. To this he listened with attention, and asked some questions.

Emmett here remarks that in a subsequent conversation with Sir George Murray, the latter said that the Duke's plan was to force the passage of the Ers, and that he, Sir George, suggested the desperate expedient of filing between it and the position. He says, "The Duke's plan would have failed, and Murray's ought to have done so."

Emmett also criticised Soult for not attacking Beresford while the latter was isolated for some days, before the battle, by the rapid rise of the Garonne. To this Napoleon appeared to acquiesce, and a later conversation with Montholon confirmed this impression.

After some further conversation, Napoleon pointed to a new battery at Prosperous Bay, and, asking, "What is to attack us there?" laughingly added, "The rats!" Then "Jusqu' au revoir."

After that, the Emperor asked Lieut. Jackson if he also belonged to the Engineers. On receiving the reply: "No; to the *Etat Major*," he most pointedly bowed him out, no doubt supposing him to have been sent by Sir Hudson to overhear what passed, "which," adds Emmett, "was most probably the fact."

Emmett had many other opportunities of speaking to Napoleon while he was building the new house at Longwood, but, after consulting Sir Hudson Lowe, he considered it safest to act upon the latter's advice, "I should take off my hat to him and pass on." But he saw a lot of Count Montholon, and lent him many books, which were returned to him profusely annotated in Napoleon's vile handwriting. Most of these he gave away, but one, "Histoire de la Campagne de 1800 en Allemagne et en Italie; par M. de Bulow, Officier Prussien, Auteur de l' Esprit du Système de Guerre Moderne; traduit de l'allemand par Ch. L. Sevelinges. (Paris)," remained in his possession, together with a transcript of Napoleon's notes, which were deciphered by Count Montholon to Capt. Wortham, R.E., and Emmett. In 1831 the latter republished the book (Londres:

Chez Whittaker, Treacher et Arnot) with Napoleon's remarks as footnotes. The Corps Library in London is the fortunate possessor of a copy of this rare book, it having been recently transferred to London from the Dublin Branch. Bulow's book is rather a criticism than a history, and Napoleon's 148 notes are interesting not only as comments on the action of Moreau, in view of their well-known rivalry, but also on the art of war in general. Unfortunately, the original book was lost.

On the death of Napoleon, Emmett received orders from Sir Hudson Lowe to make the grave. The way in which he carried out this work is best explained by a quotation from another document, a Report, dated 19th October, 1840, by Captain C. C. Alexander, the then C.R.E. at St. Helena, to the I.G.F., "transmitting a detailed report of the exhumation of the remains of the late Emperor Napoleon, etc.," a copy of which is included among the General's papers, and was also published in *The Century Magazine*.

"The Commissioners first caused to be removed the iron railing surrounding the tomb, with the stone coping upon which it was fixed. The surface of the tomb, covering an area of 11 ft. 6 in., consisting of 3 slabs of wrought stone 6 inches thick, fixed in solid masonry and secured by bands of iron, was raised and completely removed by half past one o'clock; there then appeared a retaining wall 16 inches thick, forming, as was afterwards ascertained, the 4 lateral sides of a stone vault, 11 feet long, 4 ft. 8 in. wide, and 8 feet deep. This vault was filled with earth to within 6 inches of the 3 stone slabs just removed. After having thrown out and removed the earth, there appeared at the depth of 6 ft. 10 in. a layer of Roman cement, covering the whole area bounded by the 4 side walls. The earth being completely removed by three o'clock, the Commissioners descended into the Tomb, and ascertained that it was perfect and untouched on all sides. The layer of cement being picked up and removed, there appeared a horizontal bed of masonry, 10½ in. thick, of hard stone strongly cemented and secured by iron clamps, which it required four-and-a-half hours to take up. The extreme difficulty of this part of the operation made it necessary to give directions to excavate a ditch parallel to the left side of the vault, and take down the masonry of this side in order to gain an entrance to the sarcophagus by the side, if the masonry of the surface should resist the efforts making at the same time to remove it, but this masonry having been completely taken up by eight o'clock, that part of the operation was discontinued when it had reached a depth of 6 ft. Immediately under the bed was found a strong stone slab, 5 in. thick, 6 ft. 7½ in. long, by 3 ft. broad, forming, as was afterwards ascertained, the upper surface of the interior sarcophagus of wrought stone containing the coffin. This slab was found quite entire and untouched, and was firmly secured to the lateral sides by strong masonry, built with Roman cement, which masonry was perfect.

"The masonry between the slab and the sides was then, with care, removed, and two Louis's let into the slab. At half past nine o'clock all was ready for opening the sarcophagus. . . .

"The Commissioners then descended into the tomb to inspect the coffin, which was found sound, with the exception only of a small portion of the bottom, which was slightly decayed, though lying on a strong stone slab placed at the bottom of the Tomb, resting on wrought stone pillars. . . ."

Napoleon died at sunset, on the 5th May, 1821, and was buried on the 9th, at 2.30 p.m. The site of the grave was pointed out to Major Emmett by Sir Hudson Lowe on the evening of the 5th, so that the vault and sarcophagus must have been made at great pressure, even though Emmett had probably prepared the design beforehand. He used large flagstones, which had been sent from England for the kitchen of the new house, for making the sarcophagus.

He writes: "The last words Napoleon was heard to utter distinctly were, 'Tête d'armée' . . . The body was laid out in his green coat, etc., on the bed and in the room where he died, in the cottage in Longwood grounds—a small wretched room—the face very handsome, and much like his best prints when First Consul. He had become corpulent and full in the face before death. The change was remarkable." He concludes with these words: "Well would it have been for England if it could be said that during his captivity its greatest enemy had been treated with noble generosity."

Emmett still had a long life before him. He served at Cork, Manchester, Newcastle, Bermuda, Scotland, the Channel Isles, and Malta. When the Crimean War broke out he was suggested by Sir John Burgoyne for the Royal Engineer command in the East, but was obliged to decline, sorely against his will, in consequence of the suffering in his arm, due to the Badajos wound. So he became Commanding Royal Engineer in Ireland, and gained great credit by the construction of the Curragh Camp. It may also be mentioned that in 1840, on his return from Bermuda, Lt.-Col. Emmett had been instructed to "examine and report upon the improvements which had been adopted in Heavy Ordnance, Carriages, etc., with a view to promote those changes in the construction of batteries, embrasures, etc., which might have become necessary," in which he proposed the adoption of a dwarf traversing platform, enabling the gun to fire over a 4 ft. 2 in. parapet, instead of through an embrasure. This proposal was at first rejected by a Select Committee at Woolwich, but two years later was adopted into the Service.

Major General Emmett died and was buried at Brighton in March, 1872.

Colonel Simeon Hardy Exham CB CBE

MEMOIR.

COLONEL S. H. EXHAM, C.B., C.B.E., LATE ROYAL ENGINEERS.

Colonel Simeon Hardy Exham, who died at Walton House, Felixstowe, on the 26th November last, was a typical example of an Officer of the Corps of Royal Engineers who was called upon to fill many varied positions of heavy responsibility both Military and Civil, and succeeded in all he undertook.

He served under both the War Office and the Admiralty, and latterly, on retirement, he proved how useful the experience and knowledge he had acquired could be in the management of a large estate.

Colonel Exham, who was born at Cork on the 5th July, 1850, was the second son of the late Thomas Exham, of Monkstown, County Cork, and Frances, daughter of the late Simeon Hardy. He joined the R.M.A., Woolwich, in 1869, and obtained a Commission in the R.E. in 1871. After the usual two years at the S.M.E., he went to India, but before embarking, he married Emily, daughter of the late Rev. Godfrey Clarke Smith, of St.Olans, Coachford, Cork, who, after 53 years of an ideal married life, now survives him.

On arrival in India, Exham was posted to the Bengal Sappers and Miners at Roorkee, and remained there until the Afghan War of 1878-79 broke out, when he was Adjutant of the Corps. Exham joined the Khyber Force under Sir Sam. Browne, and was present at the taking of Ali Musjid, receiving the Medal and Clasp.

In 1880, he returned to England, and after two to three years at Cork, he was selected for the highly responsible position of Adjutant at the S.M.E., where, in addition to the ordinary duties of an Infantry Adjutant, he had to keep in touch with, and work in harmony with those responsible for the more technical training of the Corps—not always an easy position. Exham, however, was equal to the task, and the relations between the Barrack Square and the Instructional Staff were more than usually cordial under his adjutancy, his unruffled temper and invariable cheerfulness having much to do with this happy state of affairs. After a term of five years, Fate decided (for Exham was never a pusher of his own interests) that he should relinquish the more military side of his profession and become a highly efficient Civil Engineer, his appointment as Assistant Superintending Engineer of the Building Works at the Royal Arsenal, Woolwich, in 1888, being the first step in this direction. After seven years here of very useful work, Exham was transferred to the Works Department of the Admiralty, where he remained until his retirement in 1911.

It was during this period of Admiralty service that Exham made his name as a civil engineer, and more especially in connection with the construction of the great Naval Base at Rosyth. The nature and extent of this vast undertaking was described in considerable detail in a Lecture which he delivered at the S.M.E., and a more general description appeared in the issue of the *East Anglian Daily Times*, of the 1st December last, from which the following is an extract, it also includes a reference to the important works which he carried out when at Portsmouth :

"In 1895 he was lent by the War Office to the Admiralty, and became Superintending Engineer at Portsmouth Dockyard. He carried out there some very important work, lengthening and reconstructing docks and workshops to meet the rapidly changing conditions of naval construction. One of the workshops there, which he designed, is still, we believe, regarded as a model. In 1903, when it was decided to provide a new naval base on the East Coast, Lieut. Col. Exham (he attained that rank in 1896) was sent by the Admiralty to make investigations in the neighbourhood of Rosyth. After spending a considerable time at a village on the coast, from which he made various expeditions, both ashore and afloat, he was able to report favourably as to the suitability of the locality for the purpose, and the Admiralty purchased a large tract of land bordering on the Forth Estuary, where the naval base was to be constructed, and Colonel Exham was entrusted with the work of designing and constructing the naval harbour, and it was built entirely under his direction. He superintended all the local survey work, soundings, etc., to enable the exact site to be determined, and it may be described as having been remarkably successful. The geological formation of the site was very peculiar, consisting of large masses of very soft material with wedges of granite pushing up through it. The planning of the docks and quay walls, in order to get the greatest advantage from the existing conditions, was a matter requiring great skill and knowledge, and the result was a triumph of engineering, which was of enormous benefit to the country.

"It might be mentioned that Colonel Exham was not only in charge of the engineering and dock construction work there, but also of the making of the arrangements with the railway company and with the local authorities for the railway connections, water supply (which had to be brought a very long distance), drainage, and all other civil and social matters. These were naturally of considerable magnitude, being associated with the establishment of a great naval base in a district very thinly populated, though adjacent to the large borough of Dunfermline. All these negotiations were successfully carried through, and Colonel Exham won golden opinions from all those with whom he was brought in contact. The great naval base of Rosyth will always be associated with his name. Many of the modern naval docks owe something to Colonel Exham's professional skill and knowledge, available to the Director of Works at the Admiralty during the sixteen years he was in the service of the Admiralty."

The satisfaction of the Admiralty Authorities of the manner in which this great work had been designed and constructed by Colonel Exham was perhaps best expressed in a debate which took place in the House of Commons on the 4th June, 1913, when an attempt was made to obtain a special grant as an acknowledgment of Colonel Exham's exceptional services.

The Rt. Hon. E. G. Pretyman, who was Parliamentary Secretary to the Admiralty at the time in question, supported the case very strongly, and in the course of his remarks said :—

" Then I come to the case of Colonel Exham. He was also an Officer of the Royal Engineers, and entered the Admiralty Service in 1895 as civil engineer. He did admirable work at Portsmouth. He was responsible for the construction of a new naval barrack, for the construction of two new docks, and for the great workshop at Portsmouth, which, I believe, is a model for all the engineering shops in the world. In 1902, the question arose of a new naval base for Rosyth, and Colonel Exham was sent there to examine and report upon a suitable site from an engineering point of view. He reported favourably upon the site, and, in 1903, when it was decided to construct the naval base, he was sent up to Rosyth and placed in charge of the whole of the constructive work, and he personally prepared a design, entirely out of his own brain, from his own observation, and from borings and calculations made upon the spot. The contract drawings were prepared at the Admiralty, but he was solely responsible for the design, which was accepted as it stood. The country does not know what it owes to Colonel Exham. He had to prepare a design for the whole of a great naval base, not for a dock or a basin or a naval barracks, which are large things in themselves, but a design laying out the whole of a great property then acquired for the Admiralty, and laying it out, not only from the point of view of the works which were to be immediately constructed, but from the point of view of the future, to make the very best possible use, both to-day and to-morrow, and in the future, of the whole of that great area for naval purposes, so far as human foresight could do it. I believe that design has given the utmost satisfaction. There is not a soul who has been connected with Rosyth, whether railway managers, representatives of Scottish local authorities, the Board of Admiralty, or anybody else, who had occasion to come into contact with Colonel Exham, who will not bear the highest testimony to the value of his services from every point of view."

Admiral Lord Charles Beresford also spoke and made several allusions to what he described as "this enormous work," "the creation of Colonel Exham's brain."

An effort was made to retain Colonel Exham's services after he had reached the usual age limit, but it was fruitless, so he retired in 1911, receiving the C.B. as a mark of appreciation. Shortly afterwards he was requested by his old friend, the Rt. Hon. E. G. Pretyman, to assist him in an advisory and administrative capacity in the management of his estate in Suffolk, and the highly useful work he did there is indicated in the following extract from the same notice in the *East Anglian Daily Times* :—

"When Colonel Exham came to reside at Walton, his long friendship with Mr. Pretyman naturally led to the association of the retired engineer with the Felixstowe dock, sea defence works, and other matters connected with the Orwell Estate. He became Consulting Engineer to the dock, and when, shortly after his arrival in the district, the sea began to make inroads on the cliffs between Cobbold's Point and the Golf Links, Colonel Exham undertook the construction of defence works. It was under his direction that the effective sea wall under the cliffs was constructed, and the numerous groynes, which have long since disappeared beneath the accumulated shingle, were put down.

"When Mr. E. Moorsom, the former estate agent, retired, Colonel Exham temporarily took charge of the estate and was responsible for its management for about a year, until Mr. J. Arnold-Foster, the present agent, became available."

At the outbreak of the Great War, in 1914, he at once applied to rejoin the Corps and shortly afterwards was appointed to supervise the construction of a semi-permanent camp at Catterick, this being one of a number of such camps constructed by firms of engineers directly under the War Office. Catterick Camp was specially important, being designed for two complete divisions representing, approximately, the accommodation required for 40,000 men. Some 2,000 separate huts were required, and these, together with the necessary accessories such as Railway Connections, Roads, complete arrangements for Water Supply, Lighting and Drainage, represented a very large and important undertaking. Nevertheless, and in spite of formidable war-time difficulties, the Camp was constructed throughout with remarkable efficiency and freedom from friction, and in an almost incredibly short space of time, reflecting the greatest credit on all concerned. Colonel Exham's share in this achievement was rewarded by the receipt of the C.B.E., an honour which everyone will agree was thoroughly deserved.

Such is the brief summary of a life of usefulness founded upon strength of purpose aided by unvarying tact and good temper, combined with much ability and an excellent constitution. A great deal of Colonel Exham's success was due to the manner in which he brought into his public life that kindliness and sympathy which had given him the happiest of homes, the love of his family, and the esteem and affection of all his friends.

We have alluded to his capacity for work and friendship, but he was also a good sportsman, played in the eleven at the R.M.A., and held his own at most other games; he was also a good shot and rider, and a yachtsman of considerable knowledge and experience.

He possessed a fine sense of duty, and gained his distinctions in a characteristically unobtrusive manner.

He has given us an example of a life's work well and truly done, and the Corps, to which he was so proud to belong, will no doubt fully appreciate its high value.

Colonel Exham was buried on the 30th November last, at Walton, his funeral being attended by a large congregation, including representatives of the Admiralty, the District Council, the Port Authorities, the British Legion, and other public bodies, and Societies with which he had been associated, who wished to emphasise the great esteem in which he was held.

This memoir has been compiled by three of Colonel Exham's brother Officers, who belonged to the same batch at the Royal Military Academy, and afterwards at the School of Military Engineering. A fourth Officer of this batch had also expressed a cordial wish to assist, but to our very great regret this Officer, the late Brigadier-General Sir Edward Raban, was too unwell to collaborate. This is the more to be regretted as Sir Edward Raban and Colonel Exham were so long associated together under the Admiralty.

R. M. R.
H. P. L.
N. M. L.

BOOKS.

BRITAIN'S SEA SOLDIERS.

A Record of the Royal Marines during the war, 1914-1919. Compiled by General Sir H. E. Blumberg, K.C.B., Royal Marines. (Devonport, Swiss and Co.)

The Corps has received a presentation copy of this beautiful memorial book of the Royal Marines. It contains 492 pages, is well printed, well illustrated—with a coloured portrait of H.M. The King as a frontispiece—and has seven useful maps in a pocket at the end.

Dealing with the experiences of "Soldier and Sailor too," its contents form a resumé of nearly every operation of the war, both by land and sea. Royal Engineer readers will turn with interest to the chapter on the Royal Marine Engineers, whose numbers approached 10,000 at the time of the Armistice. The book has been placed in the R.E. Corps Library at the Horse Guards.

F.E.G.S.

THE WORLD CRISIS, 1916-1918.

Parts I and II. By the Rt. Hon. Winston S. Churchill, C.H., M.P. (Thornton Butterworth, Ltd., 1927). Price 42s. nett.

In these two volumes Mr. Churchill concludes his book on the World War. It will have a very large circulation, and there is a distinct danger that many uninstructed readers, charmed by its literary style, will be led blindly to accept the author's criticisms and deductions without realising the fallacies in his arguments. Both soldiers and sailors must read the book because it contains a great deal of matter on the conduct of war which will be of use to them in their military education. They will have little difficulty in putting their fingers on the weak spots in the arguments on which the author bases his deductions. In military and naval circles the book will cause great resentment, because of the unfair criticism of the leaders on both sides, most of whom will not or cannot defend themselves.

The material for these later volumes, Mr. Churchill tells us, had been collected for some time, but ministerial duties had prevented him working it up. The publication of Sir William Robertson's, " Soldiers and Statesmen," evidently impelled Mr. Churchill to hasten the completion of his own book. If he had waited he might have been able to avail himself of the memoirs not only of the great Staff Officers, Robertson, Falkenhayn, and Ludendorff, but perhaps also of those of the great Commanders, Haig, Joffre, Foch and Pershing. Sir William Robertson's account of the conduct of the war by soldiers and statesmen could not, however, be allowed to pass unchallenged, as it provided Mr. Churchill with a peg on which to hang a scathing indictment of the conduct of the war by the General Staffs, both of the Allies and of the Central Powers. For material as to the conduct of the great commanders, Mr. Churchill has had to content himself with Colonel Boraston's " Sir Douglas Haig's Command," and M. Jean de Pierrefeu's "G.Q.G." One cannot help almost agreeing with Mr. Churchill that Colonel Boraston's book has "done service to everyone except his Chief," and that author can never be forgiven for his unjust and tactless criticism—in a footnote—of the leadership of the Commander of the First French Army in 1918.

Four great controversial subjects are the main features of Mr. Churchill's book. They are :—

1. The Western Front.
2. The Great Offensives.
3. Man-power.
4. Jutland.

THE BATTLE OF JUTLAND.

Of the battle of Jutland a soldier is not in a position to say much. Mr. Churchill charges Admiral Jellicoe with :—

(*a*). Allowing a quarter of an hour to elapse before passing to the 2nd Battle Squadron Admiral Beatty's signal (sent at 7.47 p.m. on May 31st)—"Submit that the van of the battleships follow me."

(*b*). Failing to realise that the German Fleet was most likely to retreat by way of the Horn Reef and Heligoland Channels, and therefore not directing his course to a point about ten miles to the south-westward of the Horn Reef Light, when he would have been in a favourable position to bring Admiral Scheer to battle, whether he made for the Horn Reef Channel or the Heligoland Channel. Instead of doing this, Admiral Jellicoe, he says, steered to the southward, leaving Admiral Scheer free to retreat by the Horn Reef Channel, the Heligoland Channel, or, if he chose, by the Kattegat, which also he took no steps to watch.

(*c*). Rejecting the Admiralty version (received by him at 11.30 p.m. on 31st May) of the over-read German wireless message—"German Battle Fleet ordered home at 9.14 p.m., Battle Cruisers in rear. Course S.S.E., ¾ E. Speed 16 knots," and continuing to steam southward himself at seventeen knots.

(*d*). Being responsible for there not being a more flexible system of fleet training and manœuvring, and attempting to centralize in a single hand the whole conduct of so vast a fleet.

(*e*). Making no attempt to take advantage of the speed of the fast division of battleships (*Queen Elizabeths*).

(*f*). Not using the British Light Cruiser Squadrons and Flotillas as they ought to have been used to parry and rupture hostile torpedo attacks, and using the merely passive "turn-away" manœuvre of the whole fleet, and thus wasting time and losing distance.

Mr. Churchill claims that the chance of a lifetime was thrown away not once, but three times: at the moment of deployment; an hour later, at 6.55 p.m., when Scheer, after heading westwards for twenty minutes, made his great miscalculation as to the position of the British Battle Fleet, and turned eastward, heading right into the jaws of the British line of battle; and, lastly, when Admiral Jellicoe rejected, at 11.30 p.m., the evidence of the Admiralty wireless as to the direction of the retreat of the German Fleet.

He concludes his indictment tersely with the words: "Three times is a lot."

Though purporting to steer in his account a middle and fair course, Mr. Churchill is writing after the event, and makes no allowance for the fog of war or for the difficulties of communication in a sea battle. He admits that the Naval Commander-in-Chief was the only man who could lose the war in an afternoon, but he minimizes the weight of the responsibility on his shoulders. Mr. Churchill damages his argument by pressing it too far. The Admiral, he says, was given the most powerful fleet that ever sailed the seas. He was refused no demand calculated to increase its strength and efficiency. But when offered the chance of a decisive victory he threw it away, not once, but three times, by over caution, inspired chiefly by exaggerated fear of the danger of under-water damage by mine and torpedo. Mr. Churchill asserts that the Battle Fleet was never seriously in action, and that only one battleship, the *Colossus*, was struck by an enemy shell; and that out of more than 20,000 men in the battleships only two were killed and five injured.

Is this a fair indictment? Why have we not held the First Lord of the Admiralty responsible for the defects in the battle cruisers which led to the destruction of the "Queen Mary" and the "Invincible," and of the "Indefatigable," or for the comparative inferiority of our armour-piercing shell? Mr. Churchill discusses these defects, but he does not shoulder the responsibility for their existence in a fleet for the creation of which he was himself responsible. He claims that he never liked the battle-cruiser type, and discouraged their construction, but had not the battleships the same defects in their ammunition hoists? It is possible, though unlikely, that the loss of three battle cruisers may have affected Admiral Jellicoe's plans.

Mr. Churchill's account of the battle is intensely interesting and well told, but it is spoilt by the evident bias and resentment shown in his conclusions. Bias against the Commander-in-Chief; resentment that the child of his own creation should not have achieved the spectacular victory which might have ended the war in 1916.

Joffre, when asked who won the Battle of the Marne, replied that it was a difficult question to answer, but he knew whom the world would say had lost it, if it had been lost.

Mr. Churchill writes on page 30, Part I, as follows:—

"These chapters will recount the fall from dazzling situations of "many eminent men; and it is perhaps worth while at this point "to place the reader on his guard against unworthy and uncharitable "judgments." The warning is by no means unnecessary.

Mr. Churchill is again "down upon" the sailors, when, on page 350, Part II, he writes:—

"The shortcomings in the Higher Command of the British Navy, "afloat and at home, which had led to Admiral de Robeck's failure "to force the Dardanelles, to the abortive conclusion of Jutland, and "to the neglect to carry the fighting into the German Bight, had given "to the enemy during 1915 and 1916 the means of developing an "entirely novel form of sea attack upon a scale the potential intensity "of which no one could measure beforehand, and which if successful "would be fatal."

This paragraph serves as introduction to an instructive chapter dealing with the U-boat campaign, and how it was at last overcome by the British Navy and Mercantile Marine. It is interesting to note that Mr. Churchill blames the Admiralty for overestimating the value of the Belgian littoral as a base for the U-boat campaign, and thus causing Sir Douglas Haig to concentrate attention on the offensive in Flanders which resulted in Paschendaele, in 1917. At the same time, in describing the Zeebrugge exploit, he records the fact that the sinkings of British vessels in the English Channel decreased from about 20 a month to 6 a month, and that the minefields laid by the Flanders U-boats fell from 32 a month in 1917 to 6 a month in 1918, as a result of Admiral Keyes' tenure of command at Dover.

THE GREAT OFFENSIVES AND THE WESTERN FRONT.

Mr. Churchill takes—and deserves—credit for having appreciated before any other statesman the fact that things had come to a deadlock in the West. He writes as follows :—

" I conceive myself entitled to repeat, now that the results are known, " the opinions which I put on record before all these battles (Loos " and Champagne, Somme, Verdun, Paschendaele and March 21, " 1918) were fought. I wrote to the Prime Minister on Dec. 29th, " 1914, as follows : ' I think it quite possible that neither side will " have the strength to penetrate the other's lines in the Western " theatre . . . without attempting to take a final view, my impression " is that the position of both armies is not likely to undergo any " decisive change.' "

This was after Mr. Lloyd George's disillusioning visit to Paris, whence he returned in a mood much depressed at the prospect of the war being unlikely to be over in a year. Mr. Churchill continues :—

" And in June, 1915 (after Festubert and the Second Battle of Ypres), " I wrote : ' It is a fair general conclusion that the deadlock in the " West will continue for some time, and the side which risks most to " pierce the lines of the other will put itself at a disadvantage.' "

From this moment Mr. Churchill apparently made up his mind that all offensives on the Western Front were doomed to failure. He elaborates his argument on this thesis at great length in a chapter entitled " The Blood Test," in which he puts forward a mass of figures to prove that every offensive cost the assailants far heavier losses than the armies which were attacked. His deduction is that all the commanders who initiated these great attacks had a very limited conception of the art of war, and he proceeds to show them how it ought to have been done.

He confesses that he " shared the common impression that the German " losses at Verdun must be heavier than those of the French," and it was with surprise he learnt after the war that the French lost 460,000 against 278,000—killed, missing and prisoners. He explains this apparent anomaly as follows :—

" All accounts, however, showed that the strain upon the French " Army was enormous. They were compelled to defend all sorts of " positions, good, bad and indifferent, and to fight every inch of the " ground, with constant counter-attacks, under a merciless artillery ; " and it was clear that they were conducting the defence in the most " profuse manner. 'The French,' I wrote at the time, ' suffered more " than the defence need suffer by their valiant and obstinate retention " of particular positions.' "

Mr. Churchill's recipe for those who are attacked is :—

" Meeting an artillery attack is like catching a cricket ball. Shock " is dissipated by drawing back the hands. A little ' give,' a little " suppleness, and the violence of impact is vastly reduced."

The maxim, *reculer pour mieux sauter*, is not unknown to the French.

But it postulates the fact that there must be room to fall back, and no reasons why the defender should not do so. Mr. Churchill talks airily about the defender being advised to invite attack by apparently weakening his line in suitable localities, where he can without detriment give up 20 kilometres or so of terrain, and thus draw the enemy on and then blast him to pieces by the fire of an overwhelming artillery concentrated for the purpose.

He considers that there was no real necessity except sentiment to cause the French to cling so obstinately to Verdun. He blames Joffre for their doing so.

Now to turn to the Germans. Mr. Churchill, who apparently has a bias against General Falkenhayn, considers that he went far to lose the war by deciding to attack Verdun. He quotes a memorandum written for the Emperor by Falkenhayn, when he selected Verdun as the point of the German attack in 1916, in which that General wrote as follows :—

> " Moreover the lessons to be deduced from the failure of our enemies'
> " mass attacks (Loos and Champagne, 1915) are decisive against
> " their battle methods. An attempt at a mass break-through, even
> " with an extreme accumulation of men and material, cannot be
> " regarded as holding out prospects of success against a well-armed
> " enemy whose morale is sound, and who is not seriously inferior in
> " numbers. The defender has usually succeeded in closing the gap.
> " This is easy enough for him if he decides to withdraw voluntarily,
> " and it is hardly possible to stop him doing so. The salients thus
> " made, enormously exposed to the effect of flank fire, threaten to
> " become a mere slaughter-house."

General Falkenhayn goes on to say that there is no sense in attacking any sector where there is no well-defined objective within reasonable reach, without which an attack would be purposeless. What a valuable nugget this extract is for Mr. Churchill! It confirms all his theories. Or, did it give him the idea for those theories? It was written during Christmas, 1915, but was not published till Falkenhayn issued his memoirs after the war—not too late for Mr. Churchill's " after the event " criticisms of the war. He blames Falkenhayn for adhering to the idea of the Verdun offensive in spite of writing this sensible appreciation, and holds that nothing could justify his obstinate adherence to the plan.

General Falkenhayn, after discussing all the alternatives, continues his appreciation as follows :—

> " Within our reach, behind the French section of the Western Front,
> " there are objectives for the retention of which the French General
> " Staff would be compelled to throw in every man they have. If
> " they do so, the forces of France will bleed to death—as there can
> " be no question of withdrawal—whether we reach our goal or not.
> " If they do not do so, and we reach our objective, the moral effect
> " on France will be enormous."

General Falkenhayn appreciated the situation correctly. France was not prepared to give up Verdun. France was not only bled white upon the anvil of Verdun, but the great Allied offensive on the Somme, planned before the attack on Verdun was launched, was not only greatly reduced in extent. but more than compromised in its results. The British lost on the Somme 410,000 men as against 180,000 Germans. Was Falkenhayn justified? He certainly was relieved of his appointment as a sop to German disappointment at the failure to capture Verdun, but he was immediately employed again in the Eastern theatre. He was not the bad soldier Mr. Churchill would have us believe.

Mr. Churchill is ungrateful. There is another nugget for him in the memorandum already quoted. In discussing the alternatives before deciding on Verdun as the objective of the German efforts in 1916, General Falkenhayn wrote as follows:—

"In the East, *the rich territory of the Ukraine is the only objective that* "*can be considered*."

The italics are Mr. Churchill's. His comment on this is:—

"It (*i.e.*, Verdun) involved the complete reversal of the policy by "which General von Falkenhayn had, in 1915, restored the German "situation. Instead of pursuing his advantage against the weaker "antagonists, he selected for the great German effort of 1916 the "strongest enemy at that enemy's strongest point."

Incidentally, Mr. Churchill, elsewhere, goes to some length to show that thanks to the ineptitude of G.Q.G. and its Chief (Joffre) the defences of Verdun were not at all what they should have been when the German attack was launched, and would have been even worse had it not been for the presence in the garrison of a Deputy and Colonel of Chasseurs (Driant) who had the courage to go to Paris and tell the politicians that the defences of Verdun were in a parlous state. Colonel Driant was killed on the third day of the assault, but he will, thanks to Mr. Churchill, go down to posterity as the classic example of the advantage of having soldier politicians serving in the Army. This contingency has, however, been provided for in the new French Defence Act, which lays down that soldier politicians cannot come and go, and if they elect to serve, must continue to do so, and can only vote by proxy.

But to return to the nugget. Mr. Churchill continues:—

"The vital need for Germany was to break the blockade . . . Only "in one direction lay salvation. If she could not break the blockade "by sea, she must break it by land. . . Only in the East and South-"East and in Asia could Germany find the feeding grounds and "breathing room—nay, the man-power—without which her military "strength, however impressive, was but a wasting security. . . The "true and, indeed, the only attainable political objectives open to "Germany in 1916 were the final overthrow of Russia and the "winning of Roumania to the side of the Central Empires. . . . "Roumania was essential to Germany. . . A sagacious German "policy at this juncture could have offered to Roumania in combina-"tion every inducement to join her neighbours, from high rewards "to extreme duress. . . The skilful employment of fifteen or twenty "German Divisions animating Austrian and Turkish Armies would "surely and easily have extended the territories which nourished "Germany so as to include, by the end of the summer of 1916, the "whole of S.E. Europe, the Black Sea, the Caucasus, and the Caspian. "The Austro-German front against Russia might have stretched "from Riga to Astrakhan. . . At every moment, and at every stage "in these vast combinations the pressure upon Russia and upon "her failing armies would have increased, and at every stage her "troops and those of her allies would have been dissipated in vain "attempts to wall in the ever-spreading flood in the East, or *would "have been mown down in frantic assaults upon the German trenches in "France.*" The last italics are not Mr. Churchill's. The sentence was an afterthought. He suddenly awoke from his dream.

What an opportunity for the Allies! What a gift to the idiots headed by Joffre who thought a decisive victory could only be achieved on the Western Front!

But was Russia in such a plight in early 1916 as Mr. Churchill made out? On page 104, Part I, he writes:—

"Few episodes of the Great War are more impressive than the "resuscitation, re-equipment and renewed giant effort of Russia "in 1916,"

which culminated in Brusiloff's offensive on June 4th, and resulted in Austria losing 100,000 prisoners in a week and a loss of nearly 750,000 men in killed, wounded, dispersed and prisoners within a month. And this, it should be noted, as the result of a great *offensive* movement on the part of the Russians. Mr. Churchill attributes the Russian success to the surprise caused by their ante dating their offensive from July 1st to June 4th.

Enough has been said to show that Mr. Churchill's book is apt to mislead. That even during the war the author of this book had brilliant ideas is not disputed. Antwerp in 1914, the Dardanelles in 1915, an Allied offensive in the Balkan Peninsula in 1916, coupled with a decisive victory in the North Sea in that year might have brought the war to an end in 1917. BUT—and the word must be spelt in capital letters—there are many factors to be considered in every appreciation, and Mr. Churchill has only learned to weigh all the factors after the events have been decided.

The writer was invited to undertake this review "as there seems to be so much in it that is at variance with the conclusions of Sir William Robertson." In his opinion, Sir William Robertson has done the nation an immense service in publishing "Soldiers and Statesmen," and that service has been enormously enhanced by the appearance of Mr. Churchill's book. Sir William Robertson's conclusions are not impaired by it. The Memoirs of General Falkenhayn and Ludendorff show that both those great minds were at one with Sir William Robertson as to the Western Front being the decisive one, and events prove the correctness of their judgment. Mr. Churchill considers that General Ludendorff lost the war by attacking in March and April, 1918. The war was lost by the moral effect on the Germans of the tenacity of the Allied Armies on the Western Front, by the effect of the blockade which was the result of British Sea Power, and by the magnificent courage of the soldiers who carried out the offensive campaign of the autumn of 1918, in spite of Mr. Churchill's prognostications, of which, fortunately, they were not aware, that no offensive on the Western Front could be successful till 1919.

In 1919, thanks to Mr. Churchill's activities—and they were in truth great—at the Ministry of Munitions, and thanks to the arrival of the Americans in their millions, the politicians intended to allow the Allied Commanders to launch an offensive on the Western Front, with subsidiary offensives elsewhere, amongst others an attack aimed at Constantinople, *via* the Dardanelles.

Man-Power.

We now come to the question of man-power. It is almost inconceivable, but Mr. Churchill is our authority, that the reason why large numbers of men (Mr. Churchill estimates the number at 1,400,000) were kept back in England, Scotland and Ireland during the winter of 1917-18, was that the Statesmen could only be sure of not being stampeded into another Allied offensive on the Western Front by witholding the drafts necessary to maintain the British Armies in France. Brigades of Infantry were reduced from 4 to 3 Battalions, Cavalry Divisions were reduced, and practically no units were at anything approaching their war establishments. This, in spite of the certainty, for such it was, thanks to our admirable Intelligence, that the Germans were transferring the troops released by the Russian *débâcle* from the Eastern to the Western Front as fast as trains could be got together to carry them. The writer can remember the late Sir Henry Wilson thanking Heaven that the German attack came in March and not in May, 1918, by which time the transfer of troops and guns would have been still more complete.

Mr. Churchill admits that

> " Sir Douglas Haig vehemently and naturally called for all the " officers and men required to bring his divisions up to full strength " at the earliest possible moment. Robertson supported him, and " was evidently seriously alarmed. From my central position " between the Army and the War Cabinet, with, I believe, the whole " information available in my possession and with constant access " to the Prime Minister, I never ceased to press for the immediate " reinforcement of Sir Douglas Haig. Mr. Lloyd George viewed " with horror the task imposed on him of driving to the shambles by " stern laws the remaining manhood of the nation. . . . . . .
> " To meet the German onslaught when it came—if it came—every- " thing must be thrown in: but the Prime Minister feared lest our " last resources should be expended in another Paschendaele. . . .
> " I urged that the Cabinet should send all the men that were needed " and reconstitute the Army, and should at the same time forbid " absolutely every resumption of the offensive. The Prime Minister, " however, did not feel that, if the troops were once in France, he " would be strong enough to resist those military pressures for an " offensive which had so often overborne the wiser judgment of " Statesmen. He therefore held, with all his potent influence, to a " different policy. He sanctioned only a moderate reinforcement " of the Army, while at the same time gathering in England the " largest possible numbers of reserves. In this way he believed he " would be able alike to prevent a British offensive and to feed the " armies during the whole course of the fearful year which was " approaching (1918). This was in fact achieved. But I held, and

"hold still, that the War Cabinet should have been resolute, as I
"believe it would have been found strong enough, at once to support
"and to restrain the High Command in France."

Mr. Churchill goes on to quote in full a memorandum written by him on December 8th, 1917, in which he shows that he, at all events, realized how unfair it was to Sir Douglas Haig to withold the reinforcements, and how it might prevent the Commander-in-Chief taking advantage of an opportunity, should one offer, to strike a counter blow, or even maintaining the "active-defensive", of which Mr. Churchill makes so much in his book--as preferable to the offensive when a prolonged offensive is not justified or is impossible.

He also states that nearly all the specific measures which he advised for combing out more men, especially those employed on naval munitions and shipbuilding, subjects on which he was in a position to be well-informed, were taken or resolved on after the catastrophe of March 21st.

"Taken in January," he says, "they would have prevented it. . .
"Nothing, however, had the slightest effect. The Prime Minister
"and his colleagues in the War Cabinet were adamant. . . They
"believed that the Germans if they attacked would encounter the
"same difficulties as had so long baffled us, and that our armies
"were amply strong enough for defence."

Does Mr. Churchill realise that his teachings now recoiled on his own head? It was he who had time and again inveighed against the idea that an offensive could be successful on the Western Front. He had been mistaken as to the enormous losses of the French in defence at Verdun—which speaks well for French propaganda—it is to be hoped that the Germans were equally deceived as to the losses they had inflicted.

Mr. Churchill has done a great service in showing us where the responsibility for the destruction of the Fifth Army really lies, and he is to be congratulated on being the first wholeheartedly to absolve Sir Hubert Gough of all responsibility for that disaster. But it is too late. May we hope that if ever again the British Nation is called upon to fight for its existence, British Statesmen will take a leaf out of the American book and not hesitate to synchronize "Registration Day" with the Declaration of War, if the principle of universal service is not adopted in time of peace. The Americans learnt their lesson from their own previous experience and our recruiting difficulties, after the Republic had been in existence close on a century-and-a-half. Su rely it is more than time for us to learn the lesson ourselves from our own history.

Mr. Churchill has a good deal to say on the Salonika Campaign, and does not hesitate to pillory Mr. Lloyd George and M. Briand for persevering with it after nearly all the advantages to be gained from it had disappeared; and there are illuminating chapters on the "Roumanian Disaster," "General Nivelle's Experiment," "The Ministry of Munitions," "The Surprise of the Chemin des Dames," "The Unfought Campaign" (of 1919), and "The Teutonic Collapse."

There are some sketch maps, but the absence of a general map is to be regretted. The index, though condensed, is sufficient for the general reader. The spelling of M. Clemenceau's name with an accent on the first " e " is incorrect, but is also to be found in Colonel Boraston's book " Sir Douglas Haig's Command."

H.B-W.

GOVERNMENTS AND WAR.

A study of the conduct of war, by MAJOR-GENERAL SIR F. MAURICE, K.C.M.G., C.B. (William Heinemann, Ltd., London, 1926).

The volume is based on a course of lectures recently delivered by the author before the University of Cambridge, of which he is Honorary LL.D.

For his subject Sir Frederick Maurice chose the relations which existed between statesmen and soldiers during the course of a long war, and as an historical example he selected the Civil War in the United States, 1861-5.

For the choice of subject and campaign, the author gives the following reasons :—

(1). He had realized that, although before the Great War he had thought and read much about the organisation of armies for war, he had never thought of studying the organization of Governments for war.

(2). A similarity exists between the two struggles, not only in their duration, but also in the fact that one of the belligerents occupied a central position and was exposed to the rigours of blockade, and that in both cases there were several theatres of war where co-ordination of effort was difficult but yet urgently needed.

(3). He believed that the judgments of Lord Wolseley (whose biography he has written), and of Colonel G. F. R. Henderson on President Lincoln's conduct of the war were written on one-sided and incomplete information, and that further investigation would modify the views hitherto held in England as to the action of the great statesman.

(4). In both wars great democracies were involved, and he wished to test the accuracy of the dictum that modern democracy can neither prevent war nor wage it, save at undue cost.

Sir F. Maurice disposes of the last point first, and comes to the conclusion that it would appear to be at least possible that mistakes in the conduct of war are not necessarily the consequence of any particular form of Government, but they may be due to causes which are remediable whether the form of Government be an autocracy, a constitutional monarchy, or a republic.

In discussing the relations between Mr. Jefferson Davis, President of the Southern Confederacy, and his generals, Robert E. Lee and J. E. Johnston, he shows Davis to have been a man of by no means outstanding ability, but he considers him to have been above the average of war ministers. Davis' early training at West Point and afterwards as a young officer in the cavalry, his subsequent political career and the experience he gained while Secretary of War in the United States from 1853 to 1857, gave him an immense advantage over his famous opponent, Abraham Lincoln, who had little or no experience of general affairs and none of military affairs. He shows how Davis failed in the general direction of military operations, in combining policy and strategy, and that he failed because he had never worked out in his mind a system for the conduct of war. Going on to discuss the relations between Davis and General J. E. Johnston, he considers that Johnston, who disliked Davis and despised him (he had known him at West Point), was in great measure to blame for the friction that existed between them. He never confided his plans to the President and consequently never won his confidence.

How different were the relations between Davis and General Robert E. Lee: "Lee's dealings with the President were a very marked contrast. Lee appreciated to a nicety the relations which ought to exist between himself and the head of the State. He invariably treated the President with the most complete courtesy and respect, gave him all necessary information, and being himself entirely devoid of personal ambition or of any trace of self-seeking, he never aroused in his chief, who was inclined to be both arrogant and jealous, the faintest suspicion that he coveted powers which should belong to the President. He was often tried by Davis every whit as highly as Johnston had been, but through all these trials he shewed a remarkable understanding of the President's difficulties and problems, and he continued quietly and tactfully to educate him in the principles of strategy and of the conduct of war."

Davis was undoubtedly good on the administrative side, thanks to his experience in an Indian campaign, in the Mexican war, and in the War Department, but it was a case of a little knowledge being a dangerous thing when he meddled in operations.

Despite the good relations which existed between Davis and Lee, the policy of the two men was never really in agreement. Davis' only policy was to defend Southern territory and play for foreign intervention. All hope of the latter was wiped out by Lincoln's declaration for the abolition of slavery. Davis could not steel himself to withstand the incessant appeals to him for protection which came from all parts of the Confederacy, or to overcome the reluctance of the several States to denude themselves of troops. This was mainly because he was not so constituted as to be able to take great risks for great ends.

"Lee's policy was clear from the first. He saw that the salvation of the South lay in early victory before the North had time to develop its resources, and he was prepared to dare much to bring this about. In Davis' mind the risks always loomed greater than the promise of success, so that not even in the high tide of Lee's success was there any real union of Confederate policy and strategy, the chief reason for this being that there was no one in Richmond to advise the President on the military problem as a whole."

When Lee took command of the army in the field, he could not induce Davis till too late to fill the place which he had occupied as military adviser, and his own extreme modesty and reluctance to push himself forward prevented him from asking for increased authority and powers for himself. Davis was eager to give Lee greater powers, but did not know how to set about it. The result was that when, after the victory of Chancellorsville in 1863, Lee advised the immediate invasion of Pennsylvania, so that by a victorious advance the growing peace party in the North might be encouraged to insist on peace, Davis failed to realize that this was the Confederacy's last chance and did not give Lee the reinforcements and support which the army of Northern Virginia might have received if there had been a man at Richmond who was prepared to take risks elsewhere in order that by invasion peace might be won. Torn between two fronts, Davis was defeated on both. Was it more important to preserve Vicksburg against Grant's advance in the west than to save Richmond from danger? The President's confidence in Lee made him approve the plan for the invasion of Pennsylvania, but he could not see further than that it would result in the threat on Richmond being removed. Instead of "going all out" to ensure the success of Lee's advance by sending him every possible man and gun, which alone would justify him in crossing the Potomac, he failed to re-inforce and re-equip his army. The result was Gettysburg, and Lee's retreat. Vicksburg was also lost, and, although the struggle went on for nearly two years longer, the last hope of victory had been shattered.

"Never again after the summer of 1863 were there opportunities which a skilful combination of statecraft and strategy could use to save the Confederacy from its fate. The greatest soldier of modern times could not do more than win victories in the field. He needed, in the circumstances of the time, the aid of a great statesman to make victory decisive, and the great statesman was in Washington, not in Richmond.

"But, it may reasonably be asked, if a great statesmen is the necessary complement of a great soldier, how can any nation reasonably expect to have both when a crisis comes? The answer is that we to-day are not living in the circumstances of 1863. We have had, and may learn from, experiences, which Davis had not.

"A reasonable competence in statesmen and soldiers is not sufficient to prevent disaster. Every war of importance in which Great Britain has been engaged since 1756 has begun unfortunately. Our troubles, like those of Davis, arose far more because we had evolved no system for the conduct of war than because of any exceptional lack of capacity in our statesmen. It requires an Abraham Lincoln to devise in the stress of war a sound system for its conduct when none has been prepared beforehand. But a Davis is well capable of administering the affairs of a nation at war, when that nation has considered in time the respective functions of statesman and soldier."

The author then describes the relations of President Lincoln and General McClellan. Lincoln had made McClellan commander-in-chief after the resignation of General Scott. McClellan was undoubtedly a good soldier. General Grant, after the war, declared :—"If McClellan had gone into war as Sherman, Thomas or Meade, and had fought his way along and up, I have no reason to suppose he would not have won as high distinction as any of us." He had real gifts of organisation and leadership, and was quickly not only respected but loved by his men. Attractive in manner and appearance, young—only thirty-nine—everyone from the President downwards was anxious to serve and help him. But appointment to the highest command seems to have turned his head. "He was lacking in the elements of courtesy to the President, of whom the best he could say was 'he is honest and means well.' After the first enthusiasm for him had cooled there was a good deal of political intriguing against him, and McClellan, finding the difficulties, which he had himself in great measure created, becoming too much for him, classed, in his anger, all the administration in Washington as unscrupulous and false."

Though McClellan had only himself to blame for the first fall from grace, it was the Government which was responsible for the next false step. The ill-managed affair at Ball's Bluff on October 21, 1861, ended in a disastrous repulse of the Federals, and as a result a Congressional Committee of enquiry was instituted, which developed into a committee on the conduct of war. Its proceedings were often injudicious, and they were periodically a thorn in Lincoln's side. Two of its principal members were hostile to McClellan, and thought Lincoln was wanting in energy in the conduct of the war. Great pressure was brought on the President for some definite military action. At first Lincoln, remembering Bull's Run, resisted the pressure and told McClellan not to fight till he was ready. But eventually yielding to the pressure, Lincoln did a very foolish thing. He assumed his power as Commander-in-Chief, and in that capacity issued three orders, in which he not only specified the date (Washington's birthday, February 22, 1861), for a general advance, but also defined the objective (Manassas Junction), and stipulated that at no time was the security of Washington (the capital) to be jeopardised.

"Lincoln was quite right to issue instructions to McClellan, but it is clear that none of the orders, except perhaps the third, was intended to be an instruction as to military policy. They were meant to rouse McClellan to action. They probably made him laugh (or swear!)." Two years later Lincoln explained to Grant that he was forced by public opinion to issue the orders because of the procrastination of his commanders. He said that "he did not know but they were all wrong, and did know that some of them were."

In his first chapter the author discusses the question of what system for the conduct of war is best suited to the Constitution of Great Britain and points out that the system adopted when Sir William Robertson became Chief of the Imperial General Staff in 1915 was very similar to that established by Lincoln in 1864.

The book, though, published first should be read as a sequel to Sir William Robertson's "Soldiers and Statesmen."

H. B.-W.

IMPERIAL DEFENCE.

By S. KING-HALL: (Fisher Unwin, Ltd.)

Admiral King-Hall's "Imperial Defence" has been written in vivid but simple style to appeal to the man in the street and to place before the ordinary tax-payer an outline of the problems that arise in considering the defence of our far-flung Empire, and which are the causes of military unreadiness and thereby waste of time as well as of public expenditure. It aims at securing the formation of an efficient Empire staff, which may think upon the same lines so as to ensure readiness in our scattered formations at the smallest cost. It reminds the public that sailors and soldiers are taxpayers too, and that it is in the fighting services that the need for squeezing every drop of value out of their several budget allotments is most fully realised. That the armed forces of the nation will more and more become the prime mover that controls the huge national war machine, and will gradually cease to be the machine itself, as they were when war was a simple matter between groups of professionals. Indeed, they tend to be but the skirmishers behind whose protection the mass of citizens may gird themselves in security for the coming fray.

There is no parallel in the world, nor has there ever been in history, to the situation in which seven separate cabinets, involving about a hundred cabinet ministers scattered round the globe, have first to sanction a declaration of war with all its tremendous consequences, and then assume joint responsibility for its conduct. Some loss of time can hardly be avoided, and this delay in starting will tend to increase as civilization progresses and war becomes more complicated, unless very definite steps are taken to prevent it.

It is manifestly unfair for the Dominions to claim rights and powers without responsibility, and attention is drawn to the intricate problem of how to ensure that the Dominion cabinets shall share that responsibility with the British cabinet. "If there is one department of Imperial Defence in which it is easiest to make false economies, it is in the department of thought. Trained intelligencies are required to control the fighting services. In order to make sound plans in good time a body of men with highly trained intelligencies are necessary, who can devote their whole time to working out the details of the organization of the Empire for defence." The foundation of a national war college is one of the author's suggestions, to produce a common doctrine on the lines of the tag that "it is better to all think wrong than all think differently." This has already materialised in the guise of the Imperial Defence College which is in session, with students from each of the services, civil departments, the Dominions and India.

"It is quite clear that the executive government must retain, in the conduct of military affairs during a war, the supremacy with which it is invested by the constitution. Indeed, apart from constitutional principles, a soldier, however capable a military leader or responsible a military adviser he may be, is not qualified by his training to steer the ship of state through the troubled waters of war! It is just as dangerous for a Prime Minister or President to assume the actual command of the forces of a nation in action. His duties lie in another sphere which needs complete mental detachment from the commotion of hostilities. We are not yet ready for a Ministry of Defence: a political solvent has yet to be found for all the difficulties involved. It will be discovered only when the nation and its fighting services are of the same mind, through mutual education." The book under review constitutes a primer for thoughtful taxpayers.

The author suggests that all fighting services must have the common aim of furthering the Government policy through a joint service opinion, and, as a preliminary step to such unity of purpose, that the funds allocated to Imperial Defence and the Fighting Services in the budget of the United Kingdom be treated by the Cabinet as a single item, and that the division of the money amongst those services be decided by the Chief of Staffs' Committee.

Thus may true unity be born.

The book is a lucid and engaging one and should be read by every citizen.

D.M.F.H.

TACTICAL SCHEMES.

From Platoons to Brigades, with solutions and notes. By Lt-Col. A. Kearsey, d.s.o., o.b.e., *p.s.c.* (Gale and Polden, Aldershot). Price 7s. 6d.

In the preface to this book it is stated that the author is working progressively through the principles of war to show how they are illustrated in schemes. The author did not carry this into effect : the principles of war are seldom mentioned and no attempt is made to show which principles are best illustrated by any scheme.

Instead, the book consists of a series of chapters dealing with types of military operations, such as appreciations, orders, attack, defence, etc. Each chapter gives one or more schemes dealing with its subject, interspersed with notes and problems which are often inapposite. For instance, in the chapter on Appreciations appears an operation order for the march of a brigade with bus and march tables, while in that on Orders is a lecture on Desert Warfare and notes on the siting and design of trenches.

In the schemes, the lesson to be taught is not given prominence—with the result that the solutions are in many cases vague and run counter to the teaching of the regulations.

The book has another fault which is serious in view of the class of reader for which it is intended. There are many inaccuracies in detail, especially with reference to the R.E. and their work. The examples of orders and messages contain many mistakes, both in spirit and in letter. While this will be obvious to anyone who reads carefully the official manuals, it is very much to be regretted that a book on tactics should be issued which is so very much out of date.

The book cannot be recommended to students except in so far as it gives examples of what should not be done.

N.W.N.-C.

ORDINARY DIFFERENTIAL EQUATIONS.

By E. L. Ince. Professor of Pure Mathematics in the Egyptian University. (Longmans, Green and Co., 39, Paternoster Row, E.C.4). Price 36s.

This is an advanced treatise on ordinary differential equations, that is, on those equations containing but one dependent and one independent variable. During the last 25 years this subject has not received much attention in this country, and Professor Ince has been at great trouble to make known the numerous important contributions made by continental mathematicians during this period.

Quite 50 years ago it was recognized that progress in solving differential equations had reached a limit, and that without new conceptions further advance was impossible.

The required enlarged outlook was made possible by the inception of the Function Theory by Cauchy in France and Riemaine in Germany, and it was seen that although an equation might not be capable of solution in the ordinary sense, it might nevertheless suffice for defining some new function; from this point of view the theory of differential equations in its higher branches becomes an integral part of Function Theory.

The modern theory of Differential Equations is founded on Lie's theory of transformation groups, and on that of the functions of a complex variable.

Professor Ince's book of nearly 600 pages comprises 2 parts.

Part I. Equations in the real domain.

Part II. Equations in the complex domain.

In the first part, classical methods of solution are dealt with, the difficult question as to whether and under what circumstances an equation has a solution is fully discussed, and Lie's theory explained; this theory is analagous to the Galois theory of algerbaic equations. It will thus be seen that Professor Ince has taken full account of recent developments; his treatise is probably the most up-to-date work on ordinary differential equations extant, and is well worth study by a student specializing in the subject. Part I is not very difficult reading, and would be intelligible to anyone who has a fair knowledge of the subject, but Part II requires tolerably advanced knowledge of the Function Theory.

There is an historical summary, from which it appears that Newton was able to solve $\frac{dy}{dx} = 2 + 3x - 2y + x^2 + x^2y$; this he did by assuming $y = A_0 + A_1x + A_2x^2$ *ad inf.*, where the A's are to be found. This is, I believe, the first example of the method of solution by infinite series, a method often the only one possible, and which has led to the discovery of the Bessil and Legendre Functions.

J. M. WADE, Lt.-Col., B.SC., LONDON.

PRACTICAL PHYSICS.

By T. G. BEDFORD, M.A., F.INST.P. (Longmans, Green & Co., Ltd.). Price 10s. 6d.

The Course of Practical Physics described is based upon the experiments provided in recent years for students, mostly in their first year at Cambridge, as part of their preparation for Part I of the Natural Sciences Tripos.

After a short introduction, dealing with observation and recording results, the book is divided into five Parts:

I. Mechanics and Properties of Matter.
II. Heat.
III. Light.
IV. Sound.
V. Magnetism and Electricity.

Considerations of space forbid the discussion in detail of theoretical principles in a book on general Practical Physics, but explanatory matter has been given where it was thought it might be found useful.

The apparatus described is that used in the Cavendish Laboratory, Cambridge, but most of it is of a simple kind, so that the experiments can be carried out in most laboratories.

The book is intended to supplement, and not to replace oral instruction.

The aims of the author have been attained by the production of this very good laboratory text-book, with its very clear explanations of the experiments carried out.

R.M.

MECHANICS APPLIED TO ENGINEERING.

By JOHN GOODMAN, WH.SCH., M.INST.C.E. (Longmans, Green & Co., Ltd). Vol. I., Ninth Edition. Price 14s. 6d. Vol. II. Price 16s.

This book has been specially written for Engineers and Students who already possess a fair knowledge of Elementary Mathematics, with the intention of assisting them to apply their knowledge to practical engineering problems. The mode of treatment of the subject is to employ simple, straightforward and easily remembered methods, as far as possible, using elementary calculus sparingly.

The introductory chapter deals with units, velocity, acceleration, work, energy and vectors. The book then takes up the subject of mensuration, followed by that of moments, which is made to include centres of gravity, moments of inertia and radii of gyration, all of which are clearly explained from first principles. A short chapter on composition and resolution of forces, followed by one on mechanisms, leads up to a detailed discussion of the dynamics of the steam engine.

Vibration and gyroscopic action are dealt with briefly, and the subjects of friction and lubrication, with their effects on machine design, are gone into thoroughly. This concludes the dynamics section of the book. The next chapters deal with stress, strain, elasticity, beams, bending moments, shearing forces, deflection, struts, and torsion, and lead up in clear and natural sequence to structures.

The last portion of the book is concerned with hydraulics and pumps.

The Appendix gives useful hints about accuracy in measurements and calculations, and a table of the differential coefficients and integrals commonly met with. At the end of Volume I are a number of examples, with the answers.

Volume II consists mainly of fully worked out examples on all the topics dealt with in Volume I, with frequent cross references.

Both volumes are very fully illustrated and clearly printed.

The author has succeeded in the very difficult task of compiling, in two volumes of reasonable size, a useful text book and reference book for all who have to deal with mechanical and instructional engineering, and has mentioned other works to be consulted for fuller information on the various subjects.

R.M.

"COLAS" ROADS.

Asphalt, *i.e.*, bitumen and stone, has long been recognized as one of the ideal road materials; but the drawbacks to its use have been its cost, and the necessity of applying it hot in fine weather.

The discovery of a means of emulsifying bitumen—of which Colas Products, Ltd., claim to be the pioneers — thereby allowing of its application cold in a diluted form, has reduced these difficulties, and the results are apparent in a steadily increasing use of bitumen in road construction.

Bitumen in itself has greater binding powers than tar, owing to its higher ductility and long life, and has a further advantage in its homogeneity and absence of chemical compounds such as phenol, cresol, etc., which are liable to contaminate neighbouring streams.

The purpose of bitumen in modern road construction and the relationship between binder and aggregate are dealt with at some length in the first four chapters of " Colas Roads," and details are given of the different methods required for Colas grouting, surface dressing, and re-conditioning roads; the booklet concluding with various specifications for these processes, and with analyses of cost.

It must be admitted that Colas itself is more expensive than tar, but its application requires little skill, and is independent of weather conditions. In fact, its use is favoured rather than hindered by rain. It is claimed that it more than repays for itself by the greater durability imparted to the road, and the steadily expanding use of this material by various Road Authorities would appear to bear this out fully.

Although the use of Colas for military roads can only be of limited extent, it would appear well worthy of consideration in those cases where gravel or water-bound macadam roads still exist.

In almost every case such roads have to carry far heavier loads than they are fitted for, and semi-grouting or surfacing with Colas might save, or at any rate postpone, for some considerable time, the necessity for complete reconstruction.

The author of this booklet is Brig. General E. G. Wace, C.B., D.S.O. late of the Corps of Royal Engineers, and now General Manager of Colas Products, Limited.

G.B.O.T.

SOME BOOKS ON HEATING.

Although fire was probably one of the first discoveries of prehistoric man, the scientific study of the use of heat for all domestic purposes has only developed in the last few years.

In this country a special study of the subject is being undertaken by the Fuel Research Board, which works under the Department of Scientific and Industrial Research. Their annual report for 1925, which contains an account of their work up to July, 1926, has just been issued. It is mainly devoted to experiments on fuel, including a special chapter on "Low Temperature Carbonisation." The details of experiments on domestic heating are described in technical papers, of which No. 12 on "The Heating of Rooms," and No. 13 on "The Domestic Grate," are especially interesting. These record the result of experiments carried out by Dr. Margaret Fishenden, D.SC., who has been engaged on such work for many years. The paper on "The Heating of Rooms" deals in some detail with the conditions necessary for the "Warmth Comfort" of man. The report begins by a study of the Heat Production of the human body; then considers the loss of heat under various conditions of environment and the different apparatus in use for producing heat. It ends with a detailed comparison of the cost of different methods of heating, mainly considered from the point of view of the production of the maximum heating by radiation.

The paper on "The Domestic Grate" gives a detailed examination of the various types of grate in use and contains much valuable information as to the points to be looked to when selecting a fitting for a model building.

In addition to these special reports, Dr. Fishenden has published in 1925, under the title of "House Heating," a book which is a complete text book of the development of Heating and Cooking apparatus in this country. It commences with a chapter on fuels, describes the growth of the modern sitting-room grate and the kitchen range, and then deals with the use of gas for heating purposes, showing that all modern forms are based on the Bunsen burner. Electrical apparatus are rather shortly dealt with, and a short chapter is given to Central Heating. This is the least satisfactory feature of a book which is full of useful detail and should be studied by everyone interested in house design.

As a contrast to the English method of approaching the subject, a book has just been published in New York under the title of "Warm Air Furnace Heating," by A. M. Daniels, which promises to become a text book on its own branch of the subject. Although heating by warm air has been in use in America for many years, the modern scientific investigation of heating apparatus and their application to buildings only dates from 1914, when the "National Warm Air Heating and Ventilation Association" was formed by the furnace manufacturers of America. In 1923, this Association erected, at a cost of £5,000 ($25,000), a special test-house for the investigation of problems connected with warm-air heating under actual home conditions.

Mr. Daniels embodies in his book the latest results obtained from these experiments. The larger part of the book is devoted naturally to details of the Piped system which is so largely used in America, but there are useful chapters on Heat Losses (Chap. V.), Chimneys and flues (Chap. XII), Humidity (Chap. XIII), which are applicable to all systems. There are also good chapters on the One-Pipe, or Pipeless System (Chap. XVII) and on "Forced Air Furnace Heating" (Chap XXI), the latter being specially applicable to large workshops, and similar buildings.

All the above publications can be obtained from the R.E. Corps Library in London.

W.B.B.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

October, 1926.—The third instalment of Commandant Janet's "*Action d'une division encadrée dans une offensive d'ensemble*" deals mainly with the crossing of the Oise-Aisne Canal, and of the Ailette, on August 29th, 1926. This operation, which was part of a general offensive by the Tenth Army in the direction of Laon, was executed with the greatest difficulty against determined opposition. The crossing of a broad unfordable canal in the face of an active enemy is bound to be a most hazardous undertaking; and the description of the difficulties encountered, especially by the engineers, and of the manner in which they were surmounted, is well worth reading.

Evolution des idées sur l'emploi tactique de l'organisation du terrain, de Napoléon à nos jours, by Lieutenant-Colonel Baills, is written *à propos* of a recent provisional manual on the organisation of field defences. The author, who is a professor at the "*Ecole du Génie*," considers that few French officers have paid any attention to this manual, because they consider either that their war experience is sufficient, or that the higher staffs only require a very general grasp of the subject. Both these ideas are fallacious, and the object of the article is to show that the new manual is based upon Napoleon's principles of defensive action, and that many subsequent failures have been due to neglect of these principles. The remainder of this instalment is devoted to an analysis of Napoleon's orders and writings, showing clearly the importance he attributed to sound defensive organisation.

General O. Boian, the author of *L'événement d'Agasu*, commanded the 14th Roumanian Brigade in an action described in an article entitled "*Une opération de guerre de Montagne*," which appeared in the February number of the *Revue Militaire Française*. An account has also appeared in an Austrian journal, and General Boian wishes to emphasize the importance of this action while acknowledging the accuracy of the two accounts. He gives his preparations and orders in some detail, but the sketch map illustrating them is too inadequate to be of any value.

Commandant Janssen begins an important article, entitled "*La manœuvre en automobile*," in this number. He discusses the size of a column consisting of a mechanicalised division and the measures necessary for its protection. Some of his conclusions, which appear perfectly sound and logical, provide considerable food for thought, especially with regard to the duties of the various protective detachments which will be essential owing to the vulnerability of the main column. The writer accepts the principle of transport of a certain number of horses by lorry, though this appears open to dispute after the experiences of our own manœuvres, and he is firmly of the opinion that the one- or two-man tank will become an essential weapon of reconnaissance.

"*Un homme est tout!*" by Commandant Cotard, is an expansion of Napoleon's statement that " In war men are nothing; a man is everything," based chiefly on Napoleon's successes with badly-clothed and fed armies, compared with the failures of inefficient commanders of well-trained and equipped forces.

November, 1926.—The final operation of the 48th Division, described in the last instalment of Commandant Janet's "*Action d'une division encadrée dans une offensive d'ensemble,*" was an unsuccessful attack on the Basse-Forêt de Coucy. The author then gives his final conclusions, the most interesting of which are:—

(1). The need for dealing with the enemy's covering and main positions in separate operations. The failure to observe this principle caused the German defeat by General Gouraud's Army in Champagne in July, 1918.

(2). The need for intensive artillery support with gas-shell when attacking a wooded position such as the Forêt de Coucy.

(3). The need for improvement of communications and the long time to be allowed for orders to reach the troops.

"*Organization d' ensemble des communications et ravitaillements dans une armée,*" by Colonel Lemoine, is a detailed study of the general reception of supplies and stores at rail-heads and their distribution in the army area. Having described fully the various conditions on which the rail and road systems of transport are organised, Colonel Lemoine then goes on to apply these systems to the various types of operation. The whole article is a very detailed analysis of a most important subject.

Commandant Cotard completes his article, "*Un homme est tout!*" with a discussion of the qualities required by a great commander, illustrated by quotations from the writings of Napoleon and from examples in military history. The only flaw in the writer's arguments to prove that the Commander is all-important appears from the fact that he does not cite a single example of the greatest war in history to support his theory.

In the second instalment of "*Evolution des idées sur l'emploi tactique de l'organisation du terrain de Napoléon à nos jours*" Colonel Baills describes how, since Napoleon's days, the French Army passed through the stage of passive defence of the 1870 war, to the unrestrained offensive of 1914. This latter was largely due to the teaching of Colonel Grandmaison just before the Great War. The writer sets out clearly and in an interesting manner the unsound bases on which this doctrine was built up, and the return to sanity of 1914-18.

The second and final instalment of Commandant Janssen's interesting article, "*La manœuvre en automobile,*" is devoted to a description of an actual manœuvre carried out by a mechanicalised division. The protective measures taken, the principles on which the movement was based, and the actual manœuvre, are considered in turn. Unfortunately, the manœuvre was confined to a move without fighting occurring, but as far as it goes, it makes an instructive study. Two interesting points are, the provision of a Chief Transport Officer working directly under the commander of each column and the writer's suggestion that the infiltration of small mechanicalised bodies through the protective screen, is one of the chief dangers to be faced in a move of this description.

December, 1926.—"*Les trois glorieuses*," by Lieutenant-Colonel Doumenc, is a description of the three days' riots in Paris, known by the title name of the article, on July 27th, 28th and 29th, 1830. The author's object is to discuss the military aspect of the disturbances and to show how Marshal Marmont, who was placed in command of the troops at first, failed to control the populace owing to his neglect of military principles, which should be applied to the quelling of civil unrest, as well as to any other form of operation. The first instalment describes the inertia of the King and Dauphin at the beginning of the riots, and Marshal Marmont's unwillingness to act on his own initiative. The problem of action in the event of riot is one that is always liable to confront the soldier, and this description of a very important example makes interesting reading.

The third instalment of Lieutenant-Colonel Baills' article, "*Evolution des idées sur l'emploi tactique de l'organisation du terrain, de Napoléon à nos jours*," deals with the employment of engineers in the attack. The writer takes as his text the following quotation from the writings of Napoleon :—"Field works are always useful, never harmful, often indispensable," and he goes on to show how engineers can be employed on engineer work during the different stages of an offensive action. The general principles of employment coincide with those in force in our own army.

General Camon's article, "*Pour apprendre l'art de la guerre*," is written to prove, if further proof is required, that the study of the campaigns of the great captains is an essential part of the training of a commander. He goes on to suggest that the best method of study is to select a certain type of operation (*e.g.*, an attack against the enemy's rear organisation) and to study it in detail. Examples of this type of operation in a number of campaigns, including the Great War, are then given as illustrations.

In this number Lieutenant-Colonel Laure begins a series of articles entitled, "*Les étapes de guerre d'une division d'infanterie.*" The writer's object is to describe the various stages through which the French division passed during the Great War, from 54 strong infantry companies with few mechanical weapons, in 1914, to 27 weak companies but strongly supported by mechanical weapons, in 1918. The writer takes the 13th Division as his model, and in this instalment describes in great detail operations from the outbreak of war to September 2nd, 1914, followed by a series of comments. Some of the latter are instructive, but a detailed account of operations of a single division is generally of interest only to those who have actually served with the formation concerned.

In "*Le salon de l'Automobile en* 1926," "X" gives a brief description of the French Motor Show and ends with a few criticisms of the administration of the money obtained by motor taxation. Apparently the "Road Fund," as known in England, is still a pious hope in France ; however, the development of motor transport can be gauged from the fact that there are only forty-four very decrepit horse cabs in Paris now, as compared to twelve thousand in 1900 !

H.A.J.P.

REVUE DU GENIE.

(*January*, 1927.)—*The French Congo.* A description of the general condition and of the communications in French and Belgian Congo—of the railway under construction from Stanley Pool to the Coast, and of a Belgian scheme for canalizing the lower Congo and using the river for hydro-electric plant.

Destruction of Communication. (*continued*). Enumerates the repairs to railways, canals and roads after the Armistice.

(*February*, 1927.)—*The Work of the Engineers in Morocco in* 1925. Summarises the number of works of various descriptions, including Signal communications, executed or constructed.

The variation of personnel from month to month, numbers, animals and tonnage transported by military railways, and length of line constructed.

Navigation of the Lower Congo. Further details of the project described in January, calculation for flow of water and scheme for progress of works proposed, involving cost of three million pounds and thirteen years, concluding with a series of replies to possible criticism.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1926. Tome. II. Nos. 4—6 inclusive).

Les Opérations de l'Armée Belge (1914—1918.) The movements of the Belgian Field Army on October 10, 11 and 12, during the retreat to the line of the Yser, are dealt with in the three numbers of the *Bulletin* under notice. The Belgian G.Q.G. was now already established at Ostend. During the night of October 9-10, the dismounted troops of the 3rd, 4th, 5th and 6th Divisions were entrained and conveyed westward, the rear-guard duties being entrusted to the Cavalry Division, the 2nd Division and a mixed force under General Clooten during this move; the British force under Rawlinson and the French troops under Ronarc'h were at this time in the neighbourhood of Ghent. By the evening of the 10th, the Belgian formations had safely reached the localities to which they had been ordered; the 3rd and 5th Divisions (less the 20th Mixed Brigade) were now on the line of the Yser—the former at Nieuport and the latter at Dixmude—the 4th Division was at Ghistelles and the 6th Division and the 20th Mixed Brigade were at Thourout. Incessant fighting and the retreat from Antwerp had sorely tried the Belgian Field Army and it was, in consequence, in need of rest in order that the men might recuperate and an opportunity might be created for reorganising the Army for its fresh effort. However, a considerable force of German cavalry was reported at this time to be in the neighbourhood, and southward, of Ypres—the German 4th Cavalry Corps had on the previous day been reported as being south of Hazebrouck. In these circumstances, King Albert held a conference at Ostend at 2 p.m. on the 10th; General Pau was present as the representative of the French High Command and Rawlinson also attended. His Majesty wished carefully to examine into the situation with a view to ascertaining exactly the dispositions of the forces of the Allies, in order that he might decide upon a region wherein his Army could with safety be rested and reorganised. At the conference the King expressed a strong desire that the Belgian troops should, as far as possible, fight in their own country; eventually, owing to the representations of Pau, it was agreed that the Belgians should retire to the S.W. of the line St. Omer—Calais; no date was fixed for the move, but it was agreed that the British and French troops (under Rawlinson and Ronarc'h respectively) should maintain their positions in the neighbourhood of Ghent until the 12th. The Germans carried out a reconnaissance in force on the evening of the 10th and ran into the part of the line near Ghent, held by the Anglo-French force; Gontrode fell, for a second time within 48 hours, temporarily into the enemy's hands, but General Clooten quickly organised a counter-attack and won back the position which had been lost. Orders were issued on the 11th for the move of the Belgian Army into France as agreed at the conference of the previous day (see No. 5 at p. 463.) At the time these orders were framed the concentration of a considerable Anglo-French force was in progress in the region Arras-St. Omer with a view to an offensive stroke against the German Right Wing; Joffre wished the Belgians to throw in their weight in this attack. On learning of the decision to withdraw the Belgian Army into France, Joffre immediately telegraphed to Pau disapproving this move and suggesting that the Belgians should concentrate in the region Ypres—Poperinghe; at the same time, Pau was directed to get immediately into touch with Foch. Certain negotiations ensued and, an agreement having been arrived between the French and Belgian High Commands, the orders for the retreat of the Belgian Army into France were cancelled; Dunkirk was now chosen as the new base and the region Furnes-Nieuport-Dixmude as the new concentration area for King Albert's Field Army (see No. 6.)

La vérité sur la défense Namur en 1914. The second and third parts of the article under this title by Colonel Merzbach and Captain-Commandant Herbiet are published in Nos. 4 and 6; in the former number an examination is made of the secret report prepared by the Germans in 1915 in relation to their artillery bombardment directed against the Namur forts, and in the latter number a critical examination is made of the series of articles by M. Jean Fleurier published in the *Revue Militaire Suisse* during the period October 1923 to July 1925.

Des rapports entre le Gouvernement et le Commandement. The second part of Captain-Commandant Dendal's article on this subject is published in No. 4; it consists to a large extent of a review of the relations which existed in France during the Great War between the Civil Government and the French High Command. The subject is of immense importance to all soldiers and as treated in the original article will prove of great interest to them and possibly may help them to fashion their own conduct when holding positions of high responsibility.

La contre-préparation. In the original article, published in No. 4, Lieut.-Colonel Willemaers sets out the Belgian, French and German views as to the counter-measures to be adopted to meet an attack which may be immediately impending. The doctrines in relation to this subject contained in official books of instructions are examined and attention is called to the experiences of the Great War which provide practical illustrations of the manner in which the situation was met in given circumstances.

Le vide du champ de bataille. The second part of Captain-Commandant Menzel's article under this title is published in No. 4; it deals with camouflage as practised in the Great War.

La bataille de Mons. Major van Egroo's article on this subject is continued in No. 5; the situation on the British front on August 24, 1914, and the German movements on the same day are dealt with.

La traction électrique. In the original article, which is published in No. 5, Captain-Commandant Collet deals with the progress which is being made in certain foreign countries in the use of electricity as the motive power for ordinary road transportation; he also compares the *daily cost*—on the basis of a journey of 20 km. per diem—of maintaining and running certain types of vehicle. According to the tables in the original article the *daily costs* work out in Belgium—on the assumed journey of 20 km. per diem—at fr. 22.01 in the case of a two-horse vehicle; fr. 21.50 in the case of a 2-ton lorry run on motor spirit; and fr. 18.705 in the case of a 2-ton lorry equipped with electric batteries. Captain Commandant Collet finally sums up the advantages of electrically driven vehicles.

La fortification permanente dans la défense du Pays. The original article is the first part of a contribution by Major Deguent and is published in No. 6; therein attention is called to recent Press announcements stating that permanent fortifications are being constructed at Königsberg. Under the old regime, Königsberg was looked upon as the *reduit* of East Prussia and had for many decades been provided with permanent fortifications; the Treaty of Versailles decreed the dismantlement of the old defences. Although, in the early days of the Great War, permanent fortifications became somewhat discredited, owing to the comparatively short duration of the stands made by the defenders at Liège, Namur and Antwerp, the pendulum has already begun to swing again, and a reaction in favour of permanent fortifications is now in progress and contributions on the subject were published in 1926, from General Normand in the *Revue des Deux Mondes* and from General Nudant in the *Temps*. The following matters are dealt with in the original article: the defence system of Belgium in 1914; the rôle of the Belgian fortresses in 1914: the defence system on the northern and north-eastern frontiers of France in 1914; the rôle of the French fortresses during the Great War. A map accompanies the article and thereon are marked the principal Belgian, French and German defences on the Western Front of the Great War.

W.A.J.O'M.

HEERESTECHNIK.

(*August*, 1926). *A Military Railway in Poland*, 1914, by Major Kretzschmann, ret. This is a sad story, but instructive! When, in Nov., 1914, the 9th German Army was advancing into Poland the existing railway system was found to be inadequate for those troops on the German left whose function it was to advance S.E. against the Russian right. To serve this flanking movement there was only a single line of railway on the left bank of, and parallel to, the Vistula. This line ran from just S. of Thorn to Lowicz, N.E. of Lodz, and lay rather far out on the German left. This fact, together with an exaggerated account of the damage done to it by the 9th Army itself when retiring over the same ground in October, contributed to a decision on the part of Army H.Q. to replace it by means of a light (60 cm.) military railway to be built parallel to it, but from 12 to 36 km. nearer to the centre line of advance.

The route was reconnoitred by an officer of Railway Troops on Nov. 11th, and it was decided that the line should run from the sugar factory at Montwy, into which the broad gauge ran, along 20 k.m. of a 75 c.m. gauge line, used for bringing beet-roots into the factory, and thence to Strykow (on the main-line, between Lodz and Warsaw), a total distance of 160 k.m.

On Nov. 12th, orders were given for the railway to be made, and the next day work started on the station-buildings at Montwy and on the conversion of the beet-root line. On Nov. 14th, the first train-load of railway material arrived at Montwy and the new construction started from the end of the beet-root line. When 30 k.m. of the line were in working order, Army H.Q. ordered the line to be used for supplies. First one station and then another was prepared as rail-head, but the supplies were not taken over by the troops. The trains stood unloaded for days in the stations, blocked the line and hindered the work. Thus, trucks which were required for sending up railway material were not available. On Nov. 25th, for the first time, supplies were taken over from the trains by the supply-columns. By Nov. 29th, the halfway point was reached (i.e., 60 k.m. of new construction in 15 days), and on Dec. 30th the line was completed to the terminus Strykow (i.e., 31 days for the last 80 k.m.). Neither the rate of progress in building nor the carrying capacity of the line satisfied Army H.Q. The chief reason lay in the over-hasty use of the line for supplies, since if both construction and the carriage of supplies have to take place simultaneously, it is natural that both must suffer. In November, an average of 200 tons of supplies were carried daily. This figure rose to 560 tons later, but even this total is not very satisfactory considering that 14 Railway Companies, comprising over 4,000 of all ranks, were employed. Up to a distance of 50 k.m. the country was almost level, so that gradients and curves were easy. Beyond 50 km. a very hilly country, with many swamps and bogs, made matters more difficult, especially as the rate at which the line had to be pushed on prevented the necessary care from being taken, so that in this sector there were frequent cases of sharp curves and steep gradients coinciding. In one place, indeed, it was necessary to divide the trains, four trucks being taken instead of eight.

To hurry the work on, ballast was dispensed with, the sleepers being subsequently packed with earth from the spot. In the dry weather which prevailed at the start this proceeding caused no difficulties of any sort: the line was firm and safe for traffic. But all this was changed in a moment when the thaw came. Many of the low-lying parts now turned out to be swampy, the track was in many places flooded, and in others sank into the mud, causing numerous interruptions of traffic and often very bad derailments. Generally, they were obliged at first to leave derailed locomotives where they lay and to put in a new portion of line. There was no idea of keeping to a time-table. The circulation of trucks was irregular, many stations were overcrowded. Thus, on Nov. 25th there was a complete stoppage of the whole line, in order to clear which on the two following days sectors had to be closed. Since, owing to these numerous interruptions of traffic, the train-personnel were often on duty for 72 hours consecutively, the percentage of sick rose extraordinarily high. Also very high demands were made upon the railway troops engaged on the line, who were continually exposed to the worst weather and were accommodated under the most unfavourable conditions. In order to keep the line going at all, the whole of the available personnel had to be used on maintenance. At first an attempt was made to improve the worst places by means of pickets, planks and heaps of logs, but the success achieved was meagre, and it soon became evident that the only method was to remove the water-logged soil and to put down a regular bed of gravel 12ins. deep. Fortunately gravel-pits were available along the line, and were joined up to it by sidings.

At the same time the drainage of the entire line, which had been almost completely neglected in favour of rapid construction, had to be undertaken; but much time and labour were expended before it became effective.

After the thaw in December there came at the beginning of January heavy snow-storms, which caused extensive snow-drifts along the whole line, and on the 4th of January, caused a complete stoppage of traffic. All attempts to clear the line by means of snow-ploughs failed, and traffic was restored only after the snow-fall had diminished and by great exertions with the aid of additional working-parties.

Since, owing to the rapid construction, it had not been possible to provide watering-stations with high tanks, the boilers had to be filled from the numerous streams and water-holes. All went well until the heavy frost came, when much time was lost by breaking up the ice, and finally the shallow ponds failed entirely as a source of supply.

Owing to the combined effects of bad weather and bad track, the demands upon locomotives were very high. As at first there were neither sheds for shelter nor workshops for repairs, the number of locomotives out of action rose to 35 per cent. in the middle of January.

To sum up, the light railway did not come up to expectations because of exaggerated ideas concerning speed of construction and simplicity in running.

It was not realized that a light railway, if it is to do good service, can no more than any other railway be hurried on with to the neglect of careful choice of route, proper earth-work and ballast.

In mobile warfare light railway construction should be confined to those few cases in which no broad-gauge lines exist. In this case all resources should have been concentrated on repairing the existing broad-gauge railway, an undertaking which would in far less time have provided an efficient and reliable line of communication.

F.A.I.

MILITARWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

November and December, 1926.—*Wireless Picture-Transference and Wireless Vision for Military Purposes*, by Dr. Bandat.

A demand for an apparatus for transmitting pictures by wireless from aeroplanes was made in the German Army during the war, and experiments to that end were set in motion. The scientist who was charged with satisfying the demand then made, has now applied his experience to a simpler task, viz., the wireless broad-casting of weather-charts. This is done by the Bavarian Government Meteorological Observatory. At the appropriate hour the subscriber switches aerial from broadcasting-receiver to picture-receiver and sets reception-cylinder revolving. The movements of the pencil on the cylinder are guided by the modulations of the wave sent out by the Observatory. It is a long, long way to Wireless Vision; but the author considers, " no longer Utopian," self-flying bombers with electric eyes, being steered and made to drop bombs by reason of the pictures they send back!

Technical Formations and their Equipment, by Col. Schneck. In the Austrian Army there was before the War an Engineer Company to every Infantry Division; a Pioneer Company to every Infantry Brigade, and a Pioneer Troop to every Cavalry Brigade. There was also a small number of Pioneer, Bridging and Railway Companies outside the Divisions. The war equipment consisted of the portable and transportable equipment of the companies, of the divisional entrenching-tool column, of the bridging trains, and, finally, of a number of Parks (mobile tool depots, pioneer material depots, engineer siege parks). Long-handled intrenching tools, forestry implements, requirements for demolitions, and a certain quantity of barbed wire, completed the sum total of the equipment. As regards technical training, little value has been placed upon it by the fighting arms.

The mobile warfare in the first months of the war already showed that the existing technical formations and means were insufficient. When, however, the war became one of position, the demands on technical formations and the demands for technical aids of the most widely differing kinds rose immensely, especially when it became a question of reducing by technical means the enemy's superiority in numbers and material, and thereby saving man-power. This brought about on the part of the commanders much activity of organization and improvisation. A large number of special technical formations for the most widely differing purposes was created, of which only the most important can be mentioned, companies for telferage-lines, electrical, rock-borer, search-light and flame-thrower formations, building companies, labour companies and prisoner-of-war working parties. Also the reorganization of the Engineer arm was undertaken, but not completely carried out. Every division was to have a complete battalion of Engineers, of 3 Companies with 12 vehicles each as technical train, and a Divisional Engineer Train of 37 vehicles, and in addition to have allotted to it a number of building companies; so as to be capable of initiating even works of some size. Since, owing to the small number of wagons available, a general increase of issue to divisions of tools, building-materials and material for obstacles was not possible, each division received instead an Engineer echelon, containing workshops, and variously equipped according to the theatre of war and to the state of operations.

At the end of the War the number of technical and labour formations had risen to 3,400, nearly as many as the number of fighting formations, and there was roughly one workman to every rifle. Even with this apparently great number of workers, the incalculable amount of technical work could hardly be tackled, and the fighting troops could with difficulty be relieved from being called upon to furnish working parties—a duty so damaging to their fighting powers and spirit.

The collapse of the Central Powers and the Peace Treaty stopped all further development in this direction ; but a war of the future will make still greater demands on the technical formations than heretofore. Since the training of the pioneers necessitates about double the time of that of the infantry, the pioneers and all special formations should at least be prepared in peace to such an extent that their training and equipment can be brought quickly to the pitch indispensable for the defence of their country. Preparation for war should include, as regards personnel, arrangements for all specialists, and especially of the directing staff in all branches. Technicians cannot be dispensed with ; their lack is bitterly revenged upon the troops.

As regards material, the army authorities must keep constantly in touch with industry in order to have at their disposal in the requisite quantities the most modern types according to the latest advance of technics. The equipment of technical formations must be placed upon a new basis. Whereas the Army used to have at its disposal a sufficient number of technicians and of workmen generally, as a consequence of progressing industrialization the replacement of capable technicians has become difficult ; also labour must be spared more than ever. This compels the greatest possible replacement of men by machines, the widest possible standardization, and, as in industry, the economic use of labour on scientific principles. The farthest reaching use of mechanical, especially of electrical, power is the key to this. Electro-pneumatic rams, cranes, circular and band saws, boring-machines for wood and iron, tree-fellers and concrete-mixers, are only some examples. The creation of simple standard patterns for the different technical branches, where feasible their production in series, will simplify issue and replacement. Otherwise it will hardly be possible for the officer, let alone the man, to master the different branches of technics. There is now no longer a place for any but the simplest types, however theoretically justified. This does not imply, however, the exclusion of individuality. The engineer will still find he has a man's work to do in war, side by side with the other arms.

The World War first opened the eyes of many in all armies to the epoch-making signification of technics and industry to the conduct of modern war. Tactics and technics are indissolubly connected. The French War Minister recently said, "I am principally concerned in creating close co-operation between science and the army, and, indeed, of such a nature that every invention shall be used for increasing our national security. Similarly must industry and finance be introduced in peace to the rôle they have to play in war."

F.A.I

CORRESPONDENCE.

SHELL FIRE V. PERMANENT FORTIFICATION.

To the Editor of the *R.E. Journal.*

SIR,

In the December, 1926, number of the *Journal* there was an interesting article by Lieutenant H. B. Harrison, R.E., on Verdun and its Forts in the Great War. He brings out the fact that the forts as a whole resisted in a wonderful way the tremendous bombardment to which they were subjected. Then he goes on to make the conclusion that Verdun showed what a valuable asset to the field armies permanent fortification (evidently of the Verdun type) can be.

But is not this conclusion based on a very slender foundation? We know that at the outset of the battle the forts had been disarmed and that they were only very partially re-armed during the struggle, so that they were practically passive shelters. What one would like to know, before forming any conclusion on their real worth, is what effect had these forts on the main struggle, as forts and not merely as shelters?

Until this can be ascertained it seems hazardous to base a theory for defence works founded on such very expensive structures as these forts were, or similar works would be. Lieutenant Harrison rightly sums up the situation in saying that "the permanent fortification of the future will be but the deliberate application of the principles of field defences as established during the Great War." But this does not imply the necessity for the construction of the type of work of which the forts at Verdun were examples.

It is somewhat sweeping to say that the War witnessed a complete change of opinion as to the value of permanent fortification. The above quoted summary as to the fortification of the future is very much the same as the conclusions that many had reached before the War. The French General Langlais used almost the same words a number of years before 1914.

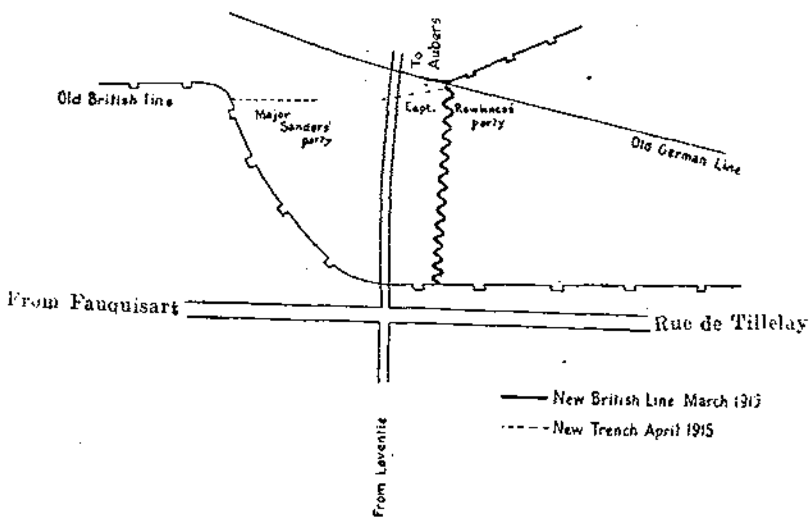
I am, yours obediently,

J. C. Matheson, Colonel (retired).

20th (FIELD) COMPANY ROYAL BOMBAY S. AND M.

DEAR SIR,—It is with some diffidence that I write to supplement the very excellent history of the 20th (Field) Coy., Royal Bombay Sappers and Miners, by Major H. W. R. Hamilton, D.S.O., M.C., R.E., but one or two episodes require correction or expansion.

April, 1915.—(Page 555, *R.E.J.*, December, 1927). The Company was employed during the whole of the period spent at La Flinque on the closing of the re-entrant mentioned, and the work was still incomplete when we handed over to the Sappers of the Meerut Division, on April 13th. The re-entrant was about 400 yds. by 400 yds., and was created by the Neuve Chapelle advance in March. Thus:



On the right we were in the old German front line, and about 30 yds. from the enemy. On the left there was about 100 yds. of old "No Man's Land." Down the centre of the re-entrant ran the flooded road from Laventie to Aubers. We attempted to complete the task in one night. On the right I had a party of infantry and two sections of sappers to bridge the flooded road, build a barricade and make drains. We got to work at dusk, and were well started when Major Sanders with Major Cumings' Company of the 12th Pioneers (attached 34th Pioneers), and a few sappers started out from the left. They had been delayed by ration parties. Although further from the enemy than my party, they were spotted immediately, and of the 60 men who got on to work about one-third were killed and wounded within a few minutes. They stuck to it, however, with great gallantry, and completed about a third of their task. Casualties on the right were few, as the men already had some cover. I personally spent a very unpleasant half-hour between the two groups, having been across to see Major Sanders, and re-align the tape, which the Manchesters, holding the line, reported moved by a German patrol. It was for this night's work that the thanks of the G.O.C. Division were received; and thereafter work proceeded almost entirely by sapping, other progress being impossible.

2nd Battle of Ypres, 1915 (see plan opposite page 560, December *R.E.J.*). The right half company under my command got through to La Brique with very few casualties, as we were ahead of the shelling. April 26th was spent in the valley south of La Brique, making Brigade H.Q. Signal and dressing station dugouts. An attack by the 9th Sirhind Brigade was ordered for the night of April 26-27, the right half company to follow for consolidation. The Brigade received orders to halt in the valley S.E. of French Farm, and eventually the attack was counter-ordered about midnight. After reconnaisance with Captain Kisch, of 21st (Field) Company, the half company spent the rest of the night consolidating French Farm, assisted by Major Cuming's Company of the 34th Pioneers. The Sikh section suffered considerably from lachrymatory shells. Sapper Dateh Singh, I.O.M., of Neuve Chapelle, 1914, then a Naik, was hit in the lungs, and finally left the company. Havildar Uttam Singh, commanding the section, obtained the I.O.M. for this night's work. On the afternoon of the 27th, the 7th Ferozepore Brigade was ordered to attack N.E. with its left on "Moated Grange." The half company and the Pioneers remained at La Brique, and it was there that Capt. K. Mason was wounded. I remained with Brigade H.Q. in "Defensible Farm," whence a panorama of the attack was obtainable. At dusk I was able to reconnoitre the whole ground covered by the attack without hearing a shot fired. Night work on consolidation of the ground won was, however, much delayed by the difficulty of getting orders, and work was not started till after midnight. During the night of 27-28th I received orders to take over command of 21st (Field) Company as from April 26th, and left this gallant company early on the morning of the 28th, and not on the 26th, as stated.

The operations at Ypres were full of lessons for Sappers. The attacks of the Lahore Division took place across the open through a gap between the French right at "French Farm" and the British left, east of "Moated Grange." The advance was down a glacis slope, across a marshy valley, and up a slightly convex rise.

The ground was devoid of features involving special tasks for Sappers There was little for Sappers and Pioneers to do by day, and three-quarters of their heavy casualties would have been saved had they been left west of Ypres. Reconnaisance by advanced Sapper parties at dusk was extraordinarily easy, and without risk. As the light failed a complete. hush spread over the country. On the other hand, although Sappers, Pioneers and material were available, and detailed reconnaisances completed shortly after dusk, it was seldom possible to start work till early morning, owing to lack of orders. On the nights of both 26-27 and 27-28 orders were only obtained after a brigade conference had been arranged. As a detail, all messages between the advanced party and the unit should be duplicated and sent by two stout-hearted orderlies at not less than 200 yards distance. Casualties to orderlies in this heavily-shelled area were very severe.

In conclusion, the trench, H-C-K. was completed at night with only a dozen or so casualties, and was within a few yards of the furthest limits reached by the day attacks, of which the cost was a loss of several thousand.

Yours truly,
M. RAWLENCE.

DIVISIONAL ENGINEERS.

To the EDITOR, *R.E. Journal*.

DEAR SIR,—In connection with General Walker's article on Divisional Engineers of the Future it may be of interest to know what is being done as regards mechanizing the 17th Field Company. The vehicle decided on for this unit is the 1-ton Morris six-wheel lorry with the standard W.D. body. The lorry will carry 14 men, including the driver; the tool cart and one L.G.S. wagon are each replaced by one lorry, and in the case of the tool cart, the tools are packed in boxes which fit on and between the seats; in this way one standard type of lorry serves both for carrying the men and the tools and equipment. Owing to financial stringency, it will not be possible at present to allot a full scale of these cross-country vehicles to the unit, but at war strength the section might, perhaps, consist of 6 lorries, *i.e.*, 4 to carry men and the remaining 2 for the tool cart and L.G.S. wagon. In addition, there would be required lorries for company headquarters carrying the personnel, technical tools and stores, water cart and travelling kitchen, etc. These lorries can travel across country almost anywhere, and they can surmount the most surprising obstacles. Generally speaking, they can go anywhere that horse transport could go, and negotiate some ground that would be impassable to the ordinary field company horse transport. In addition they can travel fast and economically on the roads. By having six vehicles for one section, the men could disperse in small parties with tools and explosives, and it would appear that these vehicles should serve very well for the trials that will be carried out this summer.

From the point of view of the 17th Field Company, these trials will be of a dual nature. The primary object in mechanizing the 17th Field Company is to enable it to work with the experimental mechanical force on Salisbury Plain. For this purpose, the question of the equipment to be carried, the amount of explosives necessary, and the special bridging equipment required, will all have to be considered in detail. Much experience should be gained during these trials, and special vehicles for bridging will be added to the unit in due course. At the same time the unit still remains a field company in the 3rd Division, and experiments will be carried out to determine the best way of carrying the normal tools and equipment of a field company in these lorries; much experience will be gained and will be available, if it should be decided in the future to mechanise the field companies of the expeditionary force.

In both cases the points raised by General Walker are of great interest. The question of using mechanical power in this way is not entirely new. In the October, 1920, number of the *R.E. Journal*, will be found an account and photos of some work of this nature which was carried out at Christchurch just after the war. At that time, however, the whole army was still imbued with the spirit of trench warfare.

The weapon of mechanical warfare was the heavy tank, and it was, therefore, the heavy tank that was considered in connection with the mechanized field company for work with a mechanical force. A complete organisation was worked out, based on the use of four heavy tanks per section. The tanks were used like very strong bullet-proof elephants, to assist with bridging—gaps from 20 feet to 70 feet could be bridged to take the heaviest tanks in a few minutes—and the work could be done under fire. The tanks were also used for mine sweeping, clearing away obstacles such as demolished bridges, carrying forward demolition charges under fire, and later they were used for cable burying and trench ploughing. Very soon after the war, however, the heavy tank became obsolete, and the question of using mechanical power to assist an R.E. field unit required reconsideration. Financial stringency, however, made it difficult to carry on this work, and the whole question has lapsed until quite recently.

General Walker referred to the possibility of using mechanical power under nine headings, as follows :--

(*a*). Reconnaissance.
(*b*). Clearances of fields of fire.
(*c*). Obstacles.
(*d*). Preparation of elaborate defences in stabilised positions.
(*e*). Bridging.
(*f*). Demolitions.
(*g*). Water supply.
(*h*). Protection against weather.
(*k*). Communications.

Some of these affect a field company working with an infantry division only ; others apply equally to a field company working with a mechanised force. I do not propose in this letter to consider the question of bridging at all ; it is a very complicated subject at the moment, and is under consideration at the War Office ; many new devices have been produced recently—mechanical and otherwise—and the subject would require a whole article to itself. As regards the remaining eight points raised by General Walker, (*c*), (*f*), and (*g*) are the only ones which will seriously affect an R.E. unit working with a mechanical force. In any case, however, I would suggest that the eight points should be divided into two classes as follows :—

Class I.—Those which are required to be carried out at short notice with the equipment belonging to the unit.

Class II.—Those for which special preparations have to be made, such as the sending up of material from the rear, and which cannot in any case be carried out at short notice.

Of these, (*a*), (*b*), (*c*), (*f*), (*g*), belong to Class I, and (*d*), (*h*), (*k*) belong, generally speaking, to Class II. With Class I, anything which we can carry, which will assist us by mechanical means to expedite the work or increase the output of the unit, should form part of the normal equipment.

On the other hand, with Class II, it will usually be better to send up any necessary mechanical appliances which may be required, from R.E. Parks in rear, when it has been decided that some work of this nature is to be carried out.

Coming down to details, the only proposals that have so far been made for gaining assistance from mechanical power are as follows :—

(*a*). The lorries—or at least one lorry per section—should have a pulley, or some means of power to take off from the engine. This would be used when required to drive a rotary pump for a temporary water supply and any other purposes of this nature.

(*b*). A proportion of the lorries should be fitted with a winding gear, and possibly a light derrick ; this would facilitate many operations which have to be carried out by the Royal Engineers in the field.

Both the above accessories have already been asked for, and will represent a certain advance in the right direction ; in addition, the question was raised about two years ago of a portable compressor plant for use in the field—particulary for rapid pile driving, and for any other work, such as drilling. The question was considered by the R.E. Board, and there were certain technical difficulties, but with the advent of a mechanised field company the question will no doubt be reconsidered. General Walker has, however, raised many other points which have not yet received much consideration, and any suggested solutions will be awaited with interest.

Finally, it is not unlikely that the mechanical force will eventually take the form of a force moving in nothing but armoured vehicles, so that the whole force will be bullet-proof. In this case the field company would also move in armoured cross-country vehicles, and the ideas which were produced at Christchurch in 1919 would have to be re-invented ; the vehicle would have to be far lighter and more mobile than the Mark V tank, but the main duties would remain the same, namely, bridging, mine sweeping and demolitions. Our immediate problem, however, is to improve the efficiency of a field company equipped with six-wheel lorries by using mechanical power in the directions suggested by General Walker.

Yours faithfully,

G. LE Q. MARTEL,

Major, R.E.

ARTHUR FFOLLIETT GARRETT PRIZE ESSAY, 1927.

Subject selected :—"Railway Work on Active Service."

The Essay should take the form of an appreciation of the Railway position and the railway problems to be met with in the circumstances outlined in the succeeding paras.

In it should be set forth fully the steps that would be taken to cope with the situation; to facilitate prompt construction; and to provide all necessary organization, staff, facilities, plant and stores to carry out construction and to ensure an adequate railway service.

(2). The Expeditionary Force consists of three Divisions and one Cavalry Division, with the normal proportion of non-divisional and L. of C. units, also four Squadrons, R.A.F.

Included in the L. of C. units are :—

One Railway Survey Unit,
One Composite Railway Company,
Two Railway Platelaying Companies,
One Railway Bridging Company,
Two Railway Operating Companies,
One Railway Stores Company,
One Advanced Railway Workshops Company,
One Base Railway Workshops Company,
One Railway Telegraph Construction Company,
One Railway Telegraph Operating Station,

also One Dock Company:

all at Small War Establishment and with the several departmental headquarters.

It is probable that the E.F. will be reinforced by one Division.

(3). The Base, which has accommodation for 8 ships at a time and limited facilities for handling loads in excess of 12 tons, is a railway-served port in a friendly country which cannot undertake military operations outside its own borders.

(4). The railway, which is 4ft. 8½in. gauge and single throughout its length, runs 300 miles to the border of the hostile State, against which operations are to be undertaken, and has one 40-mile branch at Mile 30.

(5). The E.F. will require railway communication 450 miles from the coast, *i.e.*, 150 miles into the territory of the hostile State, which is without railways.

(6). The following further railway information and intelligence has been obtained :

i. Railway in friendly State owned and worked by local private Company,

ii. Normal train service :—
- 2 mixed trains and 4 goods trains per diem, each way, to mileage 200;
- 1 mixed train and 2 goods trains per diem, each way, between mileage 200 and the terminus at Mile 300;
- 1 mixed train per diem, each way, on the branch.

iii. Crossing sidings average 10 miles apart.

iv. Line operated on Telegraph and Paper Order System. Home and Outer Home signals at stations.

v. Goods trains maximum loadings :—
- 270 tons gross, mileage 0—200 and on the branch;
- 600 tons gross, mileage 200—300.

vi. Rolling Stock :—
- 70 main line tender engines,
- 15 shunting engines,
- 3 10-ton (hand) cranes,
- 250 30-ton (bogie) trucks,
- 850 10-ton (four-wheeled) trucks,
- 80 passenger (bogie) coaches.

vii. 75 lb. rail; wood sleepers, spaced 3ft. centres.

viii. Ruling grades :—
1/40, mileage 0—200 and on the branch ;
1/100, mileage 200—300.

ix. Fuel (imported) coal.

x. Water plentiful, but loco. watering plant only sufficient for present train service.

xi. Loco. heavy repair shops at Base.

xii. Engine depots at mileages 0, 100, and 200.

xiii. Reserve of permanent way and other materials small.

xiv. Line poorly ballasted except between mileages 0—100 and 200—250.

(7). The enemy only partially trained, but mostly officered by Europeans, and having modern field artillery and aircraft and good anti-aircraft defence, has raided the friendly country for 50 miles and destroyed, or partially destroyed, the railway as far as mileage 250. At this point he is held by the forces of the friendly State, but cavalry raids have been made on the L. of C. as far back as mileage 200. The railway has been restored to mileage 240.

(8). At mileage 260 is a bridge of 8 spans of 100 ft. over a river not more than 200 ft. wide, with a maximum depth of 6ft., except in the flood season, when the river rises as much as 10ft. for short periods and is 600 ft. wide.

There are no other big bridges between mileages 240 and 300, but several small bridges, including some of 40 ft. and 50 ft. span.

(9). Maps of enemy State are inferior.

The country beyond the border of the friendly State is comparatively easy for the first 50 miles; for the next 50 miles it is more broken and gradually rising, probably necessitating some rock cutting and a ruling grade of 1/40 ; beyond this it is again comparatively easy.

There are three rivers to be bridged, one at the border, a mile beyond the terminus at mile 300, and the others at approximately 50 and 100 miles from the border. The rivers are comparatively small streams in the non-flood season, and are not more than 5 ft deep, but are liable to 10 ft floods and are 200 to 300 yards wide when in flood.

There is no surface water except from these three rivers. The villagers obtain their water from wells, but the yields are somewhat precarious except in the flood season.

(10). Operations start from railhead, mileage 240, early in December. The floods generally commence about mid-April and last till the end of June.

(11). The Commander of the E.F. anticipates but little serious resistance and has informed you, his assistant Director of Railways, that this progress will depend on the rapidity with which a railway L. of C. can be constructed and worked. He also informs you that the strength of the R.A.F. with the E.F. is slightly superior to that of the enemy Air Force.

(12). Roads are practically non-existent in the enemy territory, and such as there are will require much attention before even medium M.T. can be used, whilst there is no road metal nor ballast except between mileages 200 and 250 in the friendly State and from 50 to 80 miles from the border in the hostile State.

Essays must reach the office of the Secretary, Institution of R.E., Chatham, not later than the 30th November, 1927. Essays must not be signed but each essay must bear a pseudonym, and the name of the writer, enclosed in a sealed envelope marked with the same pseudonym, must be attached.

The following are the conditions of the Arthur ffolliott Garrett prize :—

1. The prize, which will take the form of a piece of plate, to be chosen by the recipient, was instituted by Mrs. Garrett in memory of her late husband, Major Arthur ffolliott Garrett, O.B.E., R.E.

2. Qualifications of the recipient : To be an officer on the Active List of the Royal Engineers, not above the substantive rank of Captain on 1st January, 1927.

3. The essay must not exceed **10,000** words.