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Map to illustrate
article on
"LANDING GROUNDS IN ADEN"

Scale 1:2,000,000

Miles 20 10 0 20 40 60 Miles

Heights in feet

R.A.F. Landing Grounds shown thus ⊙

SECTION OF MEAN ALTITUDES on a line drawn N. & S. from GULF OF ADEN through NISAB to the GREAT RED DESERT (OR EMPTY QUARTER)

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2,200—1.3.33.

Russians were making." Our French Allies also picked him out as a promising subaltern, since they conferred on him the decoration of the Legion of Honour.

It was, however, his very proficiency in his engineering duties which led to his missing further chances of military distinction during the years that immediately succeeded the Crimean War. He was selected to serve on the Commission for the delimitation of the boundaries between Russia, Turkey and Rumania. When this was completed early in 1857, the first outbreaks which led to the Indian Mutiny were taking place, and Gordon was anxious to get back to England. But the ability that he had shown in the survey work of the Commission was such that the Government called upon him to act on another Commission which was to delimit the boundaries in Asia Minor. Gordon appealed to be let off. But a peremptory order came from London: "Lieutenant Gordon must go." So, while his friends went off to India to take part in the exciting Mutiny campaign, he was sent to Armenia to prepare some more of those admirable maps that had so won the approval of the authorities. He did not finally conclude his survey labours till the autumn of 1858. On his return home he was gazetted Captain (April 1st) and was given an appointment as Field Work Instructor and Adjutant at Chatham, where he turned to good account the practical knowledge he had acquired in the trenches of Sebastopol.

After a few months' service on the staff at Chatham, another call came to Gordon for active service abroad. Fighting had been taking place in China, while the Indian Mutiny was in progress, and had been brought to a close, about the same time as the Mutiny, by the signature of the Treaty of Tientsin (June, 1858), which made provision for the opening of certain ports to European trade and the establishment of a British Minister at Peking. When, in the following summer, the British Minister, Frederick Bruce, went out to take up his duties at Peking, resistance was shown by the Chinese to his passage up the Peiho River, and an attempt to force a passage was met by the Chinese opening heavy fire on the British ships from the Taku forts. Such a repulse could not be overlooked, and a strong Anglo-French expedition was got together to punish the Chinese for their resistance and to enforce the provisions of the Treaty. Gordon volunteered for service with the force and in July, 1860, was attached to the second contingent that sailed for the Far East. He has described how, as he passed the coast of Sicily, he saw the spot where Garibaldi, with his thousand volunteers, had a few weeks before made his sensational landing, and we can imagine how the heart of the young English captain was stirred by the thought of the heroic exploits of the great Italian with which the world was then ringing. He can little have thought that, before he returned across the Mediterranean four years later, he himself would, as

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MAJOR-GENERAL CHARLES GEORGE GORDON, C.B.

By BERNARD M. ALLEN, LL.D.

ON Saturday, January 28th, England celebrated the hundredth anniversary of Gordon's birth.

He was of soldier stock and was born at Woolwich, where his father, an officer in the R.A., held an appointment. Before he joined the Academy he became notorious for the mischievous pranks he used to play on the cadets and the staff, and, when he himself became a cadet at the age of 15, his high spirits got him into trouble on more than one occasion. But he was by no means idle, and passed out in June, 1852, as Second-Lieutenant in the R.E. His nephew still possesses a prize which he won for proficiency in Fortification—strange forecast of tragic days to come. From Woolwich he proceeded to Chatham to complete his training as an Engineer, and there showed marked ability in map-drawing and surveying.

In February, 1854, when just over 21 years of age, he was gazetted Lieutenant and proceeded to Pembroke Dock to work on the construction of new fortifications and batteries. He had hardly been there a month when the Crimean War broke out, and in due course Charlie Gordon, as his friends always called him, left for service in the Near East. He arrived at the British camp outside Sebastopol on New Year's Day, 1855.

For nine months he worked in the trenches, where he showed alertness of mind, physical endurance and marked indifference to danger.

He soon attracted the attention of his superior officers, one of whom, Colonel C. C. Chesney, said that he gained " a personal knowledge of the enemy's movements such as no other officer attained " and adds, " We used to send him to find out what new move the

Captain Charles G Gordon NC,
Chatham, 1869

leader of another irregular force, have written on the pages of history a series of exploits no less remarkable.

Gordon arrived in China too late to take part in the one battle that preceded the entry of the British and French into Peking, though he was present at the actual entry and at the burning of the Summer Palace. It looked as though he was again to be disappointed of his chance of active service, especially as for the next two years he was called upon for nothing but routine duty with the small British detachment that was left at Tientsin to see to the carrying out of the terms of the Treaty. Then, by an unexpected series of events, he suddenly came to the turning point in his career.

For more than ten years the Chinese Empire had been devastated by organized bands of insurgents, known as the Taiping rebels (rebels of the " Great Peace "), Their leader was a religious fanatic who styled himself the " Tien Wang " (Heavenly King) and who claimed to have been caught up to heaven and have been given equal rank with the Second Person of the Trinity. In spite of his fantastic religious pretensions, Tien Wang was a merciless despot, who massacred men, women and children in places that resisted his claims to domination. The rebels had been driven back from Peking shortly before the British arrived there, and they then proceeded to lay waste the provinces of Central China and to concentrate their attack on Shanghai. For the protection of this town, a force of drilled Chinese was got together by the principal merchants and placed under the command of an American named Ward, who, after some initial success, received from the Chinese Government the title of Commander of the " Ever Victorious Army." Matters having by this time been placed on a friendly footing between England and China, the British troops were moved down from their camp at Tientsin, in order to help garrison Shanghai, and Gordon was moved down with the rest. Meanwhile the British Admiral made an agreement with the rebel leader that, for the period of a year, he was not to advance within thirty miles of the town. When that period expired, the rebels advanced upon Shanghai, whereupon the British forces co-operated with Ward's Chinese troops in attacking them and driving them off. Gordon took part in these operations and so distinguished himself by his skill and bravery that, when Ward was killed in an assault upon a rebel stronghold, his name was put forward by General Stanton as Ward's successor. Permission had to be obtained from the War Office for an English officer to enter the service of the Chinese Emperor. As an exceptional measure, Lord Palmerston's Government gave the necessary authority and in March, 1863, Gordon, who had (30th December, 1862) been promoted Brevet-Major in consideration of his recent distinguished service, took over the command of the Chinese force of 3,000 men known to the Chinese as the " Ever Victorious Army."

The position which Gordon held was of a unique character. As regards the British Army, he was placed on half-pay and was not regarded as being in Her Majesty's service for the time being. The British Government were careful to observe neutrality between the contending forces in China, just as they were observing neutrality in the great struggle that was going on between North and South in the western hemisphere. British troops were, therefore, forbidden to take any action against the rebels, except to keep them out of the thirty-mile radius round Shanghai. Gordon, however, was now in the service of the Chinese, being under the command of the new Governor of the province of Kiang-su, the famous Li Hung Chang. He was therefore free to fight against the rebels in any part of the province and he at once set to work to organize offensive movements against their strategic positions.

The first thing he had to do was to introduce order into his force, which contained a good deal of rough material and was officered by Americans and foreigners who were inclined to resent being placed under a young Englishman. An incipient mutiny was sternly repressed and malcontents who refused to conform to discipline were ruthlessly dismissed. The rest were won over by his frank manner and transparent sincerity, and, when in the opening engagements they saw how he combined meticulous carefulness in preparation with unflinching bravery in action, they became ready to follow him wherever he led them. His first victory over the rebels at Fushan on the banks of the Yangtse Estuary was gained by swiftness of movement and boldness in the handling of his heavy artillery. His next task was to wrest from the enemy the strong walled town of Taitsan, where the Imperialists had already sustained two serious defeats and where the rebels were commanded by one of their most determined chiefs. The artillery preparation was conducted with masterly skill, but when it came to carrying the town by assault, the Taipings put up a desperate defence. Gordon led his men up into the breach which his guns had made in the wall, but the resistance which he met was so fierce that for ten minutes the result was hanging in the balance, till at last an impetuous onrush by a reserve contingent carried Gordon and his " Ever Victorious Army " over into the town. This desperate hand-to-hand struggle on the walls of Taitsan was the first of several encounters in which Gordon led his men to victory. Carrying nothing but a small cane, he would place himself in the front of the line and by his personal coolness and resolution inspire them to heroic efforts. And yet he was careful of his men's lives; for he had a small force, never exceeding 3,000, and the Taipings frequently had 20,000 to 30,000 men against him. Whenever, therefore, he could take a position without direct assault, he did so. His most famous strategical coup was his capture of the strong Taiping position of Quinsan by the bold device of taking his

armed steamer, the *Hyson*, and a small contingent of troops along a canal in the rear of the town and completely cutting the rebels' communications with their main force. The bombardment from the steamer's heavy gun, with which he followed up his movement, produced such a tremendous effect, that he secured the capitulation of the town and its garrison of several thousand men with the loss of only two of his own men. On another occasion he made a bloodless capture of a very important enemy post near Soochow by a deceptive piece of strategy worthy of Garibaldi. Starting off in his steamer in the opposite direction to that where the position lay, he swerved back in the middle of the night, took a circuitous route along a side creek and pounced upon the unsuspecting foe in the early morning when they believed him to be miles away. Movements such as these could only be carried through successfully by the most detailed and careful preparation and we learn from men who served with him that he would spend whole days on end with hardly a break for food or sleep, giving personal supervision to every detail of the complicated transport arrangements that were required for moving his artillery and infantry along the numerous waterways with which the country was intersected.

Gordon never claimed that his force was "ever victorious;" in fact, he himself never made use of the name which the Chinese gave to the force before he took it over. He had three set-backs, one in a night attack on Soochow, when his men were seized with panic; a second time in an assault upon the walled town of Kintang, where, for the first and only time in the whole campaign, he was wounded; and a third time when he had to direct operations while he lay wounded in his boat and his subordinates failed to carry out his orders. But after each of these reverses, he returned to the attack undaunted, and not long after the last, he was back at the head of his troops, healed of his wound, and led them in a desperate charge over the walls of Changchow, one of the most formidable of all the rebel strongholds, defended by one of the most stubborn of all the Taiping commanders. A month later, June, 1864, he disbanded his force, as their work was finished. In fourteen months he had completely cleared the rebels out of the Shanghai district.

All through this campaign the Imperialist forces under Li Hung Chang were co-operating, but it was Gordon's little force that was the spear-point of the attack and without him none of the rebel strongholds would have been taken. It was his impetuous and gallant initiative that crushed the rebellion, and his services were fully appreciated by the Chinese Government, who sought to load him with honours and rewards. But Gordon refused to accept at their hands anything but the title of General and the robes and insignia of a Chinese general's office. He sent back to Peking the munificent monetary present which the Emperor sent him, partly because he

had, in the latter part of the campaign, had a serious quarrel with Li Hung Chang over an act of treachery committed by Li at the fall of Soochow, partly because he would not be a party to imposing any new burden on the hard-pressed Chinese peasant, from whose labour the Emperor's wealth was derived.

The British authorities recognized his services by promoting him to be brevet lieutenant-colonel (February 16th, 1864) at the age of 31, and making him a Companion of the Bath ; and, when he returned to England towards the end of the year, he found that his countrymen had shown their pride in his exploits by giving him the unofficial title of " Chinese Gordon."

Had Gordon written a book about his Chinese campaign, he might have gained notoriety. But he was as modest and retiring in private life as he was commanding and fearless in action, and he not only refused to write the story of his doings but discouraged others from doing so. He shunned society and public gatherings and preferred to live a quiet life in his house at Gravesend, where he was appointed (September 10th, 1863) C.R.E. to superintend the construction of new forts for the Thames defences. That he hankered at times after more active service is shown by the keen disappointment that he felt when it was decided in 1867 to entrust the Abyssinian campaign to an officer on the staff of the Indian Army, Sir Robert Napier. But this only made him plunge all the deeper into the religious and philanthropic life in which he was now becoming absorbed and, when friends urged him later on to try and get transferred to some post which would open up more opportunities to him, he told them he preferred to stay on in his quiet retreat on the Thames, working among the poor lads whom he had gathered round him.

In due course England became involved in another little war—this time with the king of Ashanti on the Gold Coast. He had given trouble some years before and it now became necessary to send an expedition against him. The man selected for command was Gordon's friend of Crimean days, Garnet Wolseley, who had later on been out with him in China and had recently distinguished himself in the Red River Expedition in Canada. In the month that Wolseley set sail from England, September, 1873, Gordon was acting as Commissioner and Vice-Consul on the banks of the Danube, having been transferred there after six years at Gravesend. In that same month he too received a call to Africa but for service, once more, under a foreign power. Egypt's foreign Minister, Nubar Pasha, had met Gordon in the previous year at Constantinople and had formed the opinion that the man who had done so brilliantly in the Far East might achieve great things for his master the Khedive in his newly-acquired territory in the centre of Africa. So when Sir Samuel Baker's tenure of the position of Governor of the Equatorial Province drew to an end, the Khedive Ismail wrote to Gordon

(September, 1873) and offered him the appointment. Gordon was attracted by the chance of opening up these regions to legitimate trade and thus striking a blow at the hideous slave trade, which Livingstone had been denouncing as " the open sore of the world." So he again applied to the War Office for permission to serve under a foreign ruler, and, on receiving permission, set sail in January, 1874, to take up his new task.

For three years (1874-6) Gordon laboured unceasingly in the heart of Africa under conditions which he described as more difficult than those under which he had worked in China. The climate was so deadly that all his white helpers, except the Italian Gessi, either died or were invalided home. The Egyptian officers and soldiers on whom he had to rely for governing the country proved both unreliable and unfitted for the tropical heat, while the Governor of Khartoum, who was expected to support him, thwarted him at every turn. But through every discouragement and difficulty he pressed on with his appointed task and succeeded, by unremitting efforts, in establishing a chain of posts along the banks of the Upper Nile throughout the whole length of his province, till he had opened a line of regular communication right up to Lakes Albert and Victoria. Incidentally he made a detailed survey of a long stretch of the Nile between the two lakes which had never been surveyed before, and opened up friendly relations with M'tesa, king of Uganda.

The Khedive was so impressed by the value of his work that at the end of the three years he appointed him Governor-General of the whole Sudan—an area of a million square miles. For the next three years (1877-9) Gordon ruled this huge territory practically single-handed. His main preoccupation was to combat the slave trade, which had gained such a terrible grip upon the country. While he was governing the Equatorial Province, on the southern fringe of the Sudan, he had been able to stop the traffic in slaves that used to be carried on down the Nile. But to the west of the river there were vast stretches of country where great slave-dealers, like Zebehr, were free to carry on their depredations on the natives. These men he now set himself to subdue, and although Zebehr himself had been enticed away to Cairo and then sent off to serve in the Russo-Turkish War, his young son, Suleiman, was left behind to carry on the traffic. In Gordon's first year of office, this young slaver was stirring up trouble in Darfur, when Gordon, riding across the desert on his celebrated camel at full speed and almost unattended, suddenly appeared in his camp in his gorgeous uniform of Governor-General, and with the stern voice of authority denounced him before his thousands of armed followers for his meditated revolt. Astounded at this sudden appearance, Suleiman gave in his submission and the insurrection was nipped in the bud. But, after Gordon had quitted Darfur for other parts of his huge territory, Suleiman again revolted and attacked one of Gordon's principal stations. This time it was a

fight to the death ; for Suleiman had gathered round him a number of Arab chiefs and was at the head of a formidable force. Gordon sent up an expedition against him under his old friend, Gessi, who, by a brilliant series of victories, drove Suleiman back from the south while Gordon, advancing from the north, dispersed the tribes who had rallied round him. In the end Suleiman was captured and shot and the power of the slave dealers was broken. This crushing blow dealt by Gordon at the slave trade was the greatest achievement of his Governor-Generalship, but his rule was also marked by the complete reform of the system of administration and the ruthless dismissal of officials who were found guilty of corruption or of connivance at the slave trade. Throughout he had the complete backing of the Khedive Ismail, who recognized that in Gordon he had a man on whose zeal and sincerity he could absolutely rely, and had the wisdom to give him almost unlimited power over the great district which he had entrusted to his rule.

When Ismail was deposed, Gordon, who was almost worn out by six years of strenuous and unbroken effort, made up his mind to resign, and by the beginning of 1880 he was back in England. After a few months' rest he was persuaded by his friends to take the post of private secretary to the new Viceroy of India, the Marquis of Ripon, but the work proved unsuited to him and he resigned soon after his arrival in India.

Just after he had resigned he received an urgent request from Li Hung Chang to go to China and advise the Chinese Government in their dispute with Russia. He hurried off at once to Peking and by the wise counsels which he gave helped to avert a war between the two countries. After his return home he volunteered to take the place of a brother officer in Mauritius. In this distant island he had another spell of obscure routine duty which he appreciated after his years of unceasing activity. On March 22nd, 1882, he was promoted Major-General and shortly after left for South Africa in response to a request from the Cape Government to assist them in settling the Basuto question. He did his best to secure a settlement on just lines, but the Cape Government, instead of backing him up, placed him in a most awkward position by sending an armed force against a chief with whom Gordon was negotiating. After this display of double-dealing Gordon refused to work further for the Cape authorities. Having obtained a year's leave, he spent the whole of 1883 in Palestine, where he had been for some time anxious to study Biblical topography on the spot.

It was towards the end of his stay in Palestine that the Mahdi, who had first raised the standard of revolt against Egypt in 1881, startled the world by his annihilation of Hicks' Army of 10,000 Egyptians at a spot about two hundred and fifty miles from Khartoum. It was nearly four years since Gordon had left the Sudan, and, although the condition of the country had for long caused him great

searchings of heart, he had made no attempt to influence British policy in Egypt. So little did he contemplate being called upon to take any part in Egyptian or Sudan matters that, shortly before the disaster to Hicks' force, he had entered into an agreement with Leopold, King of the Belgians, to go out to the Congo and become Governor of the Upper Congo region.

On receipt of the startling news of the Mahdi's victory, it occurred to Earl Granville, the Foreign Minister, that Gordon might be able to help the Government in the emergency, but Sir Evelyn Baring, the British Minister in Cairo, was not favourable to the idea and Gordon was not approached in the matter. On New Year's Day, 1884, he arrived from Palestine at Brussels and concluded the arrangements for entering King Leopold's service. As soon as he reached England, however, public opinion began to clamour for his being asked by the British Government to help in the Sudan crisis instead of being allowed once more to give his services to a foreign power. As the situation grew day by day more menacing, Baring withdrew his objection and Gordon was therefore commissioned by the Government to proceed to the Sudan as their envoy for the purpose of withdrawing the Egyptian garrisons in the Sudan, whose safety was menaced by the Mahdi's advance.

There have been several misunderstandings about Gordon's last mission to Khartoum, but now that the private Government papers have been thrown open to the public, it has become clear that, although there was an unfortunate confusion in the words of the instructions which the Ministers gave him in London, both Lord Granville and Sir Evelyn Baring realized that he was sent out, not merely to advise and report, as some Ministers thought, but to superintend the actual process of withdrawing the garrisons.

It may seem strange to us that Ministers in responsible positions should have contemplated the dispatch of a single individual into the heart of a country that was being over-run by hordes of fanatical dervishes and expect him to bring away in safety the 24,000 Egyptian troops that were stationed there. But it must be remembered that at that time the tribes round Khartoum had not joined the Mahdi and that Gordon had established such a personal ascendancy over these tribes that there was a good chance that, when he went among them, he would be able to induce them to remain quiet and allow the Egyptians to withdraw peaceably across their territory. Gordon himself was confident that he could succeed in the attempt and it is quite likely that, if he had been allowed, when he got to Cairo, to take with him, as he wished, the powerful ex-slaver, Zebehr, the influence of the two together would have been sufficient to keep the tribes loyal to Egypt and hold the Mahdi at bay while the evacuation was proceeding. But the prejudice in England against Zebehr was so strong that the Government refused to allow him to join Gordon.

The tragic story of the siege and fall of Khartoum is too well known to require to be told again in these pages. It should, however, be mentioned that the ordinary versions that have been given of Gordon's attitude towards the Ministers have been proved, in the light of the latest documents, to be entirely unfounded. So far from ignoring his instructions to carry out the withdrawal of the Egyptian garrisons, he set himself at once, on his arrival at Khartoum, to organize the process of evacuation. He began sending down a number of Egyptians and tried his best to arrange terms with the Mahdi, so as to secure the peaceful departure of the whole garrison. But the Mahdi contemptuously rejected his overtures; and so Gordon, within three weeks of his arrival at Khartoum, found himself encircled by the dervish forces, who opened fire upon him before he had fired a single shot. For 320 days—from March 12th, 1884, to January 26th, 1885—Gordon held the town against the dervish hordes. All the devices that his skill and experience could suggest were utilized to strengthen the town's defences, while his flotilla of little steamers, protected with mantelets and armed with heavy guns, were used to attack the enemy's posts and to obtain food from the surrounding district. During the summer months, when the Nile was high, he was even able to inflict some telling defeats on the Mahdists, but after an unfortunate disaster to his men in September, he saw that his days were numbered unless help came from the outside. He sent Colonel Stewart down the Nile to break through the lines and take news to the outer world; but Stewart was wrecked and slain. Then the Nile began to fall and the Mahdi brought up the whole of his forces in order to make his grip on the town still tighter.

By this time the Relief Expedition which the Government, after protracted hesitation, at length decided to send, had started from Cairo under the command of Wolseley, and news of it reached Gordon. His food supplies, however, were now becoming exhausted. The Mahdi repeatedly called upon him to surrender; but each time Gordon sent back an indignant refusal. His men loyally stood by him; but, as time went on they grew so weak from starvation that they could hardly hold arms or stand at their places on the ramparts. At last, in the early hours of January 26th, 1885, two days before the advance column of the English came in sight, the dervishes made their way through the defences, at a spot where the falling Nile had left a gap in the fortifications, and overpowered the famished troops who were trying to hold the line. Gordon met his fate on the steps of his palace, and with his death the town which he had so nearly saved passed into the hands of the Mahdi.

Nearly fourteen years were to elapse before the Khalifa, the Mahdi's successor, was overpowered by Kitchener's Anglo-Egyptian force and a British Governor-General was again installed in the palace of Khartoum.

DEMOLITIONS, FIFTH ARMY, 1918.

By MAJOR-GENERAL SIR REGINALD U. H. BUCKLAND, K.C.M.G., C.B.,
Colonel Commandant R.E.

"Meanwhile a generation springs up that undergoes intensive training for battle, and yet is unable to visualize the circumstances in which that training will be put to the acid test."

—"The Golden Moment," by Rear-Admiral W. M. James, C.B.
(*R.U.S.I. Journal*, May, 1932.)

FOREWORD.

By MAJOR I. S. O. PLAYFAIR, D.S.O., M.C., R.E.

THIS detailed and authentic story of the part played by demolitions during the retreat of the Fifth Army in March, 1918, is particularly welcome because there has been so much loose generalizing about their success. In the first place it should be noted that there was no attempt at wholesale devastation; the demolition schemes provided for bridges only. It is true that a large amount of machinery was put out of action before it was abandoned, and that numerous stores and dumps were set on fire, but these arrangements seem to have been mostly improvised at short notice. They were, on the whole, very successful. I personally believe that our practice of not making thorough preparations for a withdrawal is based on wrong psychology. Wise precautions to meet eventualities inspire confidence; feverish last-minute improvisations destroy it. In the case of other nations it may be otherwise.

THE WATERWAYS.

There is as yet no official history of the events of March, 1918, but there are various published accounts of the fighting, and much value is to be obtained from reading them in conjunction with Gen. Buckland's narrative. Before embarking on a detailed study it is advisable to have a clear mental picture of the run of the waterways.

The rivers Oise, Germaine, Omignon and Cologne flow roughly at right-angles to the original battle-front. Consequently their influence was rather to restrict lateral movement in and behind the German divisions than to oppose their advance directly. Moreover, with the exception of the Oise, these were only streams of the order of 20 to 30 feet wide.

The first real barrier was the line of the Crozat and Somme Canals. The former runs from the Oise at Tergnier *via* St. Simon to St. Quentin. (The stretch between the two last-named places was actually a German inter-Corps boundary.) The Somme itself is canalized from St. Simon *via* Péronne to Amiens. Excellent photographs and descriptions of the Somme Valley are to be found in *The Story of the Fourth Army*, by Gen. Montgomery. Sir Douglas Haig's dispatch of July, 1918, refers to the state of the waterways in these words :—" The rapid drying of the marshes, due to an exceptionally dry spring, enabled the enemy to attack this lightly-held front (*i.e.*, the extreme right) with three fresh divisions." And again, " Attempts by the enemy to cross the Somme were by no means confined to the recognized points of passage. Owing to the dry weather the river and marshes did not constitute a very formidable obstacle to infantry." Gen. Gough, in his book, *The Fifth Army*, says, " The Somme, never a large river above Péronne, was very low ; about four feet of water in most places."

The St. Quentin Canal is a continuation of the Crozat Canal northwards from St. Quentin. On the front of the Fifth Army it lay on the average two miles behind the German line. The construction of new crossings over this canal was referred to on February 1st by Gen. Gough in a letter to G.H.Q. giving his reasons for considering that an attack on his front was imminent.

The distance from the German front line to the " barrier " line of the Crozat-Somme Canal varied from only three miles at Tergnier to a maximum of 14 opposite Pargny. From Epéhy to Péronne is 11 miles.

The Canal du Nord from Noyon northwards " regarded as an obstacle was of little value, being unfinished and only flooded to the extent of about one foot deep of water." (Gough.)

It is, therefore, evident that the blue lines on the map did not represent much in the way of obstacles in actual fact. Moreover, as Gen. Gough points out, " the line of the Somme, as far as it was an obstacle to an advance from the east, was only a small proportion of the whole extent of the vast battlefield. . . . If the line fell back on both sides of this comparatively small frontage of the Somme (as it actually did) it would be almost impossible to hold on. . . ."

I give these quotations in order to try to get the importance of the destruction of the Somme crossings into proper perspective. Too many people have assumed that the entire fate of the battle hung on them.

THE RAILWAY BRIDGES.

After reading Gen. Buckland's narrative our sympathy goes out to R.C.E.4. It was not until March 5th that he was told that the responsibility for all railway bridges was his. To make things

worse the *light railway* bridges were added as a kind of afterthought on March 10th, although they had hitherto been no concern of his whatever. On the same day Gen. Gough wrote to G.H.Q. saying that his engineers were in close touch with O.C. the French Railway Troops operating the Chemin de Fer du Nord. "All that requires to be done is to ensure that the commander of these railway troops should receive orders from his superiors to act in accordance with the attached instructions; I should be glad if you could arrange for this to be done, and if the matter could be treated as urgent." Gen. Gough adds: "It does not seem that G.H.Q. took up this matter sufficiently seriously, for when the time came the French failed to blow them up, but the Fifth Army during its retreat destroyed over 250 bridges for which it was responsible."

According to the *Encyclopædia Britannica*, "Worse still was the confusion caused by the fact that in the case of the more important railway bridges this duty (*i.e.*, destruction) was entrusted to the railway authorities instead of to the local commanders." My own view is that it would be fairer to say that the confusion (if any) was largely due to swopping horses in mid-stream. Either R.C.E.4 should have been made responsible *in good time*, and all his requirements met, or Corps should have retained the responsibility; *one or the other*. Also, in my opinion, the British should have retained the responsibility of dealing with all bridges in their fighting area. The French are admittedly a great military people, but their ways do not happen to be our ways. Many a British general has arranged what he thought was a perfectly definite course of active co-operation, only to find when the crisis came that *ce n'était qu'un projet!* However, it takes two to arrive at a misunderstanding.

There is no mention of withdrawals or demolitions in the *Manual of Movement*, 1923, but *M.E. Vol. VIII* lays down that "the demolition of all railways controlled and operated by the railway service should be carried out by that service" (sec. 17, 9). Presumably this includes bridges. But what about road-over-railways bridges? The field engineers may destroy the road bridge and so block the railway below. And what about a level-crossing, which is just as much part of the road as of the railway? I put these questions to a very senior officer, who replied with a knowing look, "In schemes, hands off Transportation! In war, blow everything up yourself." Comment by me would be an impertinence.

Partial Demolitions.

History contains many examples of the futility of "partial" or "half-hearted" demolitions. It contains remarkably few (that I have succeeded in finding) of a bridge having been sufficiently damaged to be a nuisance to the pursuing enemy, and yet not so

seriously damaged as to be a nuisance to the other side when they turn round and advance again. It is a case of trying to have it both ways! The French regulations trounce this attitude unmercifully. "Ne détruire qu'imparfaitement une organisation quelconque au moment d'une retraite pour la raison qu'elle pourra être ultérieurement utilisée par nous en cas de reprise de terrain perdu, c'est s'exposer à voir l'ennemi tirer immédiatement parti des facilités qu'on lui a laissées, puis exécuter en se repliant les destructions que nous n'avons pas osé faire."

This was not the attitude on the Somme, for we read that it had been decided to avoid damaging the abutments of the bridges, so that, if a stand be made on the Somme, they could be more easily repaired for an advance. But supposing a stand could not be made on the Somme, there being no men to make it, and supposing there was no prospect whatever of our wanting to advance across it? One wonders what was the wording of the guidance from "G" upon which the engineers acted.

DEMOLITIONS AS OBSTACLES.

The point here is that streams and small canals within easy reach of the enemy's bridging equipment cease to have any appreciable value as obstacles unless they can be kept under fire. A really serious natural feature, such as the Meuse at Liège, is in a different category, for the rebuilding of the railway bridge there would be a major engineering operation. "It is idle to speculate on the course of events had this railway bridge been blown up. As it was, only by tremendous efforts could this line supply the two German armies during their first rush across Belgium, and even so, the German genius for organization was unable fully to maintain the momentum of the initial advance. Without it, they could only have used relatively small forces during the first all-important days; the whole German plan would have been upset; a German penetration to the Belgian coast in November, 1914, would have been prevented, and the duration of the war materially shortened." (Capt., now Major, G. E. Grimsdale, R.E., in "Strategic Demolitions," *R.U.S.I. Journal*, 1928.)

But the Crozat and Somme Canals are very different from the 1,000-ft. wide Meuse. We have seen how near they lay to the front line. It has even been suggested in a French study of the battle that the enemy intended to reach the line of these canals on the first day. (I doubt this, as does Mr. Shaw Sparrow, in whose book, *The Fifth Army in March*, 1918, the French quotation appears.) But in any case we may be quite certain that, as far as was Teutonically possible, everything was ready for crossing *all* the waterways. And at the head of the Eighteenth German Army was no trench-to-

trench nibbler that had spent the war drawing coloured lines on large-scale maps, but the freshly-imported, vigorous and highly successful whirlwind of Riga, General Oskar von Hutier. The Crozat Canal was not a second Dvina.

Several of the Engineer officers on the spot were under no delusions as to the feebleness of the obstacle likely to be produced. See page 27, noting particularly the insistence of C.R.E. XVIII Corps Troops on the need for small-arm fire at the site. The experience of the 3rd Foot Guards shows that he was right. They were unable to cross Pithon railway bridge *owing to its being swept by machine-gun fire.* The following extract from a captured order of August, 1918, shows that the 119th Infantry Division knew something about the defence of river lines!

> "The defence must be organized in such a manner as to ensure by means of infantry and m.g. fire the prevention of a crossing of the Somme valley by the enemy. Attempts to effect a crossing are to be expected. By skilful patrolling it should be possible to annihilate any hostile detachments which may attempt to reconnoitre the conditions of the river valley with a view to effecting a crossing. The troops must not allow themselves to be lulled into a sense of security by the fact that the Somme forms an obstacle to the possibilities of an enemy advance. A determined enemy will carry out an attack at this point simply for the reason that it is least expected. The enemy must be prevented from gaining a foothold on the eastern bank of the Somme at all costs. Demolition detachments must be sent out each night until the bridges have been thoroughly destroyed and the remaining portions removed. Portions which cannot be reached must be destroyed by medium minenwerfer fire."—(From *The Story of the Fourth Army.*)

Last-Minute Blows.

A great strain is taken off the engineers if the responsible Commander can see fit to authorize early destruction of any bridges that are no longer required. This will entail careful planning and perhaps a certain amount of persuasion, because the conduct of the retreat tends to be hampered by any reduction in the number of available crossing-places. But it will result in the number of "last-minute" demolitions being reduced to a minimum. This will ease the exploder situation and will increase the possibility of stationing an officer at every "last-minute" site. There was an instance of the early demolition of non-essential bridges at Offoy, but in many cases it seems that the R.E. subalterns had far too many bridges to attend to. A man can only be at one place at a time.

Every bridge blown early is a bird in the hand. The danger of

demolitions in the presence of the enemy is that there may be no time to repair a damaged charge or circuit. In the words of the official dispatch, " However, owing to the effects of the enemy's artillery fire, which blew up some of the charges and cut the leads of others, the destruction of the bridges was in certain cases incomplete. . . . Instances of great bravery occurred. . . . Many of the bridges were destroyed in the close presence of the enemy. . . ."

I.S.O.P.

I. General Remarks.

THE story of the demolitions carried out by the Fifth Army in March, 1918, covers such a large area, and includes the work of so many Corps, that it is impossible to find space in the *Journal* for many of the interesting details that my numerous correspondents have sent in. For the same reason, only the barest outline of the fighting can be included, and the difficulties under which the work was accomplished cannot be presented as fully as might be wished.

Unfortunately the records contain very few technical details. Plans and projects appear to have been kept in all offices from that of the unit concerned up to that of the Chief Engineer of the Army, but they must have been destroyed when the retreat began.

The circumstances in which demolitions were carried out in 1914 and 1918 were noticeably different.

In 1914, the retreat began unexpectedly as the result of a single day's fighting at Mons. Except at Le Cateau, it was characterized by an avoidance of desperate fighting. The four Divisions at Mons (later five Divisions) had only two Field Companies each ; the Corps had no R.E. units. The supply of explosives—except at Compiègne —was limited to what could be carried in the company transport. Important rivers were crossed : permanent bridges of solid construction were dealt with. Paper work was confined to rapid reconnaissance sketches and orders.

In 1918, retirement to the battle zone was contemplated from the outset, and demolition schemes were prepared accordingly.

Bridges were reconnoitred and numbered, lists made and forwarded for the information of higher authorities, with copies of plans and reports of the arrangements made to carry out the work. Files of correspondence accumulated.

The bridges in the area were almost all of our own construction : stock pattern steel girders up to 80 ft., R.S.J. spans of 20 ft. and

timber " military bridges " of all patterns and sizes. Others were French bridges built since the German retreat of 1917. Few were more than a few feet above the level of the water. The destruction of dumps, workshops, machinery, O.P's and pumping stations was an entirely new feature. Railways had not been destroyed by the B.E.F. in 1914. The supply of explosives appears to have been adequate, but when fighting had begun it was at times difficult to obtain transport to carry them to the place where they were required.

When the partly-prepared defences of the rear zone had been abandoned, an extensive rearguard action was fought over a depth of 26 miles* under continuous pressure from the enemy, with whom contact was never lost. The history of the daily battles is a continuous story of troops, full of fighting spirit, being obliged to give up advantageous positions, of which it was important to keep possession, on account of their flanks having been turned. This was the result of the Fifth Army being too weak to hold the front it was asked to cover. The enemy, at great loss of life, pressed on, found and penetrated the weakest points, and skilfully exploited his local successes. On the 21st of March, a thick fog deprived the defence of the assistance of their guns and machine-guns. Owing to the low level of the water the rivers proved inefficient obstacles ; the canals were narrow and could be easily bridged by the enemy. In consideration of the urgency of other work, no attempt was made to crater the roads or the causeways on the Somme. The R.E. units were largely employed as infantry to fill gaps in the fighting line.

Between 1914 and 1918 very little demolition work had to be done by the British Army, but the German retreat of 1917 had afforded a great opportunity of studying both the organization and the execution of demolitions on a large scale.

II. Disposition of the Troops.

On the 13th December, 1917, General Sir Hubert Gough, with the H.Q. Staff of the Fifth Army, took over from the Third Army the southern portion of their front down to the Omignon, held by the VII. and Cavalry Corps. In accordance with orders from above this front was gradually extended southwards : the XVIII. Corps took over from the French on the 14th January 12 miles of line south of the Omignon, and the III. Corps another 18 miles on 30th January. On the 9th March, the XIX. Corps replaced the Cavalry Corps, whose H.Q. moved to Villers Carbonnel, where they administered the various units employed under A.H.Q. on the rear zone defences.

On the 21st March, the front of the Fifth Army extended from

* The distance from Caulaincourt in the rear zone to Villers Bretonneux was miles.

Barisis, on the right, to north of Gouzeaucourt, a distance of about 41 miles.

The disposition of the troops on that date, from right to left, was as follows :—

III. Corps. 58th, 18th, 14th Divns. with the 2nd Cav. Div. in reserve south of Guiscard.
XVIII. Corps. 36th, 30th, 61st Divns.
XIX. Corps. 24th, 66th Divns. with the 1st Cav. Divn. in reserve at Péronne.
VII. Corps. 16th, 21st, 9th Divns.

Each division held a portion of the front and was distributed in depth.

Army Reserve. 39th Divn. at Allaines and Nurlu, Cav. Corps H.Q. at Villers Carbonnel, 3rd Cav. Divn. at St. Christ.
G.H.Q. Reserve. 50th Divn. at Cayeux and Rosières, 20th Divn. at Ercheu.

The 6th French Army (General Duchêne) held the line on the right, and General Humbert, commanding the 3rd French Army, lay to the right rear of the Fifth Army. At the moment he had no troops under his orders, but later he assumed the command of the French divisions which came up into the III. and XVIII. Corps' areas, and by the 25th March had at his disposal General Pellé's 5th Corps and General Robillot's 2nd Cavalry Corps. Eventually, the 1st French Army (General Debeney) came in on the right of the Fifth Army.

On the left was the Third Army under the command of General Sir Julian Byng.

III. SCHEME OF DEFENCE.

The defence scheme was based on selected positions constituting the Front Line, the Battle Zone, and the Rear Zone. Defence works were pushed on as labour became available, and many additional bridges were built to improve communications, causing constant additions to the schemes for demolitions. Even when it was learnt that General von Hutier had assumed command of the German 18th Army opposite a portion of the Fifth Army front, and an attack on a vast scale was felt to be imminent, there seems to have been no apprehension that the battle zone and rear zone might be overrun before reinforcements from outside the army would arrive. Consequently, we find complete schemes of demolitions prepared back to the line of the Somme and the Tortille, but behind these rivers little work of that nature was done before the fighting began.

IV. Period Prior to the 21st March.

(*a*) Action taken at A.H.Q.

As early as the 21st December, G.H.Q. called on all armies for proposals as regards the demolition of any bridges, including railway bridges, between the front line and the rear limit of the battle zone. The proposals were to be accompanied by dimensioned sketches showing span, nature of bridge, etc. Possible and likely deviations were to be described, with a view to the provision of stores for reparation during a subsequent advance.

On receipt of this at A.H.Q., the C.E. wrote to G., "If you will specify which bridges are selected for demolition, I will call on C.E.'s for projects for such demolitions, dimensioned sketches, etc." Corps* evidently had the matter in hand as on the 2nd January the 21st Division reported to Corps H.Q. that certain bridges were ready.

The following is not without interest. On the 14th January A.H.Q. directed the VII. Corps to make detailed plans for the demolition at short notice of two railway bridges north-east of Pezière.† On the 17th VII. Corps told the 21st Div. to take the necessary action, sending a copy of their letter to the C.E. The latter minuted it back on the 18th, "Detailed plans are in my office and also with the C.R.E. 21st Div. All arrangements made. A copy of plans with all details was sent to the C.E. Fifth Army on 5th." On being told this A.H.Q. wrote to VII. Corps on the 21st January; "It is noted that a detailed technical project for the destruction of the bridges in X.25 has been forwarded to Fifth Army. It is also desired to know, however, whether instructions have been issued to a definite unit to carry out the demolition referred to, on receipt of orders from you. If so please send a copy to H.Q." Finally, VII. Corps to Fifth Army 21.3.18, "The 21st Div. are responsible for the demolition of these bridges. Herewith copy of instructions sent to them and copy of letter giving details of arrangements made."

On the 10th February, A.H.Q. directed Corps‡ to prepare for demolition all important road, railway and canal bridges, in addition to those already in hand, as follows :—

III. and XVIII. Corps. (*a*) Canal de l'Oise à l'Aisne. River Oise and Canal de St. Quentin.§ Crozat Canal. Tergnier, Jussy, Ollezy, and the canal up to Seraucout (inclusive).

* Cavalry and VII. Corps.

† In the correspondence these bridges were referred to by their map references, X.25, etc.

‡ The XIX. Corps had not yet arrived to take the place of the Cavalry Corps.

§ The northern branch of the Crozat canal must have been meant. The name "St. Quentin canal" applies to the same waterway, but only north of St. Quentin.

Cav., VII., XVIII. Corps.	(*b*) Line of the Somme river from Ham to Cléry inclusive.
XVIII. Corps.	(*c*) Line of the Germaine river.
	(*d*) Line of the Omignon river.
	(*e*) Line of the Tortille river.

(For the action taken by Corps see below.)

On the 15th February, G.H.Q. directed the Fifth Army to arrange to have all possible preliminary measures taken so that charges could be rapidly inserted in, or attached to, any bridges situated between the present front line and the rear limit of the battle zone, which it was proposed to prepare for demolition. To avoid any chance of the expression " preliminary measures " being misunderstood, the letter went on to say : " The preliminary measures may include making demolition chambers and affixing attachments for charges, and firing leads, and fuze ; storing explosives in convenient proximity to bridges ; detailing definite officers and parties ; issuing instructions to these officers ; preparing cover for the officers who are going to fire the charges."

On the 5th March, Fifth Army issued orders to its Corps and to the R.C.E.4* to the effect that railway bridges were to be prepared for demolition, and if necessary demolished, under the orders of R.C.E.4† who would make the necessary arrangements with the French railway troops as regards bridges on lines operated by them. No bridges in rear of the battle zone were to be demolished without the orders from A.H.Q., except in such cases of emergency that it would not be possible to obtain previous sanction from A.H.Q. Bridges situated between the front line and the rear of the battle zone were to be destroyed on the initiative of Corps concerned, but R.C.E.4 would be responsible for carrying out the demolition of railway bridges, and he was to indicate to Corps the name of his officer to whom the order to destroy should in each case be sent, and the spot at which such order would be awaited. A.H.Q. would issue orders for the destruction of railway bridges in rear of the battle zone. Corps and R.C.E.4 were to report by the 15th March whether the charges had been made up, and on all the points mentioned in G.H.Q. letter of the 15th February (see above), and, further, that frequent inspections and rehearsals had been held.

* At Fifth Army H.Q. the D.G.T. was represented by the A.D.G.T. (V.) ; his Chief Railway Construction Engineer by R.C.E.4 ; and his director of Light Railways by the A.D.L.R. (V.). Lieut.-Col. E. P. Anderson was R.C.E.4. He was responsible for the construction and maintenance of the standard-gauge railway lines from Chaulnes Junction through Péronne to Epéhy, and through Harbonnières, La Flaque, Bray and Plateau Stn. to Epéhy, the remainder of the permanent railway system south, east and west of Chaulnes being under French control. His work farther north does not concern this narrative. He had nothing to do with the 60-cm. railways, which were constructed and operated by No. 6 Foreways Coy. under the orders of A.D.L.R. (V.). (Transportation always used Roman numerals.)

† The order up to this point was wired to Corps on the previous day.

R.C.E.4's appearance on the scene as a destroyer of bridges when Corps had the preparations well in hand, seems to have arisen from the following letter addressed by A.D.G.T.(V.) to G. at A.H.Q., on the 16th February :—*

" Reference your No. S.G. 907/16 correspondence, as regards railway bridges I think the arrangements for their destruction should be put in the hands of R.C.E. (IV.) as regards bridges on lines operated by British personnel, *i.e.*, on lines Chaulnes–Péronne and forward, and Etricourt line.

" I think detailed orders should be issued stating that an authority —say the Army—informs R.C.E. (IV.) and repeat to A.D.G.T. (V.) proposing to destroy a bridge or bridges. On that R.C.E. (IV.) would detail a party who would place the explosives, etc., the officer in command of that party remaining at the bridge ready to act.

" The actual destruction of the bridge should if possible not take place till this office has been consulted, as there may be valuable traffic to be worked back. This office could then give an hour at which the bridge could be destroyed without sacrificing any rolling stock.

" If the bridge has to be destroyed at once in spite of rolling stock being on the wrong side, I would propose that the orders for the actual destruction should come from the Army direct to R.C.E. (IV.).

" As regards the lines worked by French personnel, viz., Chaulnes-Ham-Froissy-Flavy and Noyon-Chauny lines,† I think instructions should be asked for from G.H.Q."

The correspondence quoted refers to railway bridges at Pezière, within half a mile of the front line. It is hard to see how the leisurely procedure suggested could have applied to them, and, in any case, it seems to have been unnecessary interference with the fighting business of the Corps, of which in a retreat the demolition of bridges is an important item.

On the 10th March, A.H.Q. issued an order that light railway bridges were to be included under the term railway bridges.

The order of the 5th March appears to have placed on R.C.E.4 an amount of work far beyond what he could carry out with the personnel at his disposal. That light railway bridges should have been added to his responsibilities is very hard to understand, as he could have had no real knowledge of the system which had ramifications all over the army front. His officers had never been in close touch with the staffs of corps and divisions, and, though some of them, and some of his men, may have had a modicum of training in explosives at

* Early in February Lt.-Col. Anderson had found non-railway sappers preparing the abutments of a railway bridge near Péronne for demolition. These men were working foul of the track without even a flagman to protect them. He reported the matter, and this incident may have given rise to the letter which follows.

† This is not very clear. Lt.-Col. Anderson is of opinion that the lines intended were : (1) Chaulnes-Ham-Flavy le Martel, (2) the metre-gauge line Rosières-Harnnières-Froissy-Bray (not marked on the map), and (3) Noyon-Chauny.

Longmoor on enlistment, they had had no practical experience of demolitions in France. That some of his bridges had to be destroyed by Corps is not surprising. On the 19th March, he asked Fifth Army for 1 officer and 15 O.R. for the XVIII. Corps area, and 2 officers and 20 O.R. for the III. Corps area, all to be skilled in the use of explosives, but he never got them.

(*b*) ACTION TAKEN BY CORPS.

III. Corps.

In their revised Defence Scheme of the 10th March, the III. Corps arranged that the demolition of bridges, "if and when necessary," was to be undertaken as follows:—

By the Division holding the right sector of the line (58th): the bridges from Chauny to Quessy (both inclusive), excepting four light railway bridges at Chauny, but including a pontoon bridge at Manicamp (14 road and several footbridges). Those in Quessy were over 70 ft. in length, the remainder about 20 ft.

By the Division holding the centre sector (18th): the six road bridges at Liez and Menessis, all footbridges, and the road-over-rail bridge west of Menessis, the line not being in use. These were mostly trestle bridges of 20 ft., in two spans.

By the Division holding the left sector (14th): the bridges from Menessis (exclusive) to one mile west of Jussy (seven road bridges), and all footbridges, but excluding two railway bridges (82 ft. 6 in. span) over the canal west of Jussy, another at the junction east of Jussy, and two road-over-rail bridges near Montescourt. These five were to be destroyed by the French.

It is to be noted that the A.H.Q. order that the responsibility for the destruction of bridges might be delegated to divisions was not issued until late on the 22nd March.

On the stretch of canal between Liez and Menessis there was a group of three bridges, each 19 ft. 6 in. in length, close together, two for road traffic and one for light railway. As matters stood Corps would have had to send their order to destroy the light railway bridge to R.C.E.4's representative, and to the 18th Div. as regards the other two, and it was quite possible that one message would get through before the other.

On the 18th of March the Corps pointed out to A.H.Q. that it was "essential that one authority should be responsible for the demolition of these bridges." What they really wanted was that R.C.E.4 should be eliminated, so that a single unit might be detailed by the 18th Div. to prepare all three bridges and fire the charges. Even then it would be a ticklish job to get them to go up together, as probably it would have been necessary to use more than one exploder. In the event all three were demolished, so presumably R.C.E.4 was relieved of his responsibility, but the reply from A.H.Q. is not recorded.

In the back area the C.E. was to arrange for the demolition of the following bridges :—

Bac d'Arblincourt (9), Manicamp (10), Quierzy (5), Apilly–Bretigny road (5), Varesnes (6), at Pontoise over the canal (2), over the Oise (2) (the suspension bridge, 261 ft. in length, duplicated by a trestle bridge of 195 ft.), a total of 39 bridges.

R.C.E. 4 was responsible (by army instructions) for the demolition of all broad-gauge and 60-cm. railway bridges, the work to be done by the French on lines operated by them.

No bridges in rear of the battle zone were to be destroyed without orders from Corps H.Q. (who would have had to refer to A.H.Q. had time allowed), except in such cases of emergency that previous sanction could not be obtained.

Upon the receipt of the order, "Man Battle Stations," or the preliminary wire, "Prepare for Attack," Divisions and the C.E. were to order demolition parties to take station, and make final preparations short of actually placing detonators in the charges.

Corps H.Q. were to issue orders for the demolition of any bridge in the battle zone by quoting its number in word form (*i.e.*, Bridge No. Ten). An immediate report was to be sent to Corps H.Q. when any bridge had been demolished.

On the 12th March the 135th A.T. Coy. started to prepare the bridges at Chauny, and all were ready by the 15th. They also took over from the 504th Field Coy. (58th Div.) four 60-cm. bridges at that place.

Explosives for use on the back area bridges were sent to the 2nd Field Squadron on the 20th, and Major Swinburne, commanding it, reported three bridges in Manicamp and one in Quierzy ready, except for placing charges which were on the spot.

XVIII. Corps.

In the XVIII. Corps the responsibility for preparing bridges for demolition was as follows :—

(*a*) South Sector (from St. Simon, inclusive up to the front line, *i.e.*, the bridges on the northern branch of the Crozat Canal and the River Somme beside it), 36th Div.

(*b*) Ollezy Sector (St. Simon to Ham, both exclusive), 172nd T. Coy.

(*c*) Ham Sector (including all bridges in Ham), 1st Siege Coy., R.A.R.E.

Responsibility for the destruction of bridges was not delegated to Divisions until the 22nd March.

For the railway bridge at Pithon, R.C.E.4 was to make arrangements with the French.

The instructions given by the C.R.E. Corps Troops to the 1st Siege Coy. were to the effect that no demolition party was to hand over its duty of demolishing a bridge to any other unit; that the order for demolishing each bridge was to be asked for from the officer commanding the troops on the spot; and that, in the event of a disorganized retreat, the bridge was to be demolished immediately after the last British officer had crossed.

Cavalry Corps, later XIX. Corps.

The C.E. XIX. Corps, after the 9th March, appears to have taken on the responsibility for the preparation of all the bridges, but much had been done by the Cavalry Corps and their attached R.E. units before that date.

On the 1st March, Lieut. Macdonald, 281st A.T. Coy., took over from the 3rd Field Squadron the bridges on the Cologne at Flamicourt and La Chapellette,* and, from this or another Field Squadron, those at Doingt (3), Cartigny (2) and Buire (2), and with Lieut. Mackenzie he completed the preparations by the 20th. On the 2nd, the O.C. of the Company, Capt. Kentish, handed over to the 258th T. Coy. the drawings and material for the two railway bridges at Roisel and for a light railway bridge over a road at Bernes, and the O.C. 258th T. Coy. was told that, in addition to these bridges, he was, in the event of a hostile advance, to destroy all bridges on the Omignon between Vermand and Monchy Lagache (6).

On the 2nd March, the 288th A.T. Coy. took over the bridges on the Omignon at Monchy Lagache (2), Devise (2), Fourques (2) and Athies (2) from the 2nd Field Squadron, who had begun fixing brackets for the charges. The Company was fully employed on rear defences, so on the 12th the O.C. saw the C.E. XIX. Corps and got permission to postpone the demolition work until the return from leave of Lieut. Robinson on the 18th.†

VII. Corps.

On the 23rd February, the C.E. proposed to G. with reference to A.H.Q. letter of the 10th, that bridges should be prepared as follows:

(*a*) Cologne Valley. Roisel‡ (2), Tincourt (4), 180th T. Coy.

(*b*) Somme Valley. Péronne (5), 180th T. Coy. Halle (1), S.W. of Cléry, lock gates and road bridge, 178th T. Coy.

(*c*) Feuillaucourt, over the Tortille (1), Allaines–Haut Allaines road (1), Moislains (2), 178th T. Coy.

*The six railway bridges at Flamicourt and at La Chapellette were later prepared by the O.C. 260th Railway Construction Coy., who says nothing of any previous work done on them. In the numbers given here and elsewhere twin bridges for two-way traffic are counted as two.

† In March, 1918, an A.T. Coy. had only two subalterns, so that it was difficult to take on, in the absence of one of them, additional work requiring the constant presence of an officer. The establishment was increased to 3 subalterns very shortly afterwards.

‡ Apparently some overlap with XIX. Corps.

He pointed out that the tunnelling companies were the most suitable units to undertake the work, as they were less likely to be moved than other R.E. units.

The above list does not include all the bridges at the places named, as several others were subsequently blown up. On the other hand, some railway bridges are included which were later handed over to R.C.E.4.

The preparatory work which he had ordered to be undertaken consisted of: (*a*) sinking shafts and making chambers behind abutments, (*b*) filling sandbags to admit of rapid tamping when the mines were charged, (*c*) storage of explosive close to the site, (*d*) detailing officers and parties for firing the charges.

R.C.E.4.

R.C.E.4 had at his disposal the 119th and 260th Railway Construction Companies R.E., and No. 3 Railway Company R.A.R.E. He allotted the responsibility for the demolition of bridges as follows:—

(*a*) 119th Coy. Péronne Junction exclusive to Epéhy inclusive.
(*b*) No. 3 Coy. (Employed outside the area with which this narrative is concerned.)
(*c*) 260th Coy. From Chaulnes Junction exclusive to Péronne inclusive.

Charges were not to be placed before orders to that effect had been received. These orders and the subsequent orders to fire would be sent from Corps H.Q. Detonators were not to be fixed until the order to fire was received.

The diaries make frequent mention of inspections and rehearsals, but in some cases the supply of exploders fell short of requirements.

In February the XVIII. Corps asked for sufficient explosives to demolish the abutments of all the 75 bridges in their area, but were told that such an amount could not be supplied, and consequently they abandoned the idea of destroying abutments. The quantity available was sufficient to cut one span of each of their bridges.

The demands for exploders cleared out the stocks available, so that the C.E. Fifth Army had to tell C.E. of Corps that the C.O.O. Havre could not supply all that were asked for. At the same time he asked the E.-in-C. that exploders might be sent from other armies. The deficiencies do not seem to have been very great, but it was necessary to use those forming part of the equipment of units, which consequently became locked up at certain points and were likely to prove unavailable if the units moved elsewhere. The C.E. Army pressed C.E. of Corps to draw at once the explosives they would

require, as accommodation in the R.E. Park was limited; after meeting their requirements as far as possible he wished to constitute at the Park a reserve for emergencies.

That the general situation as regards materials for demolitions was satisfactory may be gathered from reports of C.E. of Corps to C.E. Army.

III. Corps, on the 7th: "All explosives obtained and on site. Estimates of possible requirements herewith. Part will be required almost immediately, will indent on R.E. Park."

XVIII. Corps, on the 8th: "Have drawn all explosives required except 10 exploders, which are not yet available. When Army programme of bridge construction is carried out, we may want more."

XIX. Corps, on the 20th: "Explosives authorized have been drawn and issued to companies. Exploders in possession of units will suffice, but should like to know when additional available so as to replace those drawn from mobilization equipment."

VII. Corps, on the 12th: "Explosives required have been arranged for and are stored in close proximity to the bridges approved for demolition." On the 11th, he had said that he still lacked four exploders.

There is no record of the stock in No. 6 R.E. Park, but on the 22nd March there were "at Fins, 4,000 lb. of explosives and 1,800 lb. Tyke."* When the Corps dump at Ham was handed over to the C.R.E. 30th Division, on the 22nd, it contained 100 barrels of tar, 5,000 slabs of guncotton with primers and detonators, and on the 25th, 2,000 slabs of guncotton with primers and fuzes were sent by the C.E. Fifth Army to the C.R.E. 36th Division, at Hargicourt and Gratibus, for demolitions in that area.

On the 2nd March, G.H.Q. had asked armies for an estimate of their requirements in explosives, etc., and on the 19th, the Fifth Army replied:—

"My requirements are:

Guncotton, ammonal and its substitutes, primers, fuzes ..	*Nil.*
Detonators, electric, No. 13	5,000.
Exploders, 24 outstanding demands not fulfilled.	
16 required for stock.	
Total 40 required in all.	

Electric cable, miles, 10.

Detonators and cable have been indented for on A.O.D. but not yet received."

---

* Quoted from an order by the C.R.E. 9th Div., but Lt.-Col. Hickling, now in Trinidad, cannot say where the latter dump was located.

That the obstacles formed by the demolitions contemplated would not be entirely satisfactory was foreseen by the C.E. XIX. Corps, who, in a report addressed to G., dated 14th March, says, para. 9: "I am of opinion that a great deal of the destruction herein arranged for can easily be made good by the enemy, owing to the width of streams being small and the beds of streams being merely a few feet below bridge roadway. I think enemy could be held up to an equal degree by blowing several large craters in roads such as that through the marshland about St. Christ."

The C.R.E. Corps Troops, XVIII. Corps, in his report to his C.E., dated 13th April, 1918, says: "There was no bridge over the Somme, or the canal, the demolition of which need delay the enemy's field artillery for more than two hours, unless the site of the bridge was kept under rifle fire or machine-gun fire at close range."

The C.R.E. Cavalry Corps, writing to the C.E. Fifth Army, on the 4th March, said: "The only bridges in the battle zone, Cavalry Corps area, are over the Omignon at Maissemy and Bihecourt. They are simple wooden trestles, could be easily destroyed and very easily repaired. The bridges could be demolished with explosives as shown on plans. It would probably be just as simple to saw through the trestle legs, or, better, burn the bridge down, as done by the Germans to wooden bridges over the Somme."

The question of cratering roads was considered at A.H.Q. but was set aside, as it was considered that all available tunnellers were better employed in making tunnelled dugouts. Earth augers and linings were in stock at No. 6 R.E. Park, but there is no record of their having been utilized prior to the 24th March when the Park was destroyed. The C.E. VII. Corps, at the end of his report on bridges demolished, states: "No mines were prepared for forming craters in roads east of the Ancre." West of that river the VII. Corps conformed with the practice of the Third Army in this respect.

It is interesting to note that, in February, a report was got out by officers of the E.-in-C.'s staff on the possibility of forming inundations in the valley of the Somme between Péronne and St. Simon. After pointing out how local floods could be formed, the report went on to say: "To destroy the causeways it would be necessary, (*a*) to demolish the bridges, (*b*) to form one or more craters in the causeways, where marshy ground renders the deviations most difficult."

This was forwarded by the E.-in-C. at G.H.Q. to the C.G.S. on the 25th, and in his covering letter he said, para. 3, "Far more important than any inundations, are detailed schemes and preparations for effectively destroying the bridges and causeways in the river valleys. The French have detailed two officers to make a study of the destruction of causeways and cross roads by craters, on their own account."

The General Staff sent a copy of the report to the Fifth Army on

the 28th February, with the order : " Will you please forward your plans for inundations in your area as soon as possible," but no special attention was invited to the subject of craters in the causeways. It appears as if the considered opinion of the E.-in-C. on the relative value of two engineering methods of delaying the enemy's advance had been ignored.

On the 6th March, copies of a printed *Fieldwork Note*, giving methods of forming road craters, were sent to C.E.'s of all armies for distribution.

The demolition of dumps (ammunition, supply and R.E.) does not seem to have been considered in its practical application, and nobody appears to have pointed out that it was a matter requiring time and preparation beforehand. As will be seen in the sequel many had to be destroyed during the retreat, with what success it is hard to say as they were usually set on fire at the last moment, when nobody wished to stay to note the result. It was early realized that Roisel dump was too near the front line to be safe, and on the 17th March the enemy's shells set it alight. This fire was extinguished, but before the 20th, all explosives stored there were sent back to the base. Thereafter No. 6 R.E. Park, at Omiécourt (Chaulnes), was the chief store of explosives. It had been hurriedly moved there from Plateau station, and some of the trains were still standing under load on the 21st March.

V. 21ST MARCH.

A.H.Q.

The enemy's bombardment started at about 4.40 a.m., and the order, " Man Battle Stations," went out to Corps very shortly afterwards.

III. Corps.

The two brigades of the 58th Division, holding the right of the line from Barisis to the Oise, were not attacked. Their 173rd Brigade, which held from Beautor to Travecy, was driven back during the day, and between 9 p.m. and midnight was withdrawn west of the Crozat Canal, after which the bridges at Fargnier and Quessy (13 in all) and one over the Oise just east of Condren were blown up by Lieut. Wall and 2nd-Lieut. Bilham, 303rd Field Coy. Responsibility for ordering the destruction of these bridges had been delegated to the Brigadier, who directed that the bridge over the canal north of Condren was to be left standing for the time being, but it was destroyed later.

Portions of the narrative of the C.R.E. 58th Div. forwarded to the C.E. III. Corps on the 12th April, 1918, are worth quoting, though the bridge at Chauny referred to was not destroyed until the 24th.

All our bridges over the Crozat Canal were destroyed by the 503rd Coy. All these had alternative methods of demolition.*

The detachments stood by these bridges from the 20th March until the early morning of the 22nd, when the 173rd Brig. reported all bridges on their sector destroyed with the exception of a footbridge which was subsequently dealt with by Lieut. Wall. The 74-ft. trestle bridge north of Quessy† was not satisfactory as only the transoms were cut, but the O.C. Coy. put a party of sappers on to this bridge, who completed its destruction quite easily, the road-bearers being sufficiently shaken to allow of this being done.

Attention is called to the fact that no locks were prepared for demolition. The lock on the Crozat Canal just south of the Tergnier-Fargnier road was damaged by shell fire, thus permitting the water to escape, so that the canal from here to next lock‡ north presented no serious obstacle to the enemy.

It may here be remarked that while the preparations beforehand aimed at destroying bridges as road bridges, brigade and regimental commanders were not satisfied, and did not consider demolition completed until the bridge had been rendered impassable to the enemy's infantry. The impression gathered was that infantry commanders thought that demolition would dissipate the bridges into thin air and leave practically nothing behind—this is, of course, impossible, and it should be recognized that infantry posts are always required at the debris of demolished bridges to prevent the enemy making use of the debris.

It is also clear from the results that bridges with a lot of timber cannot be destroyed by demolition alone, and that in addition to demolition charges, with the object of quickly putting the bridge out of action, preparations should be made to fire the bridge and so complete its destruction. This was well exemplified by the 89-ft. pile trestle bridge over the Oise in Chauny, where the debris of the original bridge permitted the enemy to place planks and get infantry across. This was subsequently dealt with by the personal efforts of Major Tamlyn, 504th Coy., who in the face of the enemy placed combustibles and successfully fired the bridge. In two cases the charges did their work, but the top booms locked and the roadbearers and decking held the bridge up. When the roadbearers were cut by a second charge the bridge dropped into the river.

In the case of bridges with masonry abutments charges placed behind the abutments, so as to throw them out into the river, were very effective.

The 18th Division was likewise withdrawn across the canal during the night, and, when the infantry had crossed, parties of the 79th and 92nd Field Companies blew up the bridges at Liez, and the 80th those

* This had been prescribed by G.H.Q. on the 2nd March.

† When bridges in quoted reports are therein referred to by numbers, descriptions have been substituted to avoid overcrowding the map.

‡ Apparently 550 yards farther north.

at Menessis, seven in all. The bridge over the railway west of Menessis was not destroyed.

The Field Companies of the 14th Division at Benay were, according to orders, to send one section each to their affiliated brigades, after which the 61st and 62nd Coys. were to join the C.R.E. at D.H.Q at Clastres, whilst Major Ormiston, with Nos. 2 and 3 Sections of the 89th, was to march to Jussy to prepare the bridges there for demolition. His No. 4 Section was already there.

The attack was, however, so violent that the 61st Coy. at once got involved in the fighting. It was joined at noon by two sections of the 62nd, but eventually at 10 p.m. they were all withdrawn to Flavy le Martel, south of the canal west of Jussy. Major Ormiston arrived at Jussy early in the day, and was assisted in his work of preparing the bridges by No. 4 Section, 62nd Coy., under Lieut. Lewis.

Orders to be ready to blow up the bridges in the vicinity of Jussy reached the C.R.E. at 8 a.m., when Major Ormiston was already on his way there. At 11 a.m. a report reached D.H.Q. that these bridges were being shelled, so the C.R.E. went there to see that they were kept open for traffic. At midnight he got an order (issued to the 14th Division at 4.30 p.m.) that the bridges were to be blown up as soon as the last of the infantry had crossed, and this he transmitted verbally to Major Ormiston. The result is given in the C.R.E.'s report and may be recorded here, though the bridges were not destroyed until the early hours of the 22nd.

> No. 1. W. of Jussy. Light railway, pile trestle, 82 ft. 6 in. Large gap, last seen burning freely.
>
> No. 2. W. of Jussy. Broad-gauge single-line railway, steel girders, 82 ft. 6 in., carried on two bents of heavy wooden piles. Destroyed by No. 4 Section, 62nd Field Coy.

Lieut. Lewis had been killed by a stray shell. When Lieut. T. G. R. Makeig-Jones, 61st Field Coy., came on the scene, he found that Serjt. Arnold had cut through both girders in the centre, and destroyed the near trestle and three out of the four piles of the far trestle. The remaining pile held up the bridge, which had sunk slightly in the middle and jammed. All explosives on the spot had been used, but after a period of waiting a box of primers arrived. These were being strung into a double necklace, when some firing broke out on the far side of the canal to which our troops replied. A high-pitched voice from the far bank shouted, "Don't fire. 60th Rifles retiring." Fire then ceased. Serjt. Arnold and a sapper went across to fix the necklace on the remaining pile, the former standing in water up to his neck to do so. The fuze was lighted, and, as they ran back across the bridge, they were fired at but not

hit. The charge exploded and the bridge " collapsed beautifully." Firing then reopened from the far bank and was returned by our troops, but the fog was so dense that the opposite edge of the canal could only just be discerned.

No. 3. W. of Jussy. Pile trestle, 82 ft. 6 in. Large gap (about 20 ft.).

No. 4. W. of Jussy. Trussed steel girders, 82 ft. 6 in. Girders right down, cut through.

No. 5. Jussy. Pile trestle, 76 ft. Large gap (about 20 ft.).

No. 6. Jussy. Suspension, 82 ft. 6 in. Right down.

No. 7. Jussy. Pile trestle, 80 ft. Large gap (about 20 ft.).

No. 8. E. of Jussy. Broad-gauge railway bridge, demolished in 1914 and being reconstructed by the French. (See 22nd March, below.)

No. 9. Two timber spans, each 19 ft. 6 in. No. 10. Two timber spans, each 19 ft. 6 in.	Over one lock. Completely destroyed by Lieut. E. V. Deverall, 89th Field Coy., and rails (used as roadbearers) thrown into the water.

No. 11, and its approach No. 11a, pile trestle, 76 ft. Gap first made not very satisfactory, but Capt. Lyon, with great gallantry, after getting fresh charges, destroyed this bridge under heavy m.g. fire.

All footbridges were destroyed.

The divisional saws at Jussy were destroyed by the 4th Siege Coy. R.A.R.E., as there was not time to remove them.

The C.R.E.'s diary goes on to say :—

" The report that the bridges were left standing was due :—

(1) To the idea that the destruction of a bridge means the elimination of all sight of it.

(2) The first charges having mostly failed.*

(3) The fact that the lock gates were not blown up, though the footbridges were destroyed.†

(4) No. 8 bridge was left standing, which from a distance looked intact."

The 135th A.T. Coy. and the 182nd T. Coy. were under the orders of the C.R.E. Corps Troops. The former was told to stand to at its numerous bridges in and south of Chauny, but not to insert

* In these French explosives were used. In most cases they had been stored close to the bridge for a considerable time.

† If lock gates are destroyed the defensibility of the stretch of water above them may be seriously impaired.

detonators. The four 60-cm. bridges previously taken over from the 504th Field Coy. were handed back to that Company, but the demolition parties (1 N.C.O. and 12 men) were to stay at their posts, and take their orders from the O.C. Field Coy.

The 182nd T. Coy. blew up a considerable portion of the dump at La Motte Farm, west of Clastres: the demolition of the whole was impossible for lack of explosives. They were also ordered to destroy the dump north of Liez, but the officer detailed was told by the 18th Division on his arrival that this had already been arranged.

The following paragraphs are taken from a report rendered by C.E. III. Corps to the C.E. Army, on 16.4.18:—

> Difficulties were caused by the order for Corps to hand over all demolition of railway bridges to the R.C.E., followed by an order that all 60-cm. bridges were also to be demolished by R.C.E., finally there was uncertainty as to whether the order included road-over-rail bridges. These orders came after all preparations had been made by the Corps to demolish the bridges referred to. At the eleventh hour, as the R.C.E. had not been able to do the work, the Corps was again ordered to take it in hand; it was, however, too late, and so certain bridges were not demolished, but along each route, whether rail or road, the communication was cut in one place in spite of these difficulties. It is doubtful if this would have been done had not the Corps taken the law into its own hands when the situation became critical, and before the final orders were received.
>
> The fear of premature firing and unnecessary loss of rolling stock was unnecessary. All 60-cm. rolling stock (there was no broad-gauge stuff beyond the canal at the time) was withdrawn by my orders on the night 20th/21st except one damaged truck.
>
> The following notes are now forwarded as being of more purely engineering interest than the G report submitted by me:
>
> (*a*) Certain field companies seem to be suffering from want of training, as there were several instances of exploders being used to fire some 20 detonators in series—in one case 29. This was fortunately discovered and remedied some three or four weeks beforehand, when preparations were first being made.
>
> (*b*) The 14th Div. complain that the French explosive failed. As the 58th had complete success with it I suggest there was some mishandling of the French explosive, but it is possible that the charge had become wet.
>
> (*c*) Individual slabs were tested on receipt of the guncotton from the base or R.E. Park, some two or three weeks before the 21st March; it is estimated that 40% was unfit for use. I do not know the method of storage, but possibly it can be improved; in any case I suggest a periodical test of a slab of guncotton out of each box, especially weight test for dampness, and some

should be tested again at time of issue. Some of the initial failures were probably due to the faulty guncotton.

(*d*) Leads to exploders were cut in many cases by shell fire, and fuze seems more satisfactory. Fortunately alternative methods of firing were ready in each case.

(*e*) Hasty demolitions, *i.e.*, overloaded charges put in at the last moment, generally after initial failure, gave more satisfactory results on the whole than the deliberate charges.

(*f*) Wooden pile and trestle bridges proved more difficult to demolish than others, especially as the water level was less than two feet from the decking in some cases.

XVIII. Corps.

Shortly after noon, 2nd-Lieut. I. T. V. Norman, 121st Field Coy., 36th Division, completed the destruction of a pontoon bridge and a footbridge at Fontaine les Clercs, both of which had already been rendered unserviceable by shell fire. At 10.15 p.m., with No. 1 Section, he started to demolish the Hamel-Seraucourt group of six bridges and two footbridges. Two north of the *sucrerie* at Le Hamel were blown up at the request of the infantry after the leads had been cut three times and repaired by 2nd-Corpl. Rainbird. At 11.45 p.m. the 107th Infantry Brigade, having crossed the bridges over the river and canal just north of Seraucourt, ordered them to be destroyed, but no sooner had this been done by Corpl. Burston than the 108th Brigade sent to ask that their demolition might be delayed as they wished to make use of them. Luckily 2nd-Lieut. Norman was able to guide this brigade to another crossing-place. At 3 a.m., on the 22nd, the main bridge over the canal between Le Hamel and Seraucourt was demolished on the order of the 109th Brigade, and the remaining bridges of this group were destroyed by 4 a.m. In all cases the gaps formed exceeded expectations, and the piles were rendered useless. The section suffered no casualties and brought back all their four exploders.

The demolition parties of the 1st Siege and 172nd T. Coys., acting under the orders of the C.R.E. Corps Troops, stood to at 5.40 a.m. in the Ham and Ollezy sectors, and all final preparations were made.

XIX. Corps.

Roisel dump was heavily shelled and gassed from an early hour, and after mid-day it was impossible to get out stores. Officers of the C.E.'s staff volunteered to destroy as much as possible during the night, but General Bremner would not sanction it as there was more important work for them to do.

In the 24th Division, Lieut. A. N. Fairbourn, 103rd Field Coy.,

destroyed the trestle bridge between Vadencourt and Maissemy. This was done at 1 p.m. in the face of the enemy, and for the moment frustrated his attempt to attack Vadencourt from the south. He also blew up a similar bridge south-east of Bihecourt, and three culverts on the roads. He went later to Vermand, and stood by the bridges there.

The 239th A.T. Coy. was still working on the preparation of the road bridges at Brie* and Eterpigny, where the work was approaching completion. The 288th A.T. Coy. moved camp to St. Cren, just north of Mons en Chaussée, and the O.C. was ordered by the C.E. XIX. Corps to push on the postponed preparations for demolitions at Monchy Lagache, Devise, Fourques and Athies, which had been taken over from the 2nd Field Squadron on the 2nd March.

VII. Corps.

The only demolition recorded on this day is that of the pumping station at Gouzeaucourt by the 64th Field. Coy., 9th Division.

(*To be continued.*)

APPENDIX (PART I).

A.H.Q.

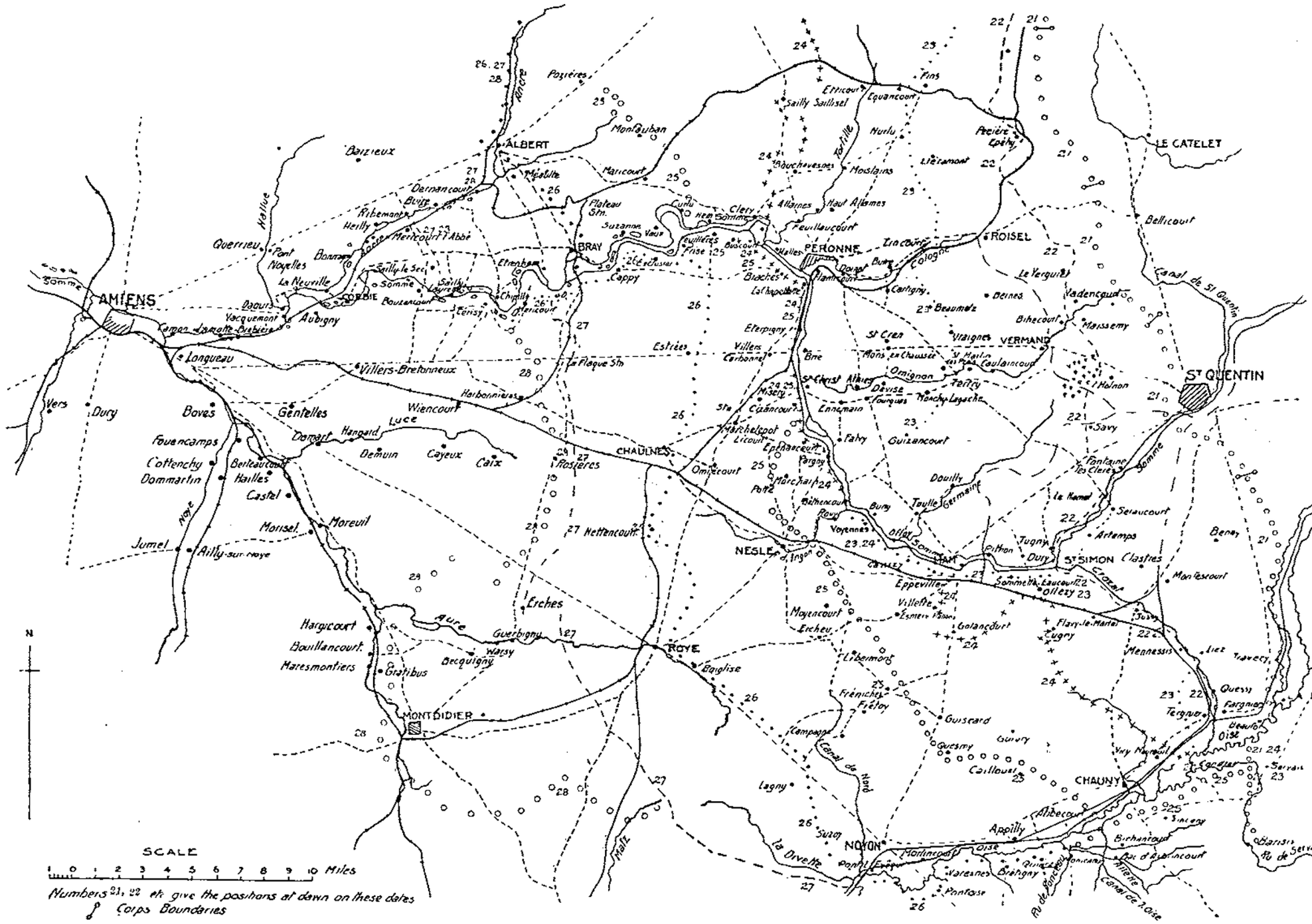
C.E.: Major-General P. G. Grant.
C.R.E.: Lieut.-Colonel F. M. Westropp.
S.O.: Capt. C. H. Egerton.
353rd E. and M. Coy.: Major B. M. Owen.
4th Army Workshop Coy.: Major C. S. Wilson.
No. 6 R.E. Park: Capt. C. K. Honeywill.

CORPS.

Corps.	C.E. Brig.-General	C.R.E. Lt.-Colonel	S.O.
III.	A. Rolland	C. F. Rundall	S. N. Barron
VII.	R. D. Petrie	C. E. G. Vesey	G. E. S. Streatfield
XVIII.	H. G. Joly de Lotbinière	J. E. E. Craster	B. I. Chambers
XIX.	A. G. Bremner, later H. Biddulph	G. S. Knox	H. G. Edleston

* Work on the bridges at Brie had been begun by the Cavalry Corps, but recently some of the bridges had been renewed and others added, so that the number now was 13 road and 5 Decauville bridges.

DEMOLITIONS, FIFTH ARMY, 1918.



C.R.E. DIVISIONS.

(Lieut.-Colonel)

Cavalry Corps.

W. H. Evans.

III. Corps.

14th. D. S. Collins.
18th. C. B. O. Symons.
58th. A. J. Savage.

VII. Corps.

9th. H. C. B. Hickling.
16th. R. F. A. Butterworth.
21st. G. H. Addison.
35th. J. W. Skipwith.
39th. H. J. Couchman.

XVIII. Corps.

20th. E. M. Newell.
30th. G. W. Denison.
36th. A. G. T. Cusins.
61st. G. E. J. Durnford.

XIX. Corps.

8th. C. M. Browne.
24th. A. D. Walker.
50th. J. A. McQueen.
66th. G. J. P. Goodwin.

Army Troops Coy.

(Captains)

135th. A. T. Phillips.
221st. C. G. Brodie.
238th. R. C. Foster.
239th. T. W. Adam.
281st. H. E. Kentish.
284th. W. R. Lewis.
288th. G. M. Borns.

Royal Anglesey Royal Engineers.

(Majors)

1st Siege Coy. J. Barker.
4th „ „ M. Parrington.

Tunnelling Coys.

(Majors)

172nd. G. A. Syme.
173rd. T. M. Lowry.
177th. L. C. Hill.
178th. G. G. Nicol.
180th. G. F. Johnston.
182nd. F. L. Mulqueen.
258th. W. A. Pope.

Only units of Corps Troops mentioned in the narrative are shown: there were many others in the Fifth Army.

THE ROAD PROBLEM OF A FORCE OPERATING IN UNDEVELOPED COUNTRY.

Winning Essay for the Cooper's Hill War Memorial Prize, 1932.

By CAPTAIN C. M. SINGER, R.E.

INTRODUCTION.

THE importance of adequate roads behind a modern army in the field is widely recognized, but the problem is rarely stated except in vague and general terms. In this essay an attempt will be made to appreciate the actual road requirements of a force; to investigate how far the art of road making in its present state can be made to satisfy these requirements; and finally to discuss the organization, equipment and training necessary to enable the work to be carried out. Bridging operations are not dealt with, being outside the scope of the subject, but culverts up to 12 feet span are mentioned.

The force considered is one of two divisions with L. of C. troops, organized in accordance with our present *War Establishments*. The theatre in which this force is supposed to be operating is Kenya Colony.

The nature of the problem will clearly vary greatly with the type of country. The existence or otherwise of railways, canals and roads will largely determine the quantity of road construction to be undertaken. Geological formations, natural features and climate will have a great effect on the engineering side of the question.

Nature of the Country and its Climate.

Along the coast lies a narrow, hot, damp, and fertile strip of country. Farther inland, at a higher altitude, is a belt of waterless bush. Beyond this again, and still higher, separated from it by an intermittent range of mountains, are open plains covered with grass on a reddish marl soil. The country is intersected by streaks of black cotton soil, varying from a few yards to several miles in width. Patches of soft sand are occasionally met with in the dry bush. Stone suitable for road metal is practically unobtainable; the few quarries worked in peace-time would probably be inaccessible in war, and in any case may lie far from the scene of operations. On the

other hand, shingle and gravel suitable for concrete making are found in places in most districts, especially in the bush area.

Communications are scanty. One railway runs inland from Mombasa, along the general line of which the force will be assumed to be operating. Roads consist for the most part of mere tracks joining native villages, though with the advent of motor-cars some of these have been improved into dry weather motor roads with rough surfacing with a species of gravel, known locally as *murram*.

Regular wet and dry seasons obtain, though some rain must be expected at any time. The rainy seasons occur in October–December and again in April–June, lasting some two months and six weeks respectively. During these periods the black cotton soil becomes quite impassable, and movement across country in any district is extremely difficult. Active operations will usually be confined to the dry seasons, as was the case in the East African Campaigns of 1915–1919.

Our study of the road problems of the force will accordingly be based on the assumption that the roads will in the main be constructed during a dry season, but must be rendered fit to take the traffic expected on them at any time of the year.

The Road Requirements of the Force.

The Manual of Movement, Sec. 139 (5), states that, " In a small war, phases of active operations . . . are likely to be of comparatively short duration." It will be convenient to examine first the traffic and roads required in the theatre of war while the force is stationary, and then to consider the developments in the road system necessitated by a period of mobile operations.

Stationary Periods.

Traffic.—Suppose the force to be for the moment stationary, and operating as far from railhead as is possible with a " normal " system of supply. *F.S.R.*, Vol. I, Sec. 104, lays down that in such circumstances the delivery points for the leading units may be from 50 to 80 miles from railhead, depending on local conditions.

For the first 25 miles or so from railhead, up to the refilling points, ammunition and supplies for the force are carried in lorries of the Maintenance Companies. In our present *War Establishments* these vehicles consist of " heavy lorries," *i.e.*, 3-ton four-wheelers, with possibly a sprinkling of heavier vehicles should the situation demand it. If, for example, the progress of railway construction is so slow that railhead is more than about 30 miles from refilling point, an extra road transport echelon may have to be added, the vehicles of which may include any in civilian use in England or elsewhere.

Beyond the refilling points, the nature of the supply and

ammunition traffic changes. Up to units' delivery points, the heavy lorries of the Maintenance Companies are replaced by the second-line transport of the Divisional R.A.S.C., consisting in the main of 30-cwt. six-wheelers, with a certain number of 3-ton six-wheelers for the carriage of ammunition.

The actual intensity of supply traffic is difficult to estimate. Behind the refilling points the three Maintenance Companies (*i.e.*, one for each Division and one for Corps Troops) are capable of putting some 150 vehicles each on the road. During quiet periods less than one-third of these may be actually in use. Before and during active operations every one of these lorries will probably be out. This traffic will tend to be concentrated into one or two main channels of communication leading from the railheads to the refilling points, near to which channels will be situated all dumps, parks, etc.

In front of the refilling points traffic may vary from the daily journeys of the 100 30-cwt. lorries of each Supply Company, to the full 350 lorries of each Divisional R.A.S.C. Here, however, the traffic will be more dispersed; the farther forward the greater the dispersion.

In addition to the supply traffic there will be a very varying amount of traffic due to the moves of units with their first-line transport, and fighting vehicles, guns, etc. Such movement will be, as a rule, greater and more widely dispersed in forward areas than in back. The nature of this traffic will vary greatly, but it may be assumed that in general it will not require roads of a higher standard than those suitable for lorries of the Divisional R.A.S.C.

Road Requirements.—The road requirements of the force while stationary can now be formulated. Communications in front of railhead fall into two distinct areas, in which the nature and intensity of traffic differ considerably, viz. :—

(i) The area between railhead and the refilling points.
(ii) The area in front of the refilling points.

A different class of road is required by the traffic in these two areas :—

(i) Up to the refilling points, roads must be capable of taking what would be known in England as fairly heavy lorry traffic—in other words, they must be fit for continuous M.T. traffic in all weathers. They should be not less than 20 feet wide, to allow of traffic in both directions. Preferably there should be two such roads running parallel, and connected by two or three cross roads of a similar nature. These two roads would give access from supply and ammunition railheads to the various refilling points of the force.

This ideal of two parallel roads will rarely be realized except during long stationary periods. Normally one such main road will have to suffice, with off-shoots to depots and other points of importance not lying on its route.

This type of road will be referred to as a " main lorry road " for the sake of brevity.

(ii) In front of the refilling points, roads are required fit for 30-cwt. six-wheelers, with occasional 3-ton six-wheelers and other lighter traffic. Here we are dealing only with vehicles which have a considerable cross-country capacity, and are capable of reaching units' delivery points in dry weather over tracks on which no work has been done beyond the clearing of shrubs and trees. They will not, however, be able to use the same unprepared tracks indefinitely, or in wet weather, or in very soft soil, so that it is essential to provide some form of rapidly constructed road as early as possible. The intensity of traffic using such roads will be low, so that they may be limited to a width of 10 feet, with passing places at intervals. On the other hand, a closer network will be necessary in the forward area than in the main lorry road area.

Roads of this type will be referred to as " forward roads."

In this area short stretches of road will also be required at certain places such as lorry parks, water points, etc., which will be more of the " main lorry road " than the " forward road " class.

Mobile Periods.

Suppose now the force to be moving away from railhead. As the force advances, the distance of the leading units from their original delivery and refilling points increases. Delivery points must be pushed forward, but cannot be allowed to get more than 40 miles, at the outside, from the refilling points. The normal maximum is 25 miles between the two, and the distance must be reduced to this as soon as possible.

First and second-line transport is, in general, capable of moving across country pending the completion of a forward road, but the heavy lorries behind refilling point have not this capability. The forward movement of the force is thus limited by the rate at which its refilling points can be advanced, *i.e.*, by the rate of construction of the main lorry road.

Two demands are thus made on the road construction programme :—

(*a*) The rapid construction of forward roads to keep pace with the advance.

(*b*) The prolongation, as quickly as possible, of the main lorry roads to enable refilling points to be established within 25 miles of the leading units' delivery points.

As a preliminary to an advance, the main lorry road system will be carried up beyond the refilling points as close to the leading troops as possible.

Railway construction in the rear will also doubtless be pushed ahead to reduce the distance between railhead and future refilling points.

During the preparation for the advance considerable extra traffic will be thrown on the roads. Those in back areas should be able to stand up to this satisfactorily, but the forward roads may need local improvement. Such improvements will often be part and parcel of the extension of the main lorry road system.

The necessity for careful planning of all road work will now be apparent. A rapidly constructed forward road system will ultimately be incorporated in the lorry road system of future back areas. To avoid waste of time and labour it is important that the forward roads be laid out with this eventuality in view, and that a reconnaissance for the extension of the main lorry roads be made as early as possible.

THE APPLICATION OF THE ART OF ROAD MAKING TO THE REQUIREMENTS OF THE FORCE.

The technical problems of road work involved in both the "forward road" and "main lorry road" classes will now be examined. Various types of construction will be dealt with and those which appear to fulfil the requirements outlined above will be indicated.

A. FORWARD ROADS.

In the construction of these roads, time and the necessity for using only materials which are readily to hand will usually be the chief considerations. Elaborate road making plant will not often be available; if any exists with the force it will be fully occupied in main lorry road construction.

It must be borne in mind that the object here is to produce a road fit for first and second-line transport in the dry season, when not more than occasional rain may be expected.

In the rainy season, no road of a lower specification than that which will be suggested for a main lorry road will suffice, and the rapidly constructed forward roads must be improved accordingly. This can be done at comparative leisure.

Location.

The actual location of the roads will, of course, depend largely on the tactical situation and the course of operations. In view, however, of subsequent developments the engineer commander will frequently lay down alignments which should, or should not, be followed. For example, in bush country, where much clearance has to be undertaken, forward roads should, if possible, lie along the line chosen for a main lorry road extension. The same will apply to situations involving any considerable amount of earthwork.

On the other hand, cases may arise where it is advisable to locate the forward road clear of a lorry road alignment, *e.g.*, where a temporary river-crossing has to be made away from the site selected for a permanent bridge on the lorry road.

Much time and labour can be saved by following existing tracks and roads wherever suitable.

Where the ground is flat or gently undulating, the location of a forward road will present little difficulty. But in hilly country it is important to site the road so as to keep the earthwork involved down to a minimum.

In the absence of mechanical excavators the quantity of earthwork to be done will be the chief factor determining the time taken to open the road. The limiting gradients given in *M.E.*, Vol. V, Sec. 7, should be adhered to in general, but it may often be advisable to increase them considerably over short distances to save earthwork. Similarly, the introduction of sharper curves than are normally used is permissible, if done with the same object. Curves must not, however, be of radius less than 40 feet if 3-ton six-wheelers are to negotiate them.

Construction.

In the country under consideration (and, indeed, in most parts of the world), the clearance of vegetation and rough levelling of the ground will in most places result in a track good enough for the purpose in dry weather. But there will be occasional stretches of road, where black soil is encountered, which will need some form of treatment, even in dry weather, to render them fit for traffic. In the bush region, also, patches of soft sand may sometimes have to be dealt with.

In all cases, careful attention must be paid to drainage if the roads are not to become impassable even after the moderate amount of rain which occasionally falls in the dry season. Side drains must be dug and the surface must be properly cambered. The camber can be readily achieved by throwing the soil excavated from the side drains onto the centre of the road and ramming it. This should be done simultaneously with the clearing and levelling of the surface. The

time and labour required for this work will vary enormously with the nature of the country.

In the easy soil met with on the grass uplands, one section of a Field Company should complete the levelling and side drains of 1,500 yards of road in an 8-hour shift, while in thick bush country the rate may fall to 100 yards per shift if no track already exists. During the 1930–31 operations near Peshawar, the rates for infantry working parties clearing and levelling M.T. tracks varied from 100 square yards per man per day in easy situations down to 10 square yards per man per day in soil containing large boulders and covered with shrubs. A mechanical grader, if available, would greatly increase the speed of working in easy ground, but would probably not be of much value in the root-infested soil of the bush area.

Cross-drainage of storm water from the surrounding country must be provided for by culverts and bridges. Small culverts should consist of pipes of diameters varying from 18 inches to 4 feet, laid singly or in batteries. Such pipes, made of reinforced concrete or corrugated iron, can be made up at leisure and held in readiness for use. They are very rapidly laid and should be quite satisfactory if sufficient waterway is provided. Dry river beds will at first be crossed by cleared and unpaved causeways, and permanent streams by standard bridging equipment.

This clearing, levelling and drainage is work which is common to all types of road. It remains to consider means whereby the road can be improved over stretches of soil too poor to stand up to traffic without treatment.

Various expedients are possible :—

(i) *Corduroy or Plank Roads.*—These are quick and easy to lay, and were much used in the 1915–19 campaigns in E. Africa. On the other hand, the quantity of timber required is large, some three cwt. per foot run of 10-foot road being needed. This timber can be held in readiness but must originally be brought from a considerable distance.

The rate of laying is commonly put at one yard per man per day, the size of the working party depending on the rate at which timber can be brought to the site.

(ii) *Concrete Slab Wheel-Tracks,* as described in the *R.E. Journal,* August, 1919. The slabs are laid to form a pair of wheel-tracks over which lorries can pass. In weight they are an improvement on corduroy roads, working out at two cwt. per foot run. Moreover, the aggregate for their manufacture will often be found close at hand, the only materials to be brought from a distance being the cement and reinforcement. The slabs can be made up at leisure and carted to the site as required. The majority of them

will be available for use elsewhere when no longer required at the original site. Their laying is simple; a party of 1 N.C.O. and 10 men should complete 20 yards of road a day. As in the case of corduroy road, traffic can use the road as soon as the slabs are laid. In most situations they would form a satisfactory surface in all weathers when laid on a well-drained formation. Black cotton soil, however, would become so sodden by rain falling round the slabs, that the latter would have to be replaced, before the rainy season, by a complete waterproof surface.

Where suitable aggregate exists close to the actual site of the work, the concrete wheel-tracks may be cast *in situ*. This will overcome the difficulty of transporting the great weight of the slabs, but the road will take longer to lay, and traffic cannot be permitted to use it within four days of laying, even when a rapid-hardening cement has been used.

(iii) *Gravel or Shingle Roads*, such as were recently employed during the operations near Peshawar already quoted. The quantity of gravel required for a 3-inch coat will be about 2½ cwt. per foot run of 10-foot road. This type of surface was laid at the rate of one yard per man per day with skilled labour during the Peshawar operations. The economical size of working party will again depend on the rate at which gravel can be brought to the site. Traffic can be allowed on at once, though at first it will be liable to displace the gravel considerably unless the latter is obtainable with a small amount of earth mixed with it as a binder.

Gravel roads will not stand up to traffic so well as corduroy or concrete slab roads. Opinions vary greatly as to the amount of traffic that they will take satisfactorily, from 10 to 500 vehicles a day being reported. Since we are dealing with a surface laid on poor subsoil, it would be unwise to expect too much. Many forward roads will not have to take more than ten vehicles a day, and this only for a comparatively short space of time, so that this type of road would be worthy of consideration wherever gravel is obtainable near the site. These roads are, however, essentially dry-weather roads; if they are to be used in wet weather the surface must be rendered waterproof by the addition of a bituminous binder. This will convert it into a bitumen-bound gravel surface, such as is referred to below.

(iv) *Bitumen-bound Earth or Sand Roads.*—These are roads in which the natural soil of the formation is treated with some

form of bituminous binder to give a waterproof wearing surface. A more elaborate variety is made by bringing a gravel aggregate to the site and there mixing it with the binder to form a bitumen-bound gravel surface. Though more suitable, as will be seen, for main lorry roads, these roads may be useful at times as forward road expedients, and must be discussed here.

An account of this process was given in *The R.E. Journal*, June, 1932, in an article on American "Mix-in-Place" roads, and an example of such work carried out in sand in Egypt was described in detail in *The R.E. Journal*, September, 1932. The method appears to be applicable to almost any type of soil except heavy clay, though the exact nature of binder to be used to give the best results varies with the nature of the soil.

A dry climate is better than a damp one; the dry-season climate of this theatre of war should be particularly suitable for this work. Experiments are being carried out to determine more definitely the capabilities and limitations of these roads; at present our knowledge both of the kinds of soil suitable and of the correct type of binder for any given soil is scanty.

On the soft sand patches met with in the bush this form of surface should be very successful. On black cotton soil this might not be so; experience up to the present with heavy oil and bituminous emulsion binders indicates that such soil might be difficult to bind. Further research, especially with fluxed bitumen binders, may provide a satisfactory solution. Should this soil not prove amenable to bituminous treatment itself, a bitumen-bound gravel surface could be added.

Bitumen-bound earth roads are capable of taking the traffic to be found on forward roads. Reports from America go much farther, up to 3,000 vehicles a day being given. Their possibilities in the lorry road system will be dealt with later.

When laid in short stretches on forward roads, the aggregate and binder would be mixed by hand in a concrete mixer. The rate of construction should be some 30 yards of 10-foot road per day, with a party of six men operating one mixer. In addition, a heater will be required, unless the binder is a cold bituminous emulsion.

Pneumatic-tyred vehicles can be allowed on the road at once (they will, in fact, assist its consolidation), but men, animals and solid-tyred traffic must be kept off until the road is thoroughly dried out.

The length of the drying-out period will depend on the weather and the binder used. Oil binders appear to dry out completely in two or three days, but these can only be laid in dry weather and when the soil itself is free from moisture. Cold bituminous emulsion binders can be laid when the soil is damp, but will take longer to dry out, especially if wet weather supervenes. It does not at present seem possible to lay this type of road satisfactorily in really wet weather; other methods must be employed on road extensions carried out in the rainy season. Once laid and thoroughly dried out, however, the surface should stand up satisfactorily in subsequent wet weather, provided the formation is well drained.

The great advantage of this form of construction lies in the small weight of material to be transported to the site. Where the natural soil makes a suitable aggregate, only the binder itself has to be brought from a distance; the weight to be transported will be about 35 lb. per foot run of road.

(v) *Surface Oiling.*—On certain types of soil, such as clay, which possess good bearing power if kept dry, it is possible to produce a satisfactory road for pneumatic-tyred traffic by pouring oil, or asphaltic bitumen, over the surface to form a waterproof seal. This has been done with some success in Iraq, but it is doubtful whether the black cotton soil or soft sand patches to be dealt with here would prove suitable. As a rapid expedient on the firmer upland soil, should this need treatment, surface oiling might be valuable. It has the advantage of requiring no special plant, the oil can be spread by hand rapidly. No actual figures are available, but a party of 10 men should be able to cover about 50 yards of 10-foot road an hour, with 20 lb. of oil (including weight of drums) per foot run of road. The oiling can only be done in dry weather, though the surface will withstand subsequent wet weather.

Only pneumatic-tyred vehicles can be allowed to use this type of road; a separate track must be provided for other traffic.

(vi) *Wire Netting, Wire Weaving, Expanded Metal, etc.*—These methods were much used on soft sand in the Egyptian and Palestine campaigns of the Great War, and form valuable temporary expedients on any soft soil. Like the gravel roads, they do not give a waterproof surface, and must therefore be replaced as soon as possible, especially if laid on black cotton soil.

Taking figures again from the recent operations near

Peshawar, an average rate of laying would be 50 yards in 30 minutes with a party of 15 men, the rolls of material having been prepared beforehand. In the case of wire netting or weaving, the weight to be transported is only some 5 lbs. per foot run of 10-foot road.

These roads are thus extremely quick to lay and light in comparison with the other types discussed, and will stand up to forward road traffic. If left down for any length of time, however, they will require considerable maintenance especially when used by traffic other than pneumatic-tyred vehicles. Wire weaving is said to need less maintenance than netting, and is therefore preferable for war-time use; its comparatively greater cost tends to rule it out in peace-time.

Conclusions.

The principal features of the expedients discussed are summarized in Table A.

It must be remembered that these will be employed on the forward road system chiefly in short stretches, to deal with bad patches of soil which are incapable of taking the traffic expected without treatment, and also as temporary expedients at certain places, such as water points, dumps, etc., where traffic is concentrated. Most of the forward road mileage will consist of well-drained untreated earth roads, capable of construction at a rate of 1,500 yards per day per section of a Field Company in easy ground.

The table brings out clearly the advantages of wire weaving. It is suggested that this expedient be adopted wherever it is essential that the treatment of bad patches keep pace with the rest of the work, to enable a forward road to be opened to traffic at once. Rolls of weaving should be held in readiness by Field Park Companies.

At the earliest opportunity the wire should be replaced by a surface that will be passable after rain, and the rolls kept for use elsewhere. The new surface will preferably be of the "bitumen-bound earth" variety, using the natural soil of the road bed. If this soil is found to be unsuitable, recourse must be had to concrete slab wheel-tracks. These slabs also must be made up in advance ready for laying. The number likely to be required will depend largely on the efficiency of bitumen binding on the soils encountered.

The importance of further research and experiment with oil and bitumen binding will now be apparent. In the light of our present knowledge it is not possible to foretell with certainty the value of such roads in the theatre of war.

It is thought that forward roads of the type suggested can be constructed at a satisfactory rate (having regard to the cross-country

capacity of the traffic using them), except in the thickest bush, or in extensive areas of black cotton soil, where progress is bound to be delayed. They will take first and second-line transport in the dry season, but must be improved and brought up to the standard of a main lorry road before the advent of the rains.

TABLE A.

Type of Expedient.	*Rate of Laying a 10-ft. Road.*	*Weight of Material per foot run of 10-ft. Road.*	*Remarks.*
(i) Corduroy Road.	10 yards per day per party of 10 men.	3 cwt.	All material to be brought from a distance.
(ii) Concrete Slab Wheel-Tracks.	20 yards per day per party of 10 men.	2 cwt.	Cement and reinforcement to be brought from a distance. Aggregate found locally. Slabs to be transported from dump to site.
(iii) Gravel (3-inch coat).	10 yards per day per party of 10 men.	2½ cwt.	Gravel occasionally available near site. Add labour for quarrying.
(iv) Bitumen-bound Earth Road.	30 yards per day with 1 concrete mixer and 6 men.	35 lb.	Concrete mixer and possibly heater required. Open to pneumatic-tyred traffic at once, and to other traffic when dried out.
(v) Surface Oiling	50 yards in one hour per party of 10 men.	20 lb.	On firm soils and for pneumatic-tyred traffic only.
(vi) Wire Weaving.	50 yards in 30 mins. with 15 men.	5 lb.	Rolls prepared beforehand. Suitable only in dry weather.

Note.—In types (i), (ii) and (iii) the size of working party and rate of laying can be increased within the limit set by the possible rate of delivery of material. In type (iv) the rate of laying can be increased by bringing up additional mixers.

B. Main Lorry Roads.

No unsurfaced earth road, however well drained, will stand up for long to the heavy traffic behind the refilling points. A main lorry road must be fit for use in all weathers, including the height of the rainy season. It will be expected to last for the duration of the campaign with the minimum of maintenance, and the rate at which it can be constructed has been shown above to be a determining factor in the mobility of the force.

Culverts and Earthwork.

In flat or gently undulating country, a main lorry road will normally follow the line of an existing forward road. Much clearance and earthwork will thereby be saved.

Half-width construction will generally be adopted to avoid interference with traffic. The pipe culverts and drainage must be adapted to the 20-foot width of road now necessary, and streams which had hitherto been crossed by causeways will now be bridged in view of the rainy season to come. Small streams, too large to be catered for by pipes, will be bridged by reinforced-concrete slab culverts up to, say, 12-foot span. Above that span, standard bridging equipment will be used. Simple slabs may be used up to about 8-foot span; on spans between 8 feet and 12 feet, slabs will be supported on reinforced-concrete T-beams, or R.S.J's if available. This type of culvert will be the quickest to erect, and involves the minimum amount of transport of materials.

Standard centering may be held in readiness and rapid-hardening cement will be used. Since culverts will need several days for their construction and the setting of the concrete, work on them should be begun well ahead of the remainder of the road work. Their completion will assist traffic in the forward area, which had previously used causeways or temporary bridges.

As the country becomes more hilly, so will the amount of necessary earthwork increase. The forward roads will often have been taken over alignments with curves and gradients quite unsuited to a main lorry road. The latter must be laid out so as to reduce the quantity of earthwork to a minimum, and with this object in view a certain latitude as regards curves and gradient is permissible. The peace-time principle of balancing cut and fill applies equally in war-time.

The actual time and labour required for the earthwork will, of course, depend on the nature of the country; both will, however, be very greatly reduced by the use of mechanical excavators and graders. For example, an excavator with a bucket of ¾-cu. yd. capacity would have an output of some 500 cu. yd. per 8-hour day in average soil, with a lift and throw of 30 feet or so, a quantity of earthwork which it would take at least 200 men-days to complete by hand. Several such machines should be made available from the opening of any campaign in which a large amount of road work is probable. They have great cross-country capacity and can work well in advance of the completed road. Modern excavators run on heavy oil, and their fuel is thus easily transported. Owing to their vulnerability and slow speed, they should not normally be risked on work within range of the enemy's artillery.

Thorough consolidation of the formation by rolling is of the utmost importance. No form of foundation or surface will successfully

stand up to heavy traffic if there is serious settlement of the subsoil beneath.

Foundation and Surface.

Elaborate paved surfaces laid on concrete foundations, such as asphalt or wood-block paving, stone sets, etc., are out of place here owing to the time and skilled labour required for their construction and the quantity of material to be brought from a distance. At the most it would only be possible to lay such a surface in a few special situations where traffic is exceptionally concentrated, such as at a railhead loading point.

Of the expedients discussed for forward roads, corduroy roads and concrete slab wheel-tracks are unsuitable for extensive use on account of the large weight of material to be transported, combined with the comparatively poor surface which results. Wire weaving and gravel roads are not likely to stand up to the traffic in really wet weather, and in any case always need a good deal of maintenance. We are left with the bitumen-bound roads, and the surface oiling method of treatment, both of which are further considered below.

Dealing first with forms of construction in common practice in peace-time :—

(i) *Macadam Roads* on a hand-packed soling foundation, whether bound with water, tar, bitumen or cement. These roads suffer from two serious disadvantages in war-time construction :

(*a*) The enormous weight of stone required. Each ½-mile of a 20-foot road contains some 3,000 tons of stone.

(*b*) Their slowness in construction. One roller with 32 men will take 27 days to complete a ½-mile, even in peace-time conditions.

In the country we are considering the difficulty of obtaining suitable stone at all will rule out this type of road. It is worth noticing in passing that the weight of material to be handled and the slow rate of progress will always seriously prejudice the value of macadam road construction in war-time, even in districts where suitable stone is obtainable close along the alignment of the road, *e.g.*, on the N.W. frontier of India.

(ii) *Concrete Roads.*—A well-designed and well-constructed reinforced-concrete road has two advantages over a macadam road :

(*a*) The weight of material to be brought to the site is less, the total quantity required for ½-mile of 6-in. thick slab, 20 feet wide, being about 1,800 tons. Moreover, some 1,500 tons of this consists of aggregate, which will often be available within a short distance, leaving only 300 tons of cement and reinforcement to be brought from a distance.

(*b*) The rate of construction possible is slightly higher. A party of 30 men with one concrete mixer will lay ½-mile of this road in 25 days, though their work is liable to be held up if it rains. In addition, a period of four days must elapse after laying before the road can be opened to traffic, rapid-hardening cement being used.

On the other hand, a concrete road cannot be laid satisfactorily on gradients steeper than 1 in 30 or so.

Many engineers hold that, since concrete forms a rigid covering which is liable to crack up badly should any settlement of the subsoil take place, it is useless to lay a concrete road on recently made fills which have not had time to consolidate thoroughly. Reinforced-concrete roads have, however, been laid with great success on marshy ground, and it would seem quite possible to make a good concrete road over even newly made fills, provided that the filling has been carefully laid, rolled and drained, and that the slab is designed in accordance with the best practice. The details of design form in themselves a large and somewhat controversial question into which it is not proposed to enter here.

Bitumen Binding and Surface Oiling Methods.

Where a bitumen-bound earth or sand road is to be made on a large scale, on a main lorry road, the " mix-in-place " method is adopted. If the natural soil of the surface forms a suitable aggregate, a tractor-drawn harrow first scarifies the surface. A tank lorry then spreads the binder, and tractor-drawn bladers and graders complete the mixing *in situ* and re-spread the mixed material to camber.

In this way an extremely rapid rate of construction is achieved, 6,000 sq. yd. a day (*i.e.*, ½-mile of 20-foot road) being reported from Egypt, though a considerable amount of special plant is required.

The quantity of binder needed will vary with the nature of the soil from about 1½ gal. per sq. yd. normally, up to 4 gal. per sq. yd. in some cases. An average of, say, 2 gal. per sq. yd. is equivalent to some 80 tons per ½-mile of 20-foot road.

There should be no difficulty in securing an adequate supply, whatever form of binder is used—heavy oil rich in bitumen, cold bituminous emulsion, fluxed bitumen, etc.—all are in common use in civil practice. Moreover, the Persian oil fields and Iraq are large sources of supply of such oil and bitumen, and are conveniently situated in relation to operations in Kenya.

Where the natural soil is unsuitable as an aggregate, gravel or *murram* must be brought from outside and spread along the road. The subsequent mixing will be done by tractor-drawn plant as before, though the daily mileage of road completed will probably be halved. The quantity of gravel required will be about 700 tons per ½-mile of

20-foot road, so that in this case the rate at which gravel can be brought to the site will be the limiting factor determining the speed of construction.

The surface oiling treatment aims at giving a rate of progress at least equal to the "mix-in-place" method, without the elaborate plant necessary for the latter. A tank lorry fitted with a sprayer is all that is necessary. It is doubtful, though, whether this type of surface would be of much value on a main lorry road. Its unsuitability (as at present developed) for traffic other than pneumatic-tyred vehicles necessitates the provision of a separate track for horse transport, etc., which in many places would become quite impassable in the rainy season. Surface oiling is a rapid forward road expedient on certain firm soils, rather than a method of constructing a road to take all forms of traffic.

It must be remembered that both bitumen binding and surface oiling are essentially fair-weather processes. The former cannot (as far as our present experience goes) be carried out satisfactorily in really wet weather, while the latter demands an absolutely dry soil. All such work must consequently be done in the dry season before the rains set in.

Conclusions.

The forms of construction dealt with above are summarized in Table B.

Common to all these types of road is the preliminary earthwork, drainage and rolling of the formation, the time and labour spent on which will depend entirely on the nature of the ground. The most we can do is to expedite this part of the work by skilful location of the use of mechanical plant.

The table shows clearly the overwhelming advantages of the "mix-in-place" road, carried out with the natural soil of the formation. While this method will probably prove satisfactory on the sandy soil of the bush and on the loam of the uplands, it is, perhaps, too much to expect that it will equally be successful on black cotton soil. On the latter, therefore, a concrete road is recommended. A main lorry road should be located with a view to avoiding cotton soil as far as possible, and only comparatively short stretches of concrete road should be necessary. In addition, a concrete surface will be found necessary in places where traffic is exceptionally heavy, such as at railhead loading points, entrances to dumps, lorry standings, etc.

The laying of the concrete stretches will proceed simultaneously with the "mix-in-place" work, so that the general rate of construction of a main lorry road should not be affected thereby. Where the earthwork is not heavy, it should be possible to complete ½-mile of 20-foot road (or 1 mile of 10-foot road) per day.

TABLE B.

Type of Construction.	*Time to complete ½-mile of 20-ft. Road.*	*Labour and principal items of Plant.*	*Weight of Material per ½-mile of 20 ft. Road.*	*Remarks.*
(i) Macadam Road (*e.g.*, bitumen grouted and sealed).	27 days.	32 men. 1 roller.	3,000 tons stone 80 tons bitumen Say 120 tons per day.	Stone practically unobtainable in the area of operations.
(ii) Concrete Road (slab 6-in. thick).	25 days.	30 men. 2 concrete mixers.	1,800 tons. Say 60 tons per day.	1,500 tons of this is aggregate, which may be found at or near the site. Traffic allowed on the road 4 days after laying.
(iii) Bitumen Binding by "Mix-in-Place" method :— (*a*) With natural soil of road bed.	1 day.	40 men. 5 tractors with harrow, grader and blader. 1 sprayer. 2 light rollers.	80 tons oil or bitumen.	Pneumatic-tyred traffic allowed on road at once; other traffic after about three days.
(*b*) With imported aggregate.	2 days.	Ditto.	700 tons aggregate 80 tons bitumen Say 390 tons per day.	Ditto. Rate of transport of gravel will be limiting factor.
(iv) Surface Oiling.	1 day.	1 sprayer.	35 tons oil.	Suitable only on firm soil and for pneumatic-tyred vehicles.

(No actual figures available.)

Note.—(1) The time and labour figures given are for undisturbed work with skilled labour—appropriate allowances must in all cases be made for war-time conditions and unskilled personnel. (2) Progress will be doubled in types (ii), (iii) and (iv) if only a 10-foot road is laid.

Organization, Equipment and Training.

The Control of Road Construction and Maintenance.

The Manual of Movement, Sec. 105 (1), lays down that road work " will be usually organized in two areas, separated by an arbitrary line, drawn at a convenient distance from the front as may be agreed between those concerned under instructions issued by Q.M.G. This line may be varied from time to time as circumstances dictate. The forward area comes under the orders of the engineer organizations of the fighting formations, the back area under the orders of representatives of the Director of Works."

It is thus left open to us to suggest what portion of the work shall be the responsibility of the C.R.E's of the Divisions, and what the responsibilities of C.R.E's, L. of C. areas. We have seen that the road work falls technically into two distinct classes, which have been for convenience termed the " forward road " and " main lorry road " types of construction. This, then, would appear to be the best division of responsibility. The " arbitrary line " referred to in the *Manual of Movement* will be drawn through the foremost points reached by the main lorry roads. This may be as far back as the refilling points. As the main lorry roads are pushed ahead in anticipation of an advance or of the rainy season, so will the " arbitrary line " move forward.

The maintenance of a road should be the responsibility of the authority that constructed it. Forward roads will thus normally remain in the charge of the Divisional C.R.E. until they are converted into main lorry roads. As the force advances, forward roads not required for conversion will often be abandoned, but if their retention is considered necessary they may be taken over by the C.R.E., L. of C. area, when they fall far behind the " arbitrary line."

The importance of close co-operation between those responsible for the two classes of road has already been pointed out, especially as regards the survey and location of the road systems. Quoting again the *Manual of Movement*, Sec. 105 (1), " very close co-operation between the authorities responsible for the two areas is always necessary, especially in phases of operations resulting in the movement of the dividing line between them."

Organization and Equipment of Units engaged in Road Work.

The work involved in the construction of forward roads, which requires no special plant, should be within the power of the Divisional Engineers as at present equipped. Infantry working parties may be brought in to assist in situations where, for example, considerable earthwork is required.

For the construction of the main lorry roads, our present *War*

Establishments provide Army Troops Companies and Road Construction Companies. Many calls will be made on the former, and their employment on roads must be limited to the more technical work, such as the construction of bridges, culverts and large retaining walls. They may also be able to give technical supervision to the concrete surfacing, without, however, supplying the labour for the work.

By far the greater part of the road work will fall on the Road Construction Companies, and it is clearly important that they should be able to carry out this task. Each company, as at present organized, consists of a skilled headquarters of R.E. officers and N.C.O's and 250 native labourers. They are not provided with any of the mechanical road-making plant necessary to achieve a satisfactory rate of progress. Whatever type of road is made, excavators and medium-weight rollers will be needed for the preparation of the formation. Where "mix-in-place" methods are adopted, tractors drawing harrows, graders and bladers will also be required. Concrete mixers are essential for work on small culverts or concrete surfacing. All this plant is unlikely to be found in an undeveloped country; if any existed in peace-time in the leading towns, it would probably be removed or destroyed by the enemy before the landing of our force.

It is suggested, therefore, that a Road Construction Company be provided with such plant, without which it can do little. A typical list of the main items of its mechanical equipment might be:—

1 excavator of ½- or ¾-cu. yd. bucket capacity with both bucket and drag-line equipment.
1 8-ton roller.
1 2-ton roller.
2 concrete mixers, of between 5 and. 10 cu. ft. capacity.
1 tank lorry with sprayer attachment.
(30 H.P. tractors, on a scale of about four per corps, with harrow, grader and blader, might be kept at the Engineer Base Depot for use when required.)

These machines will all be petrol or diesel engined and require drivers. Under existing *War Establishments* the drivers will have to be drawn from the 60 engine (i.c.) hands in the E. and M. Company (L. of C.), unless local inhabitants can be found to do the work. The handling of this plant on the work, however, demands a certain degree of skill and experience, particularly as regards the excavators and rollers. It would be much better if the drivers formed part of the Road Construction Company itself.

Neither plant nor drivers need be held in peace-time, but they should be earmarked for war. The headquarters of the unit will, in

effect, become part of the Supplementary Reserve, and contain men accustomed to the handling of these machines. The unskilled labour necessary to complete the unit will still be drawn from local sources.

Training and Research.

The normal fieldworks training of R.E. units should be such as will fit them to undertake the expedients recommended for forward road work. This is already largely the case, though more stress might be laid on wire weaving work than is usual at present, and opportunities for work on bitumen-bound earth or sand roads, using a concrete mixer, are still rare. It is to be hoped that before long most R.E. units will have the chance of seeing such a road laid, if not of laying one themselves.

The urgent importance of further research, both in the laboratory and in the field, on bitumen-bound roads must be emphasized. Our present knowledge of the types of soil to which this method is applicable is very limited. More detailed information is needed as to the best specification of oil or bitumen to apply to any given soil, and as to the wearing properties of these roads in varying climates.

It is unfortunate that an R.E. officer's peace-time experience of roads is so largely confined to macadam roads—a form of construction that will rarely be of value in war. Officers should take every opportunity of becoming familiar with details of other methods of road making, and so be prepared to undertake in war whatever type of construction circumstances indicate to be most suitable.

GREYMOUTH HARBOUR—NEW ZEALAND.

By CAPTAIN E. C. SCHNACKENBERG, B.SC., A.A.S.E., N.Z.E.

GREYMOUTH HARBOUR, on the west coast of the South Island of New Zealand, presents novel and complicated problems for a harbour engineer, and the following notes, dealing more particularly with a recent large quarry blast involving 14,600 pounds of powder, are written accordingly, with the hope that they will be of interest to brother officers of the Corps.

THE PORT.

The port, situated at the mouth of the Grey River, with a bar at its entrance, has a normal tidal range of 4′ 6″ for neaps, and 9′ for springs, and at extraordinary tides 4′ and 10′ respectively.

One and a half miles up-river from the present harbour entrance is a water-gap, through which the Grey River flows on its way to the sea. Before training walls were built to define its position, the entrance would shift from place to place, owing to the various meanderings of the river flowing from the water-gap through the extensive shingle beds of the coastal plain, on which now stand the towns of Greymouth—population 6,180—and Cobden—1,190. (See Drawing 1, and Photo. 1.)

The existing breakwaters and internal half-tide training walls, extending seaward on the southern and northern sides of the river, are designed as training walls for the river, and the breakwaters have been extended from time to time with a view to reaching deeper water.

Very little dredging is done, it being almost restricted to the berthage area, the average annual cost for the years 1921 to 1931 being £4,500. It is impracticable to dredge on the bar.

The available berthage in the river, with a minimum depth of between 18′ and 20′ at M.L.W.S., amounts to 3,132 lin. ft., which is ample for the tonnage and class of vessel visiting the port. In 1910, for a peak registered tonnage of 383,816 tons and 2,673 lin. ft. of berthage, there was the not excessive rate of 143 tons per lin. ft., since when, with a declining tonnage to 203,691 tons in 1930 and 3,132 lin. ft. of berthage, there is the equivalent of 65 tons per lin. ft.

The largest vessel at present working the port is one of 2,550 tons gross, or 1,513 tons net register, being 303′ long, of beam 46′, and of moulded depth 20′ 2″.

Photo 1.—Greymouth Harbour.

Greymouth harbour - New Zealand 1

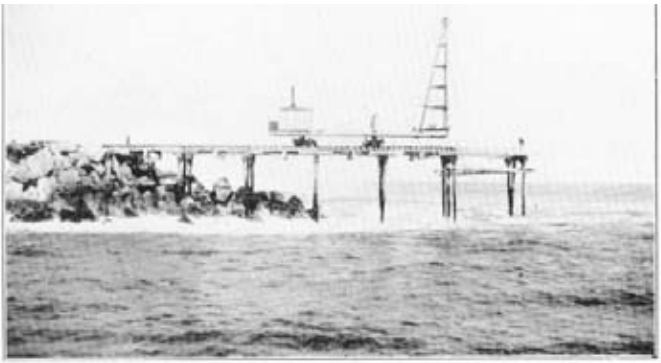


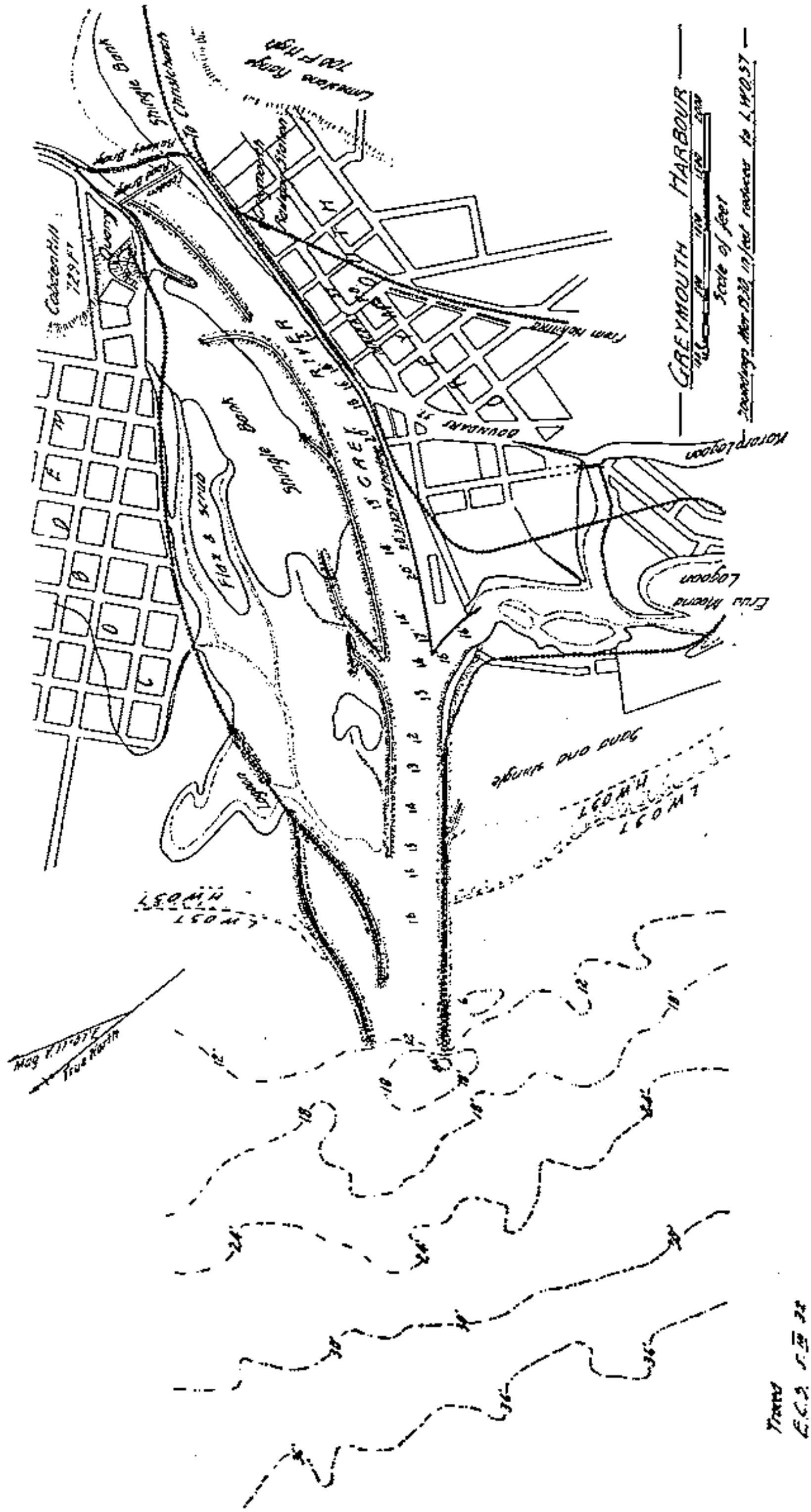
Photo 2.—South breakwater extension—staging and pile-driver.

Photo 3.—Quarry before blast, showing working face.

Photo 4.—Quarry after blast.

Greymouth harbour - New Zealand 2-4.

DRAWING 1.


GREYMOUTH HARBOUR
Scale of feet
GREY RIVER
Shingle Bank
Flax & Scrub
Karoro Lagoon
Cobden Hill 729 Ft
Limestone Range 700 Ft High
to Christchurch
from Hokitika
Boundary St
Sand and shingle
Lagoon
Mag. True North

The wharf is served by a railway, and equipped with five travelling hydraulic and two steam cranes of capacities varying from 5 to 15 tons.

The control of the port is vested in the Greymouth Harbour Board, all the members of which are government nominees.

The port has a considerable trade, principally in coal and timber, and a growing one in butter and cheese, which together make it the sixth largest port in New Zealand. The tables below indicate the extent of the port's trade and shipping, while it is to be noted that the great falling off during the years 1931 and 1932 is due to the economic situation which overshadows the whole world to-day. There has also been a falling off since the middle of 1923 due to the completion of the Otira tunnel, which has given rail connection between Canterbury and the west coast.

TRADE.

YEAR ENDING MARCH.	POPULATION HARBOUR RATING AREA.	EXPORTS.			IMPORTS, TONS.
		COAL, TONS.	TIMBER, C.B.M.	GENERAL MERCHANDISE, TONS.	
Average, 1911-30 ...	24,937	309,079	43,922,349	4,449	28,642
1931 ...	25,000	289,516	22,125,066	1,188	14,913
1932 ...	—	200,560	19,591,475	1,248	10,272

SHIPPING.

YEAR ENDING MARCH.	NO. OF VESSELS.	TOTAL REG. TONNAGE.	AVERAGE TONNAGE.
Average, 1911-30 ...	477	243,377	510
1931 ...	276	172,799	626
1932 ...	229	149,593	653

THE GREY BAR.

For over half a century, engineers have been reporting on the Greymouth Harbour with a view to overcoming the serious handicap to the trade of the port caused by the bar, which still demonstrates the fact that it is a troublesome element. For days at a time, vessels have been held up unable to sail, owing to either too heavy a sea on the bar, or lack of water due to shoaling. For example, during the three years previous to December, 1931, the bar was unworkable for an average of 40 days in the year. What is still wanted is a scheme which will give Greymouth a safe harbour to be

worked practically at all times and by larger vessels, but, unfortunately, it appears that the cost of any such scheme would be prohibitive.

Nature has provided three great forces to test the ingenuity and patience of the Engineer to the Board. The condition of the bar depends on the result of their combination.

1. The Grey River.

The Grey River, a torrent rising in the precipitous mountains of the Southern Alps with a rapid descent to the sea, is subject after heavy rains, or from the melting of the snows, or from both combined, to sudden floods of great height and force, giving a sufficient velocity for the transportation of large quantities of detritus. With a watershed area of 1,487 square miles, and an average coastal annual rainfall of 99 inches—registered in Greymouth over the past 39 years—rising to 200 inches at the source, the river is estimated to have a normal fresh-water discharge of 4,400 cusecs, and has an average velocity of from 1 to 2 knots, or in times of flood, up to 10 and even 11 knots, with a corresponding discharge of approximately 150,000 cusecs.

2. Littoral Shingle Drift.

The west coast of the South Island, in common with various other parts of the coast of New Zealand, possesses a strong littoral drift, or constant stream of moving material derived from the wastage of headlands and denudation in some places, together with the enormous supplies of shingle and sand transported to the coast by the rivers to the south of Greymouth. The Southern Alps are comparatively close to the sea, varying in distance from approximately 40 miles at Greymouth to about 24 miles at Hari Hari, which is 56 miles south of Greymouth. In consequence the rivers of this area have extremely steep gradients, and in times of heavy rains and melting snows, huge discharges. Nearly the whole of this area, from the foothills to the sea, is covered with ancient morainic material, and thus there are immense deposits of shingle and sand to be swept down to the sea or denuded from beach and cliffs with the greatest of ease. It is believed* that the better water obtaining of late years across the bar is partly due to a diminution of the supplies of shingle and sand carried in the littoral drift, since, with the decline of gold-mining by sluicing in the watersheds of the rivers to the south of Greymouth, the quantity of sand and gravels carried down to the coast must necessarily have become less.

The principal causes of littoral drift being tidal current, wind and

* Report of Commission, Greymouth Harbour Board, 1925.

wave action, the resultant direction of flow must of necessity be determined by the predominant combination of these. In the case of the west coast of the South Island, the currents produced by tidal action travel parallel to the shore from south to north, which is the direction of the prevailing drift. Opinions* differ, though, as to what is the predominant factor. Mr. Sharp, from float tests in calm weather, has found a fairly constant current travelling northward at the rate of about one and a half miles per hour, but he has also observed, during heavy gales from the north-west, a reverse induced current. The combination of an oblique on-shore wind and wave action must be a large factor towards the formation of littoral drift. Anyone who has bathed on an exposed west coast beach, particularly on those immediately to the north and south of the Greymouth breakwaters, has experienced that strong and swift undertow induced by wind and wave action.

3. Rough Conditions on Bar.

A very heavy sea rolls in practically the whole time, the worst seas coming from a direction, W.S.W. magnetic, which is that of the prevailing wind. This sea is largely caused by the long fetch, or distance of open sea stretching uninterruptedly for thousands of miles, across which the wind blows before reaching the coast line. It is quite common for the roughest sea on the bar to synchronize with fine and calm weather locally. It is this sea which prohibits, for more than two or three days in the year, favourable conditions for dredging on the bar, while during the long intervening periods what good work could have been done would be nullified. Experienced dredgemasters here are of the opinion that anything over a 3′ sea would be too rough for dredging, but that while a dredge might operate on a 4′ sea, the rougher conditions would enable little efficient work to be done, and that at the same time there would be a definite risk involved for the suction gear and for the vessel in the restricted confines of the breakwaters.

Usually during a dry summer and autumn, resulting in low river flow, there is severe shoaling on the bar. There was such a period early in 1925. In April there was only 5·28″ of rain, May 3·12″, and June 4·62″, resulting in a depth on the bar early in July of only 7′ at L.W.O.S.T. At the end of July, however, a small fresh increased the bar depth to 13′ at L.W.O.S.T.

The best conditions for improvement of the bar seem to be a fresh in the river and at the same time a sea sufficiently rough to keep the sand and shingle of the bar stirred up. The state of the sea is apparently the more important factor. A small fresh in the river and a suitable sea quite often result in a much improved bar, while

*H. H. Sharp, Assoc.M. Inst.C.E., *Proceedings N.Z. Soc. C.E.*, 1915-16.

a big fresh with the wrong kind of sea will give poor conditions. Drawing 2 indicates the typical conditions on the bar before and after a strong fresh accompanied by a suitable rough sea.

Breakwaters and Training Walls.

To gain the utmost scouring effect from the ebb current of the river, it would obviously be necessary to limit the width of the entrance, so that what might be lost in width would be gained in depth, by the concentration of the current. This has been the general policy of the Board since Sir John Coode's report of 1879, divergence from it being merely as to detail. Sir John advised an entrance width of 400 ft. at L.W.O.S.T., and an overlap by the south breakwater of 120', to give an estimated depth of 18' at H.W.O.S.T.

Mariners have from time to time expressed the opinion that an overlap by the south breakwater would give better shelter to the bar, thus making it easier for navigation than with coterminous breakwaters. It has been found, however, that an increase in overlap decreases the scour, and, in consequence, the depth on the bar. It is considered that the safety of shipping must depend primarily on sufficient bar depth, and anything detracting from this must be detrimental to the port, even though the bar, owing to smoother conditions, might be easier for navigation.

Sir John's recommended entrance width was increased to 450', and by 1887 there was an improvement in bar depth at H.W.O.S.T. from 13' 4" in 1884 to 17' 6". In 1891, with an overlap of 570', there was the average depth of 21' 11", while a decreased overlap steadily improved the bar depth. An unfortunate increase in entrance width to 600' gave immediate shoaling, while the later reduction to 500' caused improved conditions which have since been maintained, the average depth for the 10 years 1921 to 1930 being 23', and during 1931 25' 6", a depth better by 1' than the previous record.

From these experiments with the variation of overlap and entrance width, it is considered that the best conditions on the bar result from coterminous breakwaters and a 500' entrance width.

Furkert Scheme.

With the object of improving the entrance and the harbour generally, a Commission of three engineers was appointed consisting of:

Colonel F. W. Furkert, C.M.G., M.INST.C.E., M.I.MECH.E., Engineer-in-Chief, P.W.D., Chairman,
Wm. Ferguson, Esq., M.A., B.A.I., M.INST.C.E., M.I.MECH.E., and
The late J. Blair Mason, Esq., M.INST.C.E.,

who, in February, 1925, presented a report embodying recommendations for the extension of the existing breakwaters, together with the dredging of the Kororo and Erua Moana Lagoons—all the works to be done out of the Board's revenue.

WORKS CONSTRUCTED AND UNDER CONSTRUCTION.

The first extension, recommended by the Commission, of the north breakwater by 220', to a point coterminous with the south breakwater, was completed early in 1930, the expenditure being £34,000. This extension seemed to have immediate noticeable results—record depth of 25' 6" during 1931.

It was decided, in July, 1930, to extend the north and south breakwaters simultaneously for 150' as the quickest and most direct means of giving an improved working depth. As Colonel Furkert pointed out, "experience has indicated that so far as the moles have been carried to date—at both Westport and Greymouth—their extension has resulted in improvement, and this improvement can confidently be expected with reasonable future extensions. Similarly any increase in the tidal area of any port automatically improves the scour and deepens the channel, so that dredging of the lagoon, thereby increasing the size of the tidal compartment, would improve the depth in the channel, whether the moles were extended or not, and the two things would be mutually beneficial."

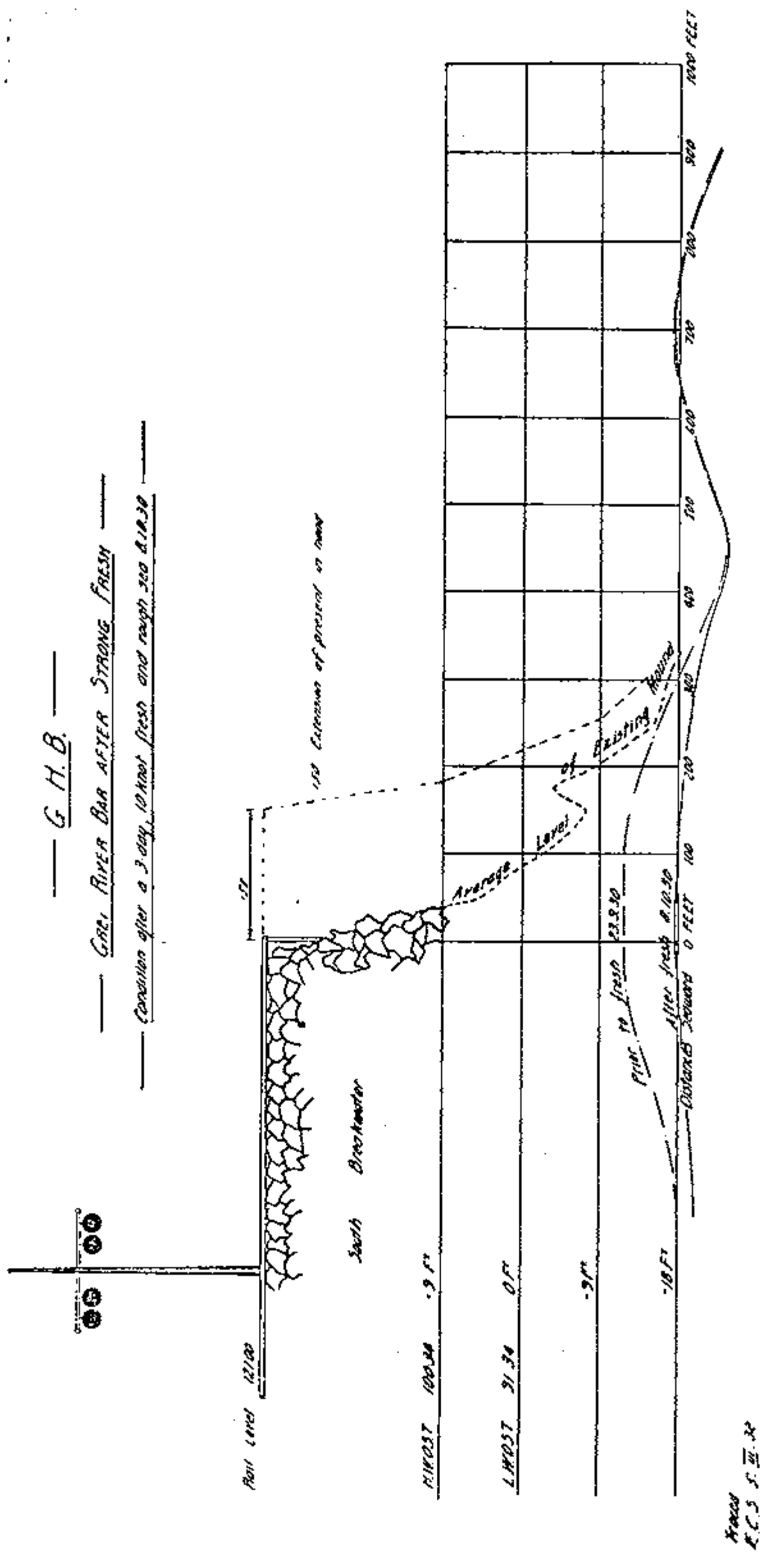
This 150' extension is now in hand, the estimated expenditure involved being as follows :—

North Breakwater, 60,000 tons at 9s. ..	£27,000
South Breakwater, 41,000 tons at 10s. 3d. ..	£21,000
Plant and 10% for contingencies	£23,000
	£71,000

For this expenditure a three and a half years' programme is anticipated, to enable the Board to do the work out of revenue.

The present extension is being carried out from staging, this being considered the best method, even though considerable difficulty may be expected and storm losses faced. It was thought that the initial cost and time involved in this could be more than counterbalanced by the general saving in rock volume usually effected by this system, which permits of the bottom stone being placed more quickly over a longer length, and with a proportionate reduction in end scour. It is not proposed, on account of the severe periodical storms which are to be expected, to use any great amount of other than first- and second-class stone. See Appendix I for classification of stone.

DRAWING 2.


G. H. B.
Grey River Bar after Strong Fresh
Condition after a 3 day, 10 knot fresh and rough sea 8.10.30
150 Extension of present in hand
15'
Average Level of Existing Ground
South Breakwater
Rail Level 121.00
H.W.O.S.T. 100.34 +9 Ft
L.W.O.S.T. 91.34 0 Ft
-9 Ft
-18 Ft
Prior to fresh 23.9.30
After fresh 8.10.30
Distance Seaward
0 FEET
100
200
300
400
500
600
700
800
900
1000 FEET

The 200′ of staging was commenced in April, 1931, and completed by August. Excepting the piles for the last pier, all were driven with considerable difficulty through a mound which is about 6′ below L.W., using ironbark piles, *eucalyptus crebra*. This mound consists almost entirely of first-class stone, being all that is left of a 150′ extension finished in 1903 to a level of 6′ above H.W.O.S.T. Pile shoes of the diamond point type were tried first, but proved unsatisfactory, while the conical cast-steel shoe, shown in Drawing 3, gave every satisfaction. Photo 2, and Drawing 3, give an idea of the method of the staging construction.

The pile-driving gear consisted of a 4-bogie undercarriage, bearing a framework of four ironbark piles each 65′ long, so arranged as to be capable of sliding sideways on the rolled steel joists which separated the bogies. Cantilevered out on this ironbark pile framework, 26′ 6″ from the centre of the outer pair of bogies, was a 40′ piling frame, while at the other end were the usual boiler and winch. During driving the bogies were clipped to the rails, and, by the available sideways motion, the piling frame could be shifted to drive the outer pile rows.

Cobden Quarry.

The stone used in the recent breakwater extensions has all come from the Cobden Quarry, which, with a practically unlimited supply, can be quarried under almost ideal conditions. The quarry is on the northern side of the water-gap which separates the two portions of the Rapahoe Range—a narrow ridge some 10 miles in length, with the highest point 1,462′ above sea-level. The range is an arenaceous limestone—Cobden limestone—underlain by mudstone.

The Cobden limestone, of a total thickness of about 700′ at the quarry, is in the main a yellowish-white, moderately soft rock, with a north and south strike and dipping at angles of from 25 to 32 degrees to the west. The rock, which weighs about 13 to 14 cub. ft. to the ton, weathers well, the worst condition apparently being when exposed to salt spray. A recent analysis of three typical samples gave the following results :—

A—a top seam, about 20′ thick, nearly worked out.
B—a middle seam, about 18′ thick.
C—a bottom seam, about 20′ thick; poor for breakwater purposes.

	A.	*B*.	*C*.
Insoluble materials (silica, etc.) ..	15·16%	14·55%	33·02%
Residue after roasting ..	62·70%	61·80%	72·26%
$CaCO_3$	80·23%	82·27%	60·06%

The total output from the quarry during the six years 1926 to 1931 was 167,049 tons, of which first-class stone was 42·8%, second-

class 13·9%, first and second together 56·7%, and third-class and spoil together 43·3%. One of the biggest problems and items of cost is the disposal of the third-class stone and spoil, which is practically useless for breakwater purposes.

Working of Quarry.

The quarry, as may be seen from Photos 3 and 4, consists of parallel strata of rock dipping at an angle of about 32 degrees. The strata are considerably broken, and some are separated by a layer of mullock.

Two methods of working the quarry are in use, that of benching and that of blasting by means of tunnel shots. It is considered that conditions must be ideal for benching to give satisfactory results, and with the character of the rock changing from this ideal state as the work in the quarry progresses, a tunnel shot is used.

For instance, one in 1912, using 4,300 pounds of Kynock's blasting powder, brought down an estimated quantity of 42,000 tons of rock, together with 31,000 tons which slid off an upper face remote from the shot. Again, in 1928, a charge of 8,900 pounds of blasting powder was fired—an undercharge to safeguard buildings and to prevent undue fracture—which "well loosened" an estimated volume totalling 48,000 tons, while a further 80,000 tons came down during the earthquake of 17th June, 1929, evidently having been loosened as a result of this shot.

In view of the necessity for obtaining an immediate large output of first-class stone for the south breakwater extension, it was decided last year to concentrate on a large blast.

Preparing for the Blast.

Accordingly, the output of heavier stone was suspended, but the removal of mullock and third-class stone from the toe of the western face in preparation for the shot was proceeded with, and altogether some 10,000 tons were so removed. See Photo 3 for the cleaned-up toe. The whole face was well cut down to the level of the floor, and even undercut a little at the bottom.

A preliminary survey indicated the general scheme of two tunnels with comparatively long cross-drives, the idea being to drive the tunnels from the southern face about 100 feet back into the quarry with one tunnel about 50′ above the other. No. 1 tunnel was commenced on November 5th, working three shifts per day, work on No. 2 being deferred until the toe of the western face was cleared. No. 1 tunnel had advanced 97′ when a further consideration of the project, with the information gained from the tunnel section and from the clearing of the toe, modified the original scheme to one of

three main tunnels with side pockets for the charges, the idea being finally to locate the pockets and charges in each tunnel after an examination of the stone met with in driving. The three tunnels, of total length 392', were completed on February 3rd in 165 shifts of two men per shift. Appendix II gives data of cost and rate of tunnelling.

CALCULATION OF CHARGES.

Henry A. Gordon, ASSOC.M.INST.C.E., F.G.S., late Inspecting Engineer, Mines Department, N.Z., carried out a number of large blasts in Cobden Quarry in the 'eighties, and in his *Miners' Guide* explains that from the observed character of the rock, "the blast was so proportioned that the height overhead was not more than one and a half times the line of least resistance, and the quantity of explosive used was proportional to the cube of that resistance."

Gordon's formulæ were :—

$$L = \frac{2}{3} D$$

$$C = \frac{L^3}{E} \qquad \text{where,}$$

L = length of Line of Least Resistance (L.L.R.), in feet.
D = depth of charge below the surface, in feet.
C = charge used, in pounds.
E = coefficient, depending on the explosive used.

Gordon further says, "If we take gunpowder as unity, and the coefficient of strength, as found by experiment, to be for powder 32, the other coefficients will be got from the following table of experiments on explosives" :—

NAME OF EXPLOSIVE.	STRENGTH OF DIFFERENT EXPLOSIVES TAKING GUNPOWDER AS UNITY.	SPECIFIC GRAVITY OF EXPLOSIVES, TAKING GUNPOWDER AS UNITY.	VALUE OF E, BEING COEFFICIENT USED FOR QUANTITY OF EACH EXPLOSIVE.
Gunpowder	1·00	1·00	32
Dynamite	2·88	1·65	92·1
Gelignite	2·94	1·65	94·1
Gelatine-Dynamite ...	3·54	1·59	113·3
Blasting-gelatine ...	4·09	1·60	130·9

Blasting powder had been found to be satisfactory in previous blasts, so it was decided to use it again, together with Gordon's formulæ, but for "E" to use the factor 36. This value of the coefficient agrees with that used in calculating the charges for the 1928 blast, and also the value of "K" given by Molesworth for use in the commonly accepted formula, $C = L^3 \times K$, where his

coefficient "K" is the reciprocal of Gordon's coefficient "E." For soft rock, using blasting powder as the explosive, Molesworth gives

$$K = \cdot0278, \text{ or, } E = \frac{1}{K} = \frac{1}{\cdot0278} = 36.$$

In order to check the quantity of the charges as calculated by these formulæ, each charge was treated as if for a mine. Then, by substituting the value of each charge in the formulæ given below from the *Manual of Military Engineering*, Vol. III, the effective radii of rupture were calculated.

$$\text{Effective H.R.R.} = K \sqrt[3]{C\frac{\cdot10e}{S}} \quad \text{and}$$

Effective V.R.R. = 0·7 effective H.R.R., where
H.R.R. = Horizontal Radius of Rupture, in feet.
V.R.R. = Vertical Radius of Rupture, in feet.
K = coefficient, dependent on the nature of the rock.
= 1·4 assumed for limestone.
e = explosive factor = 1·0 for blasting powder.
S = soil factor = 2·0 assumed for limestone.
C = charge used, in pounds.

These radii of rupture were then plotted in plan and in section —see Drawing 4 for plotting together with a summary of L.L.R., H.R.R. and V.R.R.; Appendix IV for calculations.

It will be noticed from the drawing that the ellipsoids cover the volume of the blast fairly well, taking into account the section of rock marked on the plan "loose rock."

Charging the Blast.

Eight boxes, each sufficiently large to contain the whole of the charge intended for their respective chambers, were made up out of ½" tongued-and-grooved dry timber. These were put together in the chambers, leaving the top half of the front open until the charge was placed. They were lined inside—those for No. 3 tunnel both inside and out—with bitumen-impregnated felt which was well lapped and tarred. Selected tamping was then placed round the box.

A ramp track was constructed up the southern face, which was served by a truck drawn by a 2 h.p. electric winch. Up this ramp were drawn the powder boxes to the tunnel mouth, where they were opened and then handed along into the tunnel by a string of men inside, and in the reverse direction the returned empties. The back-filling for tamping, and the quick-hardening cement concrete for the plugs—see page 68—were loaded into empty powder boxes with flax handles and taken into the tunnel by the same method.

Of course, as the tamping progressed, fewer men were required in the tunnel.

Loading the chambers was commenced with No. 1 tunnel, the total charge of 14,600 lb. of blasting powder being loaded by an average of 20 men in the net time of 11 hours. The loading of chamber H was completed six days after the commencement of chamber A, the delay being due to the necessary cessation of work, caused by the rain which fell after tunnel No. 1 was completed, and which leaked through the rock fissures into the bottom tunnels. Rain again fell heavily after the charging of No. 3 tunnel was completed, continuing until the early hours of the following morning, the morning of the blast, but that no water leaked into the boxes to damage the powder is indicated by the success of the shot.

TAMPING.

A chamber having been loaded, the electrical connections were tested, taking the same precautions as though for the shot itself, and the concrete plugs were then placed and tamping commenced. In front of each box there were first 6″ of soft tamping, and then, to seal the chamber, a 12″ concrete plug—using quick-hardening cement—which was extended across the tunnel and 6″ to either side of the chamber. See Drawing 4 for typical arrangement of concrete plug and tamping at chamber mouth. 128 cub. yd. of tamping and 18 cub. yd. of concrete were used in back-filling a length of 324′ of tunnel, including the plugs. The tamping was not brought right to the entrance of each tunnel. This tamping and concrete work was placed in 84 hours by an average number of 18 men per shift, the electrical circuits all being retested at each change of shift. The concrete plug for chamber H was completed at 2 p.m. on the 24th, the tamping of the tunnel completed by 7.30 p.m. the same day, and the shot was fired at 6.40 a.m. the following morning, the 25th February, 1932.

IGNITION SYSTEM.

It had been decided to use two independent electrical systems, and, when the time came, to fire these simultaneously. Each system consisted of three series circuits, one for each tunnel, joined in parallel outside the tunnels, each circuit having the detonators—two No. 7 per chamber—in series. The first, or red system, used a packet—5 pounds—of gelignite as a primer in each chamber. Into this packet were inserted the two detonators, while, one on either side of it, were tied two more packets. The second, or black system, used in each chamber a 25′ length of Cordeau-Bickford detonating fuze wound into the charge, the two detonators for the chamber being placed one in either end of the length of fuze. As a result each chamber had four detonators, two for each system. The four

leads into each tunnel were encased in a square grooved timber trough, 2" x 1", with a wooden cover nailed on, whose joints were staggered with those of the trough. It shows faithfulness in the workmanship and excellence in the supervision in that right through the proceedings the continuity tests were perfect.

In the bottom, or third tunnel, there was an extra in the way of a primer. Here, a box—50 pounds—of gelignite was placed in chamber F, and half a box in each of the chambers G and H, as an extra to the three packets of gelignite of the red system, and the Cordeau fuze of the black system. The purpose of this gelignite was to give a boost to, or to accelerate the combustion of, the powder in these chambers, the idea being, if possible, to get a momentarily earlier explosion and to give a slight extra kick to lift the toe—shown in Photo 3—so that the whole block of rock above the tunnels might slide down on to the quarry floor. That this purpose was to a certain extent realized may be gathered by comparing the photos before and after, 3 and 4. By the fact, however, that more rock did not slide down on to the quarry floor, it has been concluded that, if anything, the shot was not overcharged. The shot was fired from the Greymouth end of the Cobden Bridge, some 300 yards away, by power from the mains stepped down to 26 volts A.C.

Relative Quantity of Explosive.

The estimated quantity of stone to be brought down in the blast had been put at 75,000 tons, equivalent to 5·1 tons of rock per pound of blasting powder used. The actual quantity brought down has been estimated from survey—see Drawing 4 for edge of quarry after the shot—at 105,000 tons, equivalent to 7·2 tons per pound of powder. See Appendix III for summary of costs of blast. It is of interest in reference to this edge-of-quarry-after-shot line—marked *P*, *Q*, *R* on Drawing 4—that this new southern face line is a perfectly clean break with no sign of any surface cracks running back into the solid rock.

The quantity compares with 3·46 tons of rock for every pound of blasting powder in Gordon's largest blast of 1882, using 6,000 pounds of dynamite, an average considered by him large, since he thought the blast had every advantage, and 9·8 tons for the rock actually thrown down by the blast in 1912.

Gordon concluded as a result of his blasts in the quarry that, " the average quantity of rock blasted for every pound of ordinary blasting powder is $2\frac{3}{4}$ tons in large blasts." Molesworth agrees with this. Results at Fishguard Harbour, for a hard rock of vitreous texture, vary from 3·5 tons to 7·2 tons of rock per pound of powder, while the quartz rock at Holyhead Breakwater gave an average of 4 tons, with extremes from 2 to 5 tons of rock per pound of powder.

Mr. John R. Leggo, N.Z. Representative for Nobel's, told the

writer that he uses a maximum of 10 tons of rock for every pound of gelignite, which reduces to, say, 5 tons of rock for every pound of blasting powder. He then considers the rock factor—a factor to be gained only by experience—and reduces his estimate accordingly. He said that for this blast he would have used the maximum of 5 tons to a pound of powder.

Acknowledgments.

The author is indebted to the following gentlemen: T. A. Johnston, Esq., B.SC. (ENG.), ASSOC.M.INST.C.E., Harbour Engineer and District Engineer, P.W.D.; David C. Milne, Esq., B.SC. (ENG.), Assistant Harbour Engineer; John R. Leggo, Esq., Nobel's N.Z. Representative. Some of the photos are by Mr. Milne.

APPENDIX I.

CLASSIFICATION OF STONE AT COBDEN QUARRY.

1st Class	25 tons–10 tons.
2nd Class	10 tons– 2 tons.
3rd Class	2 tons– 1 ton.
Box stone (spoil)	1 ton down.

APPENDIX II.

COST OF TUNNELLING AT COBDEN QUARRY, 5/11/31–3/2/32.

	Costs.			*Cost per lin. ft.*		
	£	s.	d.	£	s.	d.
Explosives, Detonators and Fuze ...	74	9	0	0	3	9
Power	52	6	6	0	2	8
Lighting	6	1	1	0	0	4
Miscellaneous	24	0	0	0	1	3
Labour—unit wage 17s. 6d.	284	14	2	0	14	6
Totals	£441	10	9	£1	2	6

Length of tunnels driven	392 ft. 6 in.
Average cross-sectional area	12·1 sq. ft.
Volume of rock excavated	178 cub. yd.
Cost per cubic yard	£2 9s. 5d.
Weight of gelignite used	575 pounds.
Weight of rock per pound of gelignite	·62 tons.
Volume of rock per pound of gelignite	1·24 cub. yd.
Number of shifts, 2 men per shift	165 shifts.
Average rate per shift	2·4 lin. ft.

APPENDIX III.

COST OF BLAST AT COBDEN QUARRY, 25/2/32.

	£	s.	d.	Costs. £	s.	d.	Cost per ton.
Driving tunnels :							
See Appendix II				441	10	9	1·01d.
Tamping, Loading and Concrete :							
Wages—unit 16s. 6d. ...	185	8	1				
Cement	24	0	0				
				209	8	1	·48d.
Explosives :							
Powder, 14,600 lb. ...	927	14	2				
Gelignite, 3 cases ...	11	11	0				
Fuze and Detonators ...	4	16	7				
				944	1	9	2·16d.
Boxes :							
Wages—unit, 18s. 6d. ...	18	9	4				
Bitumen impregnated felt	7	17	6				
Timber, etc.	6	9	10				
				32	16	8	·07d.
Lighting :							
Material, Installation and current				32	3	4	·07d.
Power :							
Air Compressor, Winch and Oil ...				16	19	0	·04d.
Transformer and connecting circuits to power line				13	13	9	·03d.
Miscellaneous				21	14	0	·05d.
Totals				£1,712	7	4	3·91d.

Estimated amount of stone brought down ...	105,000 tons.	
Cost per ton	3·91d.	
Estimated probable percentage of 1st and 2nd class stone	50% ...	52,500 tons.
Cost per ton of 1st and 2nd class stone ...	7·82d.	

APPENDIX IV.

CHARGES FOR BLAST AT COBDEN QUARRY.

A. *Calculation of charges:*

Formulæ:—$L = 2/3\ D$ where L = Line of Least Resistance in feet.
D = Depth of charge below surface, in feet.
$C = L^3/E$ C = charge used, in pounds.
E = coefficient depending on explosive = 36 for this blast, using powder.

Charge "A."

D = 65 ft.—See Drawing 4.
$L = 2/3\ D = 2/3 \times 65 = 43{\cdot}3$, say 45 ft.
$C = L^3/E = 45^3/36 = 2531$, say 2550 lb.

Charge "G."

For this charge, with $D = 48$ ft., the Line of Least Resistance is defined by the distance of the charge from the free face—
$L = 35$ ft.
Thus, in this case, $D/L = 48/35 = 1{\cdot}37$, which is O.K.
Then, $C = L^3/E = 35^3/36 = 1180$, say 1150 lb.

B. *Calculation of Radii of Rupture:*

Formulæ:—Effective H.R.R. $= K \sqrt[3]{C.\frac{10e}{S}}$

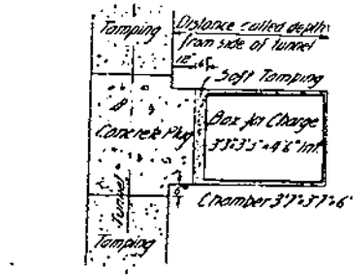
Effective V.R.R. = 0·7 effective H.R.R., where
K = 1·4 for this limestone.
S = 2·0 for this limestone.
e = 1·0 for blasting powder.

Charge "A."

Effective H.R.R. $= K \sqrt[3]{C.\frac{10e}{S}}$

$= 1{\cdot}4 \sqrt[3]{\frac{2250 \times 10 \times 1}{2}} = 33$ feet.

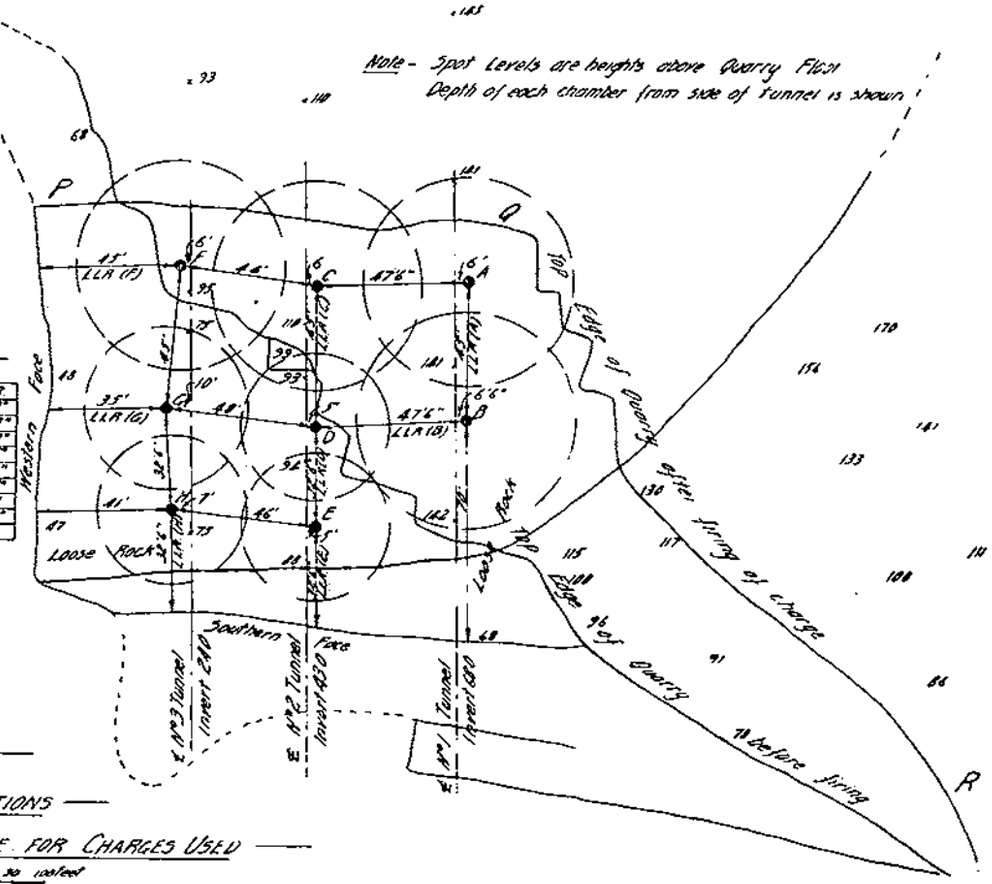
Effective V.R.R. = 0·7 effective H.R.R.
$= 0{\cdot}7 \times 33 = 23$ feet.



Chamber A. showing Typical Arrangement of Concrete Plug and Tamping

— Summary of Charges —

Chamber	Charge	L.L.R.	H.R.R.	V.R.R.
A	2550	45'0"	33'0"	23'0"
B	2350	47'6"	34'6"	23'6"
C	2550	45'0"	33'3"	23'0"
D	950	32'6"	23'6"	16'5"
E	950	32'6"	23'6"	16'5"
F	2350	45'0"	33'0"	23'0"
G	1150	35'0"	25'0"	17'6"
H	950	32'6"	23'6"	16'5"
Total	14,300			



— G. H. B. —

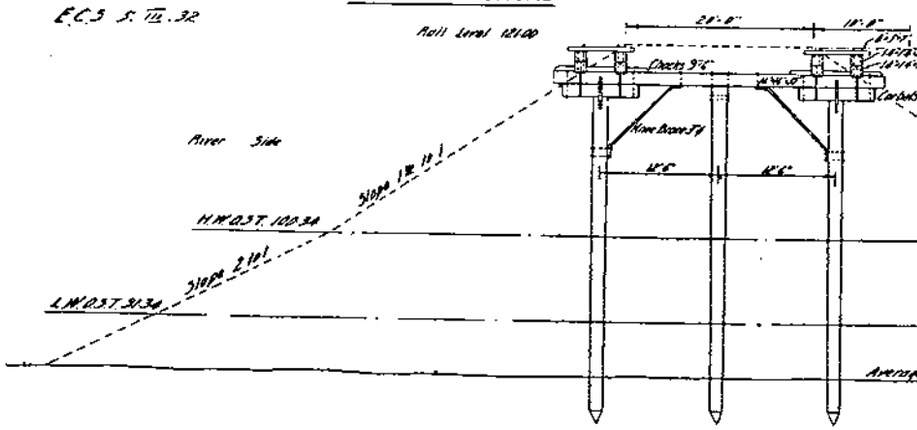
— Cobden Quarry Plan & Sections —

— Shows Calculated Ellipsoids of Rupture for Charges Used —

Scale of feet

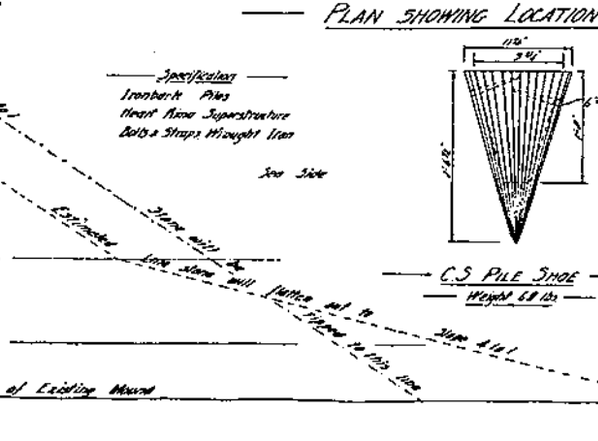
— Cross Sections —

E.C.3 S. III. 32



— Typical Section of South Breakwater and Staging —

— Plan showing Location of Charges —



— Side Elevation —

Scale of feet

Traced E.C.3 S. III. 32

— G. H. B. —

— Extension of South Breakwater —

GRAVEL-PACKED TUBE WELLS FOR CAWNPORE CANTONMENT.

By CAPT. O. S. G. SHEPPARD, R.E., AND CAPT. J. A. DAVIES, R.E.

PART I.—WATER SUPPLY SCHEME—CAWNPORE CANTONMENT.

REQUIREMENTS.

CAWNPORE Cantonment, situated on the southern bank of the Ganges, on the east side of Cawnpore City, has a population of 10,000, made up roughly as follows :—

Royal Artillery—1 battery.
British Infantry—1 battalion (less 1 company).
Royal Tank Corps—1 Armoured Car Coy. (less 1 section).
British Military Hospital.
Indian Military Hospital.
Harness and Saddle Factory (Ordnance).
Private bungalows.
Ordnance quarters.

The water supply was obtained mostly from shallow wells, but a tube well, installed by the Ordnance, supplied Ordnance subordinates' quarters and a few adjacent bungalows.

In 1928 it was decided to provide an M.E.S. piped-water supply, and an estimate was prepared. As this article deals mainly with tube wells, it is not proposed to give details of the daily water consumption estimate. Suffice it to say that a total daily supply of 252,000 gallons was to be provided, or 12 hours' pumping at 21,000 gallons per hour. This worked out at 25 gallons per head per day. Water for irrigation or water-borne sewage was not allowed for.

There were four alternatives from which to choose :—

(1) Bulk supply from municipality.
(2) Shallow wells.
(3) River Ganges.
(4) Tube wells.

The first alternative was ruled out as unreliable, and the second on account of the impurity of the water, which would have to have been treated before it could have been guaranteed potable. A supply from the Ganges would have also required treatment, but another grave objection to this third alternative was that, in the summer, the river shrinks to a very small stream, whose course

varies considerably every year. As the bed of the river is about a mile wide here it would have been necessary either to dredge a special channel near the pumps, or to make some arrangement for extending the ends of the pump suctions as required.

Tube wells would give a potable supply, and would satisfy all other requirements of the case. Several wells had previously been sunk in Cawnpore, and one actually in Cantonments, and had proved satisfactory.

GEOLOGICAL CONDITIONS.

The evidence was to the effect that water-bearing strata could be expected between 140′ and 190′, but that the depth varied a good deal for sites quite near together. The intervening strata are clay, sand and *kankar* (small nodules of limestone) mixed, in various proportions, and which present no difficulty to boring operations. The water-bearing sands in this vicinity were known to be rather fine, and were considered to be capable of yielding not more than 9,000 g.p.h., with a depression head of about 30′. The average rest water-level to be expected was 60′.

Although the geological conditions were not ideal for tube wells, there was no doubt that a perfectly satisfactory supply could be obtained at a reasonable cost, and orders were issued to proceed with the preparation of the project and estimate on these lines.

PROJECT.

Although this paper is chiefly concerned with the tube wells themselves, a very brief description of the whole scheme will not be out of place. A site for the wells and pumping house was selected near the centre of the area of the supply. The depth of the rest water-level and the fact that probably three wells would be required pointed to air-lift pumping, and the plant was estimated for on this basis. It was, however, the intention that no plant would be ordered until the exact water conditions were known. Electric energy for lighting and ventilation was already obtained very cheaply from the local supply corporation, and it was therefore decided to use this normally, and to install a stand-by oil engine for use in emergencies. The estimate provided for two 30-kw. motors each driving an air compressor (244 cu. ft. of air per minute at 100 lb. sq. inch), each of these sets being capable of dealing with the full pumping load. The water from the wells was to be delivered into a 150,000 gallons sunk reservoir, from which duplicate 10-kw. centrifugal pumps would pump it into an overhead tank, 40′ high, and of 100,000 gallons capacity. The supply to the mains was by gravity from the overhead tank. Provision was made for a 50-kw. oil engine stand-by generating set.

PART II—GENERAL THEORY OF TUBE WELLS.

SURFACE WELLS.

The safe yield of any surface well is limited by the "critical velocity" of the sand forming the water-bearing stratum. This may be defined as that velocity of flow which will just cause the finest particles to move. If this velocity is not exceeded the particles of sand forming the floor of the well will not be displaced. But if it is exceeded the finer particles of sand will gradually be drawn to the top, the floor of the well will rise, the well will silt up, and the yield will greatly diminish. By removing the silt the original yield can be restored, but if this practice is resorted to often cavities will be formed, the steining will sink and crack, and the well will be eventually destroyed. The critical velocity varies according to the gauge of the finest particles of sand, but an average figure is 3' per hour. Where the sand is composed of a mixture of several grades, it is the finest grains that limit the critical velocity. The yield of a well is therefore $\pi \frac{D^2}{4} \times 3 \times 6{\cdot}25$ gallons per hour, where D is the diameter in feet.

TUBE WELLS.

In tube wells the "floor area" is replaced by a certain area of strainer, the object of which is to allow the finer grains of sand to pass, while blocking the coarser grades. The size of the strainer mesh must be very carefully chosen. If it is too small it will be blocked up. If the mesh is too large the coarse grains will pass through and silt up the well. When a well of this type is being developed the fine particles of sand are drawn through the screen and up the tube in suspension, leaving the coarser-grade sands, through which the underground supplies of water can flow without disturbance, packed round the strainer. The rate of flow per unit area will be maximum at the strainer, and will gradually diminish outwards. At a certain distance from the strainer the rate of flow will equal the critical velocity of the stratum, and therefore beyond this point there will be no disturbance of the sand. Between this point and the strainer the sand will grade itself according to the critical velocities of the various-sized particles composing it, the coarsest grains being nearest to the strainer.

The strainer is therefore surrounded by a roughly egg-shaped "cavity" of which it itself is the major axis. This "cavity" is only a cavity in the sense that the sand in it is of a lower density

and of a greater porosity than the surrounding sand. The surface area of this cavity is such that

$$C = A \times v \times 6{\cdot}25$$

Where C = yield in g.p.h.
A = surface area of cavity in sq. ft.
v = critical velocity in ft. per hour.

Experience has shown that the rate of flow through the strainer may be up to 3 ft./min. (60 times as great as the rate through the floor of a surface well) in fine sands.

DEPRESSION HEAD.

When a well is pumped at a constant rate, the water-level will fall until the inflow equals the yield, and a balance is obtained. The inflow is caused by the difference in head between the rest water-level obtaining in the underground water reservoir surrounding the well and the level of water in the well. This head is known as the "depression head." If it is plotted against the flow the graph will be a straight line until a certain point is reached, after which an increase in the depression head will not yield a corresponding increase in flow. The flow at this point is the maximum at which it is practicable and economical to work the well. The depression head will be greater the closer the general texture of the stratum. It varies inversely as the size, *i.e.*, diameter of the well. But it is not sound to use too large a well in order to reduce the pumping costs, as it is necessary to maintain a certain velocity of flow up the tube in order that any fine sand drawn into the well may be carried up in suspension, and not fall and silt up the well. Brownlie recommends that this velocity should be between 3 and 5 ft./sec.

CONE OF DEPLETION.

The well is the axis of an inverted cone called the "cone of depletion," the slope of whose sides represents the hydraulic gradient. If a series of wells is to be sunk they must be sufficiently far apart that their respective cones of depletion do not intersect below the rest water-level. The slope of the sides of the cone will depend on the porosity of the soil, and on the depression head (*i.e.*, on the rate of discharge).

GRAVEL-PACKED WELL.

The gravel-packed type of well has no strainer, in the usual sense of that term. The gravel is introduced, as the well is developed, to take the place of the sand removed by pumping. The gravel is introduced either by means of the annular space between the casing pipe and the tube well, or through subsidiary tubes sunk round and near the main tube. Eventually, when the well is completely developed, the whole "cavity" consists of gravel.

Introducing the gravel through the annular space between the casing and the well piping is open to the objection that the gravel is apt to pack and jamb, even if a large casing pipe is used. (American practice is to use a casing pipe of 6–8″ larger diameter than the well piping.) Nevertheless it is quite satisfactory if the filling is done carefully, and some engineers seem to prefer it to the more expensive method of subsidiary wells. Three of these are often employed, 18″ from the central tube well.

Some engineers prefer to be able subsequently to develop their wells further, by working them at a greater depression head, and feeding in more gravel. If this is the case, on grounds of expense it is preferable to have the single large casing, which, of course, cannot be withdrawn.

In place of the strainer of the ordinary well is substituted a length of slotted tube. The slots either vertical or horizontal, are usually about 3/8″ wide. It follows, therefore, that the gravel must be at any rate larger than 3/8″.

The advantages of the gravel-packed type of well are :—

(1) No strainer to get choked.
(2) No strainer to deteriorate in course of time. The copper wire of the Ashford strainer is liable to corrosion in limy water, and electrolysis is another source of destruction.
(3) No strainer to get damaged easily while it is being lowered into the well.
(4) In fine sands a greater flow can be obtained ; and sometimes a strainer well will give no yield at all.
(5) The well can be withdrawn without damage to the slotted pipe.
(6) Usually no more expensive.
(7) The friction head is less.

It is important to realize that the gravel in no way acts as a filter. Its function is only to fill up the cavity formed by the removal of sand during development. If the stratum immediately above the water-bearing stratum is firm and solid it is sometimes possible to dispense with the gravel filling. The " cavity " is then a cavity in the true sense.

Part III—Tenders and Specifications.

Method of carrying out work.

It was decided to call for tenders on an item rate basis, in preference to a guaranteed supply—no water no pay—basis, as it was considered that this would be cheaper, and would enable the M.E.S. to exercise a better control over the work. The tender was limited

to the construction of the wells. It is not possible to specify the pumps required until definite information with regard to depth and quantity is available.

SIZE AND NUMBER OF WELLS.

As has already been stated, it was considered that the strata available was not capable of yielding more than 9,000 g.p.h. Using a 6" well the velocity of the water would therefore be 2·04 ft./sec. This is lower than that recommended by Brownlie, but a smaller well would have made the arrangement and proper proportioning of the air and eduction pipes difficult A flow of 21,000 g.p.h. was required, or between three to four wells.

SPECIFICATION.

Three points were kept in mind in preparing the tenders and specification :—

(1) Control and responsibility for all decisions to be kept by the M.E.S.
(2) Tenderers to be allowed as much latitude as possible in carrying out the work subject to (1).
(3) The specification to be as flexible as possible to allow for unforeseen conditions and eventualities.

The following is a *précis* of the more important clauses :—

(1) *Number and size of wells.* A series of tube wells, sunk and developed, to give a delivery of 21,000 g.p.h. The actual number to be decided after the water conditions were definitely known. The tenderers were informed that it was considered that the strata would yield about 9,000 g.p.h., and that 6" wells would be suitable. They were, however, at liberty to quote for any other sizes.
(2) *Type.* Gravel-packed.
(3) *Depth.* To be sunk to such a depth as to yield an adequate supply to the satisfaction of the M.E.S., up to a maximum of 400'. (Although it was hoped to find water at 140', it would be necessary to continue the bore down to about 250' in order to obtain sufficient submergence.)
(4) *Shrouding.* To consist of pebbles, broken stone, or well-burnt *jhama.* To pass a $2\frac{1}{2}$" ring but not a $\frac{1}{2}$" ring, and 50% to pass a 1" ring.
(5) *Well pipes.* B.S. screwed wrought-iron or steel pipes galvanized or coated with an approved preservative.
(6) *Well screens.* Piping as above. The slots to be 3/8" wide, cut either vertically or horizontally, but sufficient metal to avoid weakening to be left between the slots. The lower

end to be provided with a blank flange, screwed and provided with a locking device. This flange not to be made of cast-iron. To be galvanized, sherardized, or coated with an approved preservative after the slots had been cut. The length and position of the screen to be determined at the time of the sinking of the well.

(7) *Casing pipes.* The diameter to exceed the diameter of the well pipes by at least six inches, preferably more.

(8) *Sinking casing.* To be sunk truly vertical, and to be withdrawn if the deviation exceeds one inch in 100 ft.

(9) *Development.* To be pumped at a rate of not less than 20% in excess of the rate at which it is finally intended to work the well, and until the effluent is cleared of suspended matter. The M.E.S. to be the sole judge of when the well has been fully developed.

(10) *Samples and Records.* The contractor to keep samples of all strata met with and a record of their depths; also a daily record of rates of boring, sinking, pumping, etc.

(11) *Sufficiency of plant.* The contractor to provide sufficient plant to enable the sinking of one well to be started before the casing of the previous one is withdrawn.

(12) *Water conditions.* The tenderers were informed that satisfactory water-bearing strata were to be expected between 140′ and 190′, with a rest water-level of 60′, but that no extra payment, etc., would be made if the conditions proved to be different. They were provided with a blue print of existing boreholes in Cawnpore.

(13) *Payment.* This was to be made under five items:—

(*a*) Sinking and withdrawal of casing, according to size, at different rates per foot of bore for 0–100, 101–200, 201–300, and 301–400 ft.

(*b*) Supply and fixing of well pipes according to size, at different rates per foot as in (*a*).

(*c*) Supply and fixing of screens according to size, per ft.

(*d*) Supply and filling of shrouding material, at a rate per cu. ft., this price to include all development and testing charges.

(*e*) Filling in extra bore with rammed *kankar*, at a rate per foot of bore—in case the well was sunk deeper than was eventually found to be desirable.

(14) *Time.* Work was to commence within one month from the date of acceptance of the tender. The tenderers were required to give a time guarantee for sinking the wells and for fixing the well piping, screens, eduction and air piping.

ACCEPTED TENDER.

The rates of the accepted tender are given in Appendix I. It will be observed that this firm quoted for 6″ wells with 14″ casing, or alternatively for 10″ casing and 5″ subsidiary wells. The former was accepted, on account of the great saving in cost. But eventually the firm found that they had no 14″ casing available, and it was agreed that they should use $10\frac{3}{4}$″ casing and three subsidiary wells, to get paid as if they had used 14″ casing. This was all to the advantage of the M.E.S.

PART IV—PRACTICAL POINTS IN CONNECTION WITH BORING AND DEVELOPMENT OF TUBE WELLS.

SITING OF WELLS.

The tender had provided for the siting of the individual wells by the firm, the general area being pointed out to them. A water diviner very quickly found that there were four parallel underground streams about 50 yards apart at a depth between 150′ and 240′. In actual practice it was only necessary to tap three of these streams, but the diagnosis of the diviner was amply confirmed. Water diviners are often regarded as freaks, and it is not realized of what practical use they can be to the engineer. A trained water diviner can not only trace the course of underground streams, but can give an indication of their depth and capacity.

BORING PLANT.

The method of boring employed at Cawnpore was by a water-jet combined with a cutting tool. The lay-out of the plant is shown in Fig. 3, and is, briefly, as follows :—

A staging (*A*), equipped with lifting tackles, etc., is erected over the site where the well is to be sunk. The boring tool (*B*) is suspended by means of one of these tackles, and is lowered into the hole as boring takes place. The well casing (*C*) is supported in the same way, and it sinks into the ground as the boring tool cuts the earth away from underneath it. Stops *D* and *D′* are provided to control the sinking of the casing and to prevent the casing being lost if it suddenly enters a cavity or soft soil below ground, and starts to sink rapidly. The bottom stop is removed, and the tube sinks till it comes up against the top stop. Another length of casing pipe is added, with stops. *D′* is now removed and the casing sinks to the next stop.

The boring tool *B* consists of a mild steel pipe of 5″ diameter down which water is pumped at the rate of 15,000 gallons per hour. The lower end of the pipe is fitted with a cutting head of a form

depending on the nature of the strata through which the tool has to cut. For ordinary soft soils the head illustrated in Fig. 1 is used: it consists of a serrated edge cut on the mild steel tube. Boring is effected partly by the cutting action of the serrated edge and partly by the erosive effect of the water issuing from the tube. The tube is moved eccentrically in the casing (by hand manipulation from on top), and the soil is cut away from underneath the casing pipe. The top end of the boring pipe is provided with a swivel head and lever arms to enable it to be turned. These lever arms are manned by coolies who rotate the tube slowly, and lower it into the well as

FIG. 1

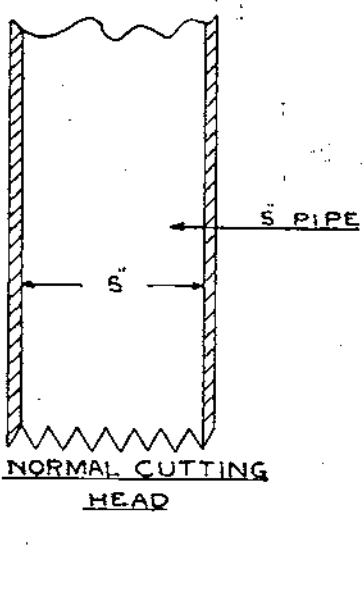
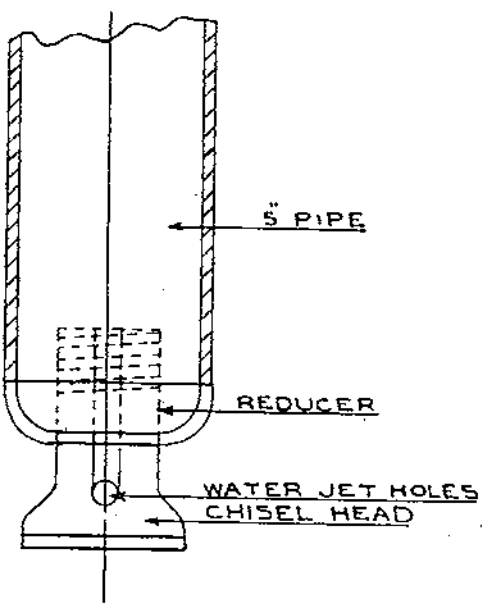


FIG. 2



necessary. The soil, as it is cut away by the tool, is carried up the casing pipe by the rush of water and deposited on the surface. The water drains back to a sump, where it is collected so that it can be used again.

The problem of finding 15,000 gallons per hour is not always easy to solve. At Cawnpore boring was started with the aid of a surface well, but this would not stay the pace. A 7" tube was therefore sunk at one of the sites indicated by the water diviner, and the water obtained from this was used to sink the main casing. To sink the 7" tube a sump was constructed of 10,000 gallons capacity, and this was filled by means of water-carts from surface wells.

For boring through harder strata a different type of boring head is necessary. This is illustrated in Fig. 2, and consists of a chisel head fitted to the end of the boring tube, a hole being bored in each

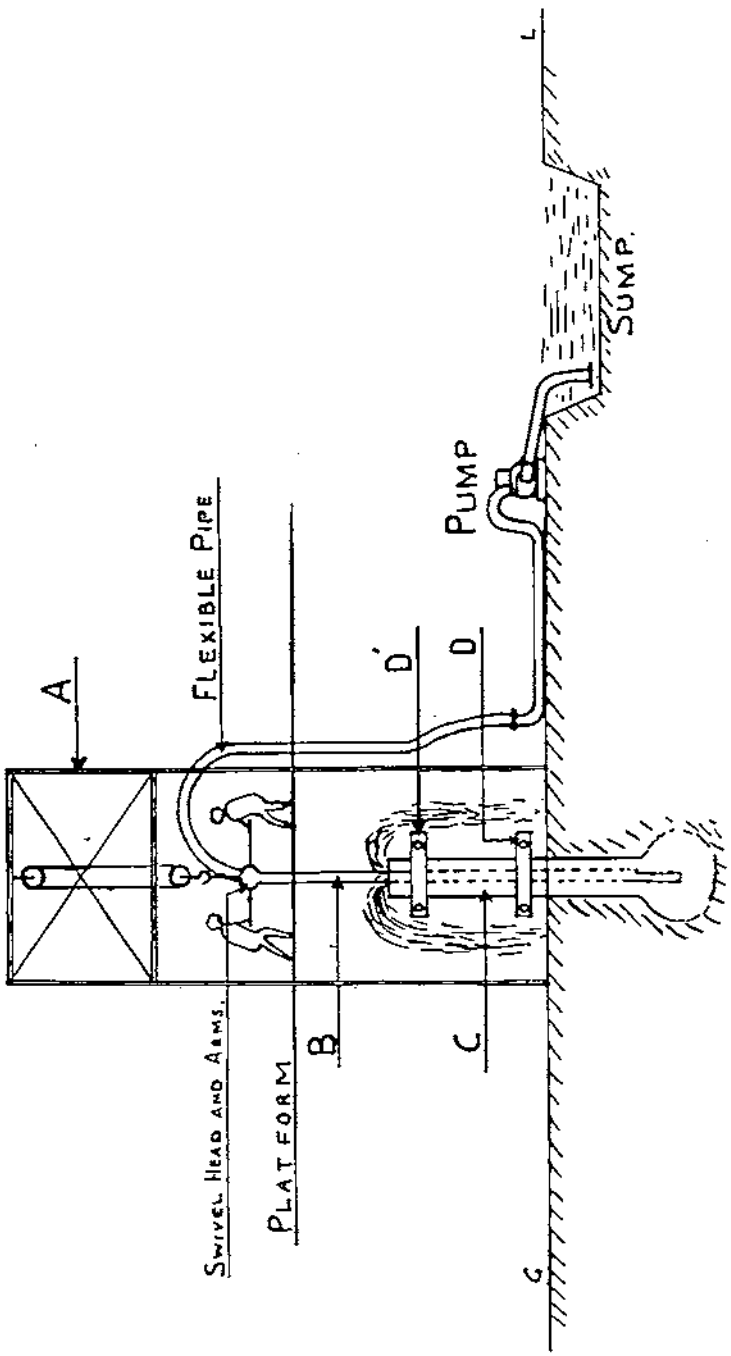

A
FLEXIBLE PIPE
D'
D
PUMP
SUMP.
L
SWIVEL HEAD AND ARMS.
PLATFORM
B
C
G

FIG 3.

face of the chisel to allow the water to issue as a jet. The tool is operated in the same way as a jumping bar, and the water-jet

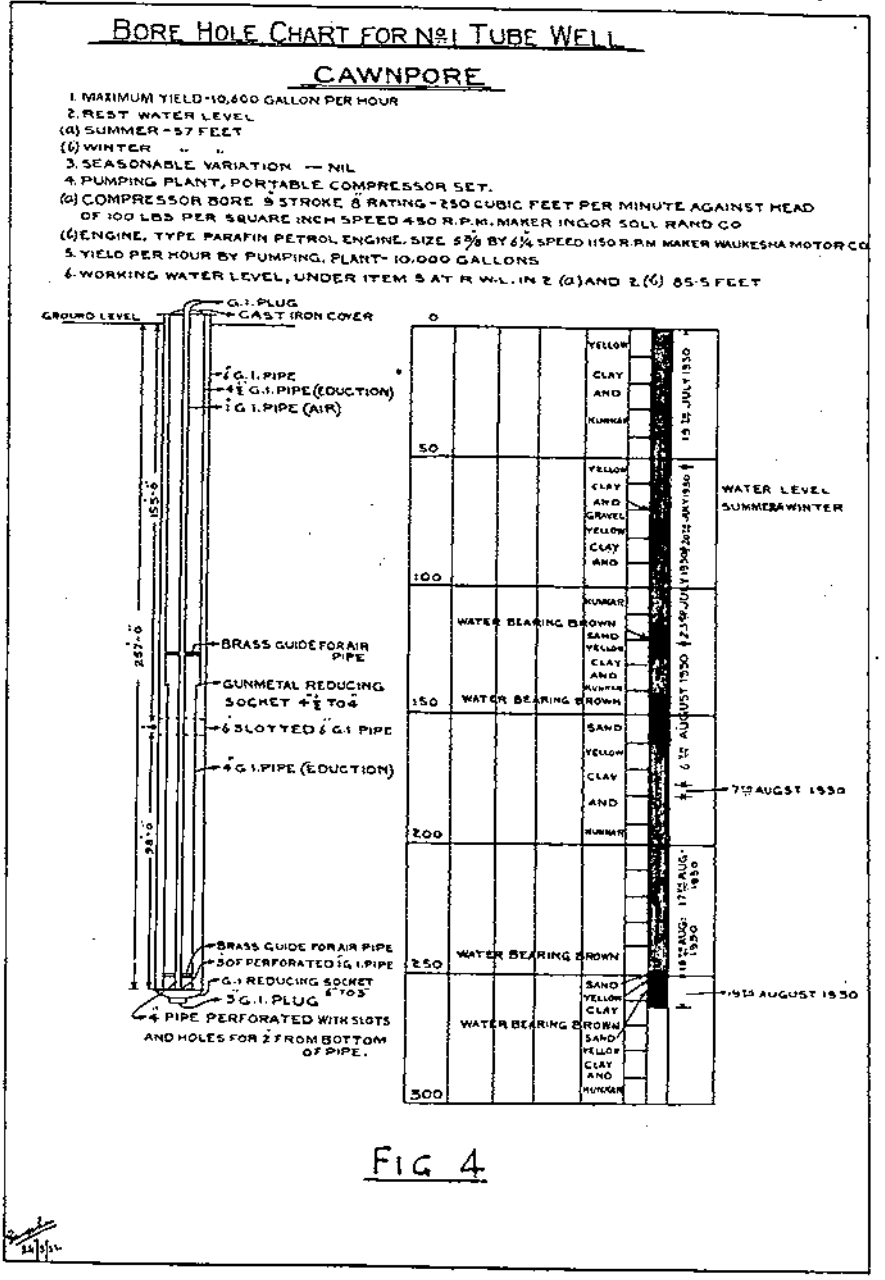


FIG 4

assists by its erosive action and by carrying away loosened material up to the surface.

Fig. 4 shows one of the borehole charts obtained at Cawnpore.

It will be noted that the strata consist very largely of clay and *kunkar*. Water-bearing sand was found between 100′ and 150′, and between 250′ and 300′. As this bore was the first to be carried out it was carried down to 400′ in order to ascertain the prevailing conditions and to check the water diviner's forecast. As will be seen, the forecast of the water diviner was reasonably accurate.

The rate of boring for the wells is given in Appendix II.

DEVELOPMENT OF A TUBE WELL.

As has already been explained, development of a well consists in pumping water from the well until sand ceases to issue from the tube. In a gravel-packed well a cavity is formed round the strainer, and gravel is fed into it as the sand is sucked away, until no more is absorbed.

For the development of the wells at Cawnpore the following arrangements were made. It was decided to employ an air lift for pumping, using a portable Ingersoll-Rand compressor which was available. The rest water-level in the well was at 57′, the depression head being 28·5′. A temporary $4\frac{1}{2}$″ eduction pipe was fitted, with a central 1″ air pipe made up locally in the M.E.S. workshop. The air-pipe was kept central in the eduction pipe by means of three spiders situated at intervals throughout its length, and at its bottom end was perforated with 75 holes for a length of two feet. A starting submergence of 190′ was allowed for. Running submergence, 170′.

The well-head used for development is illustrated in Fig. 5, and needs no explanation except that, by closing the stop valve A, the well could be " blown-back " when required.

A $10\frac{3}{4}$″ diameter casing was used, the tube well being 6″ diameter (internal). The subsidiary tubes were originally intended to be of 7″ diameter, but it was found in practice that a larger size was desirable, and $10\frac{3}{4}$″ tubes were substituted.

The rate of progress of development, and the quantities of gravel used, are given in Appendix II.

The yield of the wells proved to be as follows :—

No. 1 Well	..	..	..	10,000 g.p.h.
No. 2 Well	..	..	..	11,000 ,,
No. 3 Well	..	..	..	11,000 ,,

These figures are just above the estimate. It also seems certain that three separate streams have been tapped, as, when pumping from any well, no drop in water-level is noticeable in the other two.

The quality of the water has so far proved satisfactory, and chlorination has not been necessary.

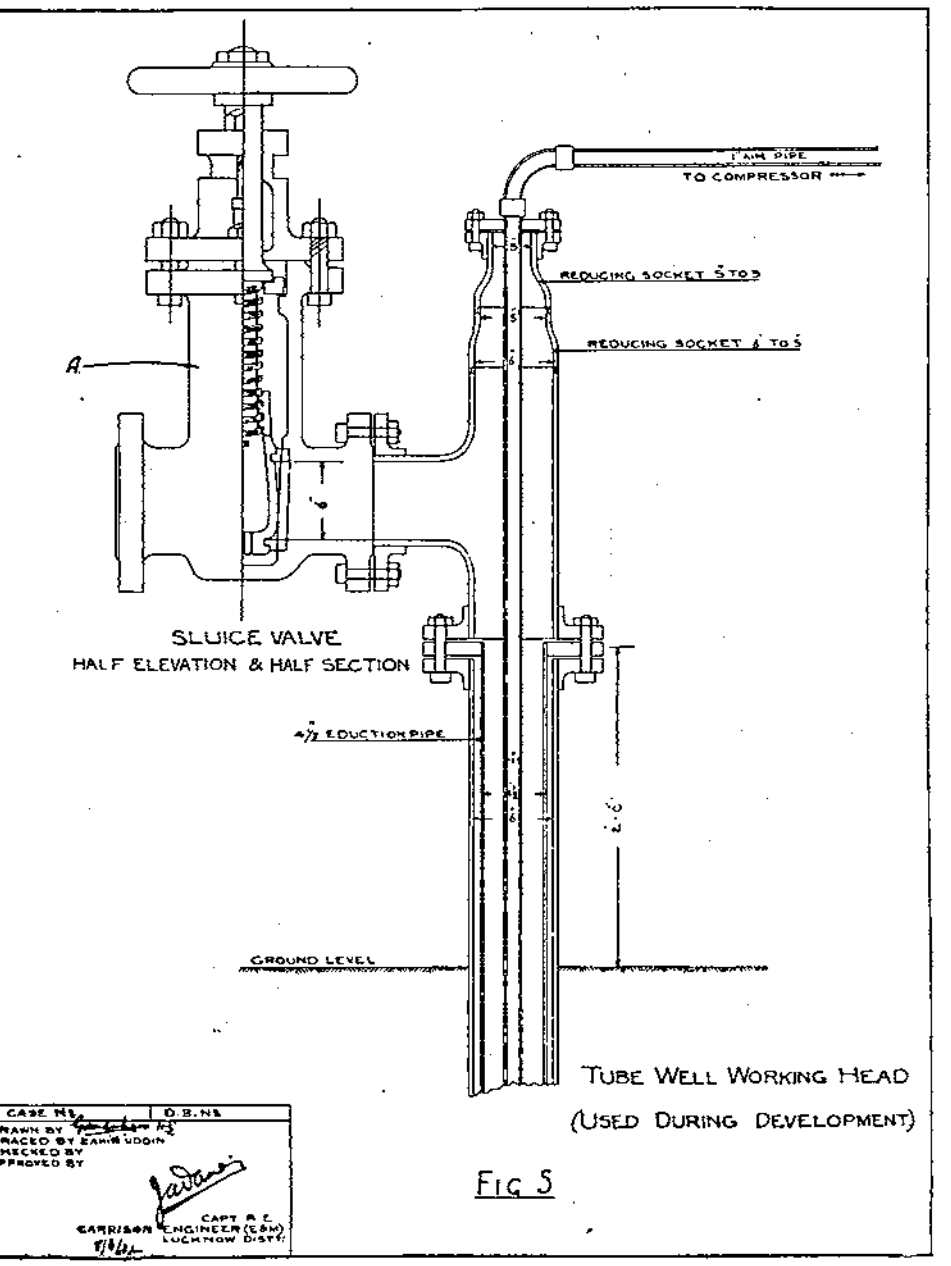

1" AIR PIPE
TO COMPRESSOR
REDUCING SOCKET 5" TO 3"
REDUCING SOCKET 4" TO 3"
A
SLUICE VALVE
HALF ELEVATION & HALF SECTION
4½" EDUCTION PIPE
GROUND LEVEL
TUBE WELL WORKING HEAD
(USED DURING DEVELOPMENT)
CASE No.
D.B. No.
DRAWN BY
TRACED BY
CHECKED BY
APPROVED BY
CAPT. A. C.
GARRISON ENGINEER (E&M)
LUCKNOW DIST.

FIG 5

APPENDIX I.

Item of Work.

ITEM 1. ERECTION AND DISMANTLING OF BORING PLANT, preparation of site, freight and haulage of plant to site :.. ... ... Per complete job, irrespective of the number of wells sunk ... ... Rs. 2500/-

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ITEM 2. SINKING OF BORE (rates to include withdrawal of casing on completion of work).

14" casing pipe, internal diameter 14".

		Rate tendered per r/ft. Rs.
Bore and casing sunk and casing withdrawn :	0–100 ft.	15/-
	101–200 ft.	15/-
	201–300 ft.	18/-
	301–400 ft.	18/-

Time guarantee, per well, from commencement of work, including erection of plant, and sinking of casing, but excluding well piping, development, and withdrawal of casing :

	Time guarantee in *days.*
First 100 ft.	40
Second 100 ft.	60
Third 100 ft.	70
Fourth 100 ft.	80

APPENDIX I—*continued.*

Item of Work.					
ITEM 3.	WELL PIPING (rates to include fixing only of eduction and air piping and temporary well head).	*Well piping, internal diameter.*			
		6″	7″	8″	
		Rates tendered in rupees, per rft.			
	Well piping supplied and fixed : 0–100 ft.	Rs.	Rs.	Rs.	
	101–200 ft.	3/12/-	5/8/-	7/8/-	
	201–300 ft.				
	301–400 ft.				
	Time guarantee per well from commencement of work, including fixing of well piping, screen, eduction and air piping, and temporary well head, but exclusive of development and final withdrawal of casing :	Time guarantee in days.			
	First 100 ft.	Six days			
	Second 100 ft.	Six days			
	Third 100 ft.	Six days			
	Fourth 100 ft.	Seven days			
	Specification :—Well piping will consist of Stewarts & Lloyds G.I. piping, water quality. Preservative coating—galvanized.				

ITEM 4.	SCREENS (rates to include blank flanges and couplings).	*Screens (internal diameter).*		
		6″	7″	8″
		Rates tendered in rupees, per rft.		
	Screens supplied and fixed :	Rs.	Rs.	Rs.
		18/-	21/8/-	25/-
	Specification :—Screens will be cut from G.I. water quality piping. Preservative coating—Galvanized.			

APPENDIX I—*continued.*

Item of Work.

ITEM 5. SHROUDING MATERIAL.

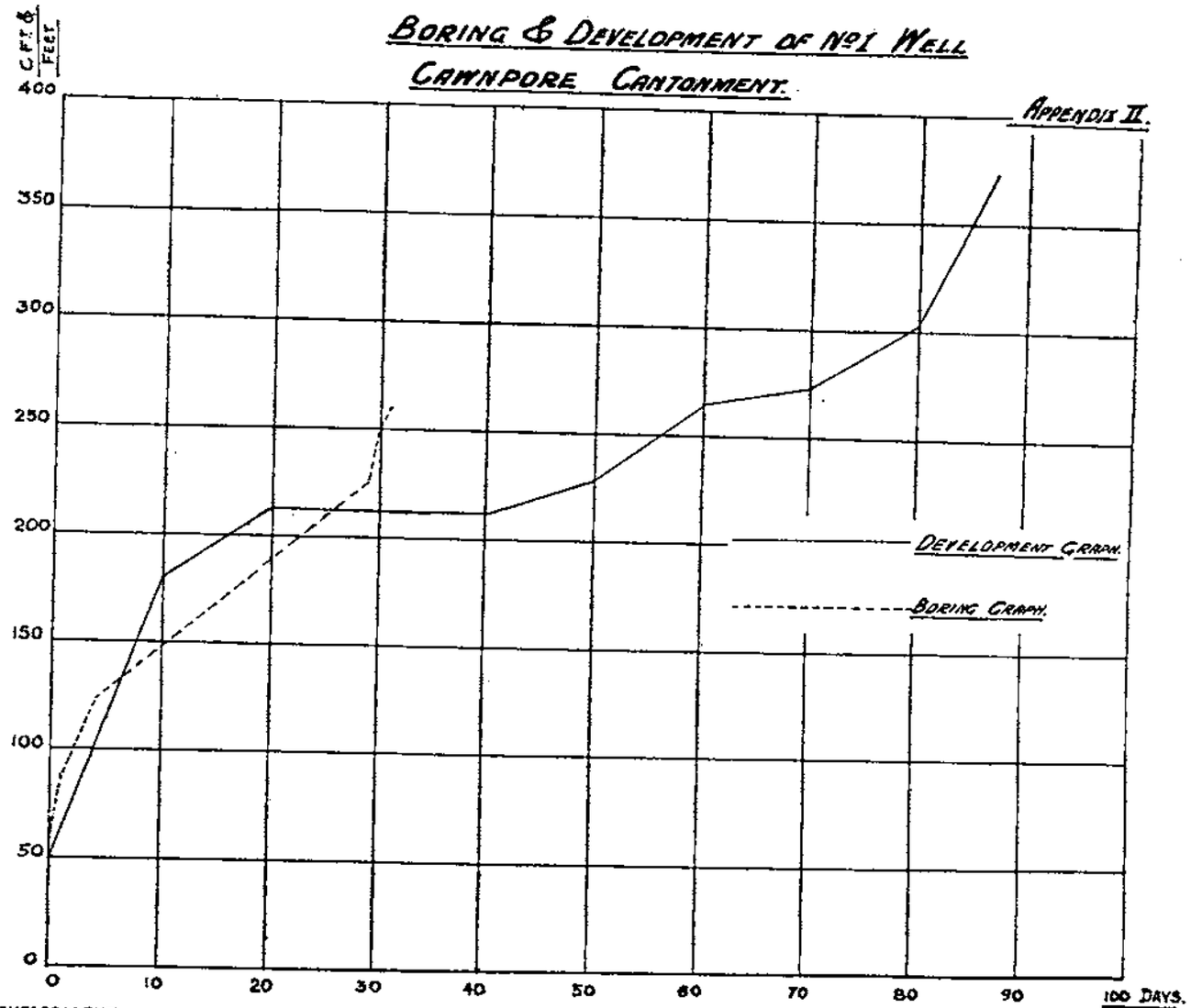
The rate will include all development and testing charges, which will not be paid for separately.
Specification :—Material will consist of rounded gravel pebbles or broken road metal.
Rate supplied and filled—Rs. 2/8/- per cubic foot.

ITEM 6. FILLING IN EXTRA BORE WITH RAMMED KANKAR.

Rate—supplied, filled and rammed—Rs. 1/- per rft. of borehole.

BORING & DEVELOPMENT OF No I WELL
CAWNPORE CANTONMENT.

APPENDIX II.



DATES OF DEVELOPMENT

28.8.30. 6.9.30 16.9.30 26.9.30 6.10.30 16.10.30 26.10.30 5.11.30 15.11.30 22.11.30

DATES OF BORING

19.7.30 7.8.30 19.8.30

A FIELD COMPANY IN BURMA, 1931.

"ANON."

1. GENERAL ENGINEERING CONSIDERATIONS.

BURMA is divided into two zones, the "wet zone" and the "dry zone," the former lying to the south, and the latter to the north of a line running roughly east and west through Toungoo. The rains continue from about May until the end of October, the average fall in the wet zone being from one hundred to one hundred and fifty inches, and in the dry zone from about twenty to thirty inches.

Road communications in the country are in a very backward state, due mainly to the facts that the Irrawaddy and its side streams have from time immemorial provided the main channels of communication, and that practically the only crop is rice, which is harvested and taken to collecting stations during the dry weather from December to March, a time when the soil is baked by the sun and bullock carts can be driven with ease over the whole country.

The existing roads may be classified as under :—

1. Trunk roads, metalled and bridged throughout.
   (*a*) Rangoon-Pegu-Toungoo-Mandalay-Maymyo-Wetwin.
   (*b*) Rangoon-Prome-Allanmyo.

2. "Local project" roads comprising short lengths of from ten to thirty miles of metalled roads radiating from each civil district headquarters. These roads often utilize the old existing bullock cart track bridges, which, though they stand up to traffic in an amazing way, cannot be regarded as fit for continuous use by buses and lorries. In many places, however, these roads cross wide *chaungs* (or river beds), which have never been bridged, and which, though passable during the dry weather, are usually impassable during the rains, and are subject to sudden and dangerous spates.

In a secondary class of this category may be placed a number of old metalled roads which have been allowed to fall into decay.

3. Country cart tracks, unmetalled and usually unbridged. These tracks have been worn into deep ruts, usually of different depths, are slippery after rain, and as a rule have very steep gradients at the approaches to *chaungs*, or where they cross over watersheds.

In the dry season, after a certain amount of work on rut-filling or on the construction of diversions over the now sun-baked paddy fields, quite long stretches of these tracks can be made passable by

mechanical transport. During the rains, the only solution is to surface the road with timber corduroy, materials for which are easily obtainable should the track happen to pass through forests, but are non-existent in the open rice-growing plains.

Except in parts of the dry zone, the supply of water is adequate, it being easily obtainable from rivers, tanks or wells. Its quality, however, is far less satisfactory, as besides being decidedly impure chemically, it usually contains a very high content of suspended matter. In parts of the dry zone, especially just before the advent of the rains, the situation is considerably more difficult, the only sources of supply being tanks, which have been filled by the previous year's rain and which have been thoroughly fouled by cattle and bathing, and occasional wells, usually only sufficient for the requirements of a small village. In the places where troops were formerly stationed, but which have been abandoned as cantonments, there are usually a number of disused wells, which, after cleaning, are capable of providing a supply of good water.

2. THE OUTBREAK OF THE REBELLION AND ITS PROGRESS UP TO 31ST JULY, 1931.

Before reviewing the course of the rebellion it will be as well to consider its causes as set down by the local government. "It must be remembered that the Burman is by nature restless and excitable; that the peasantry are incredibly ignorant and superstitious, the belief in the efficacy of charms and tattooing as conferring invulnerability being still widespread; and that the history of Burma is a record of successful rebellions.

"In 1930 several special factors combined to create conditions favourable for a rebellious outbreak. The political ferment of the last two years had disturbed men's minds; prices had been falling, and though the really big drop in the price of rice did not begin until after the rebellion had started, the Burman peasantry had already begun to feel the pinch; minds were also disturbed by the earthquakes at Pegu and Pyu, which were regarded as portents, and by the rioting between Burmans and Indians in Rangoon in May, 1930, which rioting ended, so Burmans thought, in a Burman victory. The communal feeling against Indians, of which these riots were a result, was due to the competition of the Indian labourer who, with a lower standard of living, was able to undercut the Burman in the labour market."

The first outbreak occurred on the night of December 22nd, 1930, a few miles from Tharrawaddy town, the headquarters of a district which, even in Burmese times, had an evil reputation as a criminal and restless area, and where there had been considerable trouble in the cold weather of 1927-28 over paying the "capitation tax."

This outbreak took the district authorities completely by surprise, and rapidly spread to the villages in the north of the neighbouring district of Insein. There was evidently a definite organization behind the rising. Most of the rebels were reported to be wearing uniforms, and were also tattooed in order to make them invulnerable. Information was obtained of a mysterious leader, whose name was ascertained to be Saya San, and of a headquarters, considered by the rebels as their king's palace, in the forest ten or fifteen miles east of Tharrawaddy.

Troops were called out and the palace reached and burnt by the 3/20th Burma Rifles on December 31st, 1930. It was hoped that this would have a great effect in stamping out the rebellion, but, though it had some temporary effect, this was not as lasting as was expected at the time. After the first few days of January the rebels showed little disposition to attack Government forces, and the main body retreated into the foothills of the Pegu Yomas. To meet this situation a cordon of posts was put along the foothills with the object of intercepting the rebels if they raided into the plains, and a drive through the Yomas was organized. The jungle, however, was so thick that practically no rebels were seen.

In February most of the troops were withdrawn, some remaining as a striking force to support the police, and for the next few months to the lay mind it appeared that the rebellion was at an end. For the 14th (Field) Company, Q.V.O. Madras Sappers and Miners, who arrived at Mandalay on a normal relief in the first week of February, there seemed no prospect of active operations.

This apparent calm, however, gave no indication of the true state of affairs. Risings, some more successful than others, occurred in various districts. An outbreak at Yamethin on January 4th was promptly suppressed; another organized by Saya San occurred in the Dedaye township of the Pyapon district on January 7th, but in this case reports of impending trouble reached the district authorities and a summary defeat was inflicted on the rebels by the police, thirty to forty insurgents being killed in the engagement, and the rising being completely crushed. In February the district of Henzada became disturbed, but prompt measures prevented an outbreak in the neighbouring district of Bassein.

A more serious outbreak occurred in Thayetmyo in April, and very soon the whole of this district became disaffected, followed in May by the neighbouring one of Prome. Troops had again to be dispatched to assist the civil authorities.

At the end of January, the usual preparations for rebellion commenced in the Shan States, but so well was the secret kept that information was not obtained of it until May. Armed villagers began to collect in June, and a "Victory City" was built. On July 2nd the military police had a sharp engagement with a large

body of rebels on the Namtu river, and on July 6th a heavy attack on a military police post was repulsed. On July 7th the "Victory City" was burnt, and there followed a thorough search for the scattered rebels and their leaders, culminating in the capture of Saya San himself on August 2nd, after he had been headed back by the Government forces in an attempt to break away from the Shan States and escape across the Irrawaddy north of Mandalay.

During April and May the 3/20th Burma Rifles and the 2/15th Punjab Regiment were operating continuously in the disturbed areas, but it was obvious that, to restore order, considerable reinforcements were required. During May and June, the pre-rebellion garrison was reinforced by one British and three Indian infantry battalions from India, the latter being increased to five during August.

Up to the end of July the civil districts of Thayetmyo, and to a lesser extent, Prome, Henzada, Tharrawaddy, and Insein, were in a very disturbed condition. Throughout these districts ranged gangs of armed rebels or dacoits (there was often very little difference between the two), in some cases in large concentrations, but usually in small parties. The country was divided up into a series of military areas, corresponding in the main to the civil districts, in each of which the Military Commander rendered whatever assistance was required by the civil authorities with the forces at his disposal. The troops for the most part were occupying posts from which they could operate on receipt of information, but such was the terror the rebels inspired in the villagers, and so ruthless their vengeance on informers, that recent and reliable intelligence was not of frequent occurrence. It was not so much a question of dealing with organized resistance on a large scale as of suppressing countless small isolated gangs, whose whole object was to avoid contact with government forces, and whom it was often very difficult to recognize as enemies.

3. The Work of the Field Company up to the end of July, 1931.

Throughout March and April there was no call on the Sappers for work, but water parties were organized and equipped, ready to move out with mobile columns at short notice.

In April it was decided that Shwebo should be occupied by a company of the first reinforcing infantry battalion to arrive. Shwebo was an old cantonment, and accommodation, though dilapidated, existed. Water supply, however, presented difficulties, for although there had been a number of wells when the station had been occupied, all but one of these (which sufficed for the civilian population alone), had been in disuse for many years, and were either dry or very choked up. The only other source of supply was a rapidly falling tank containing practically unpotable water.

The Military Engineer Services, working through the Public

Works Department, arranged all accommodation and water supply, but to supplement the existing facilities a section of Sappers and Miners was sent to Shwebo to erect the company's mechanical pumping set at one of the wells and to connect it with a temporary piped distribution system. (For the benefit of those not conversant with the equipment of a Field Company, Sappers and Miners, the mechanical pumping set consists of a 5-h.p. Petter engine direct-coupled to an Aquatole belt elevator with a centrifugal pump for cases where a force is required. Its output is 4,000 gallons per hour from 40-ft. depth.—*R.E. Journal*, March, 1931, page 93, *et seq.*)

This section remained at Shwebo from May 2nd to May 14th, and assisted the Public Works Department in the installation of the system. It then returned to Mandalay, the pump being left in position with a maintenance party of three men, and it was continuously in use until February, 1932.

When the outbreak occurred in the Shan States, there was a chance that the rebels would attempt to damage the big railway viaduct at Gohteik on the Maymyo-Lashio line. As some difficulties were experienced with civilian railway personnel operating the searchlights in conjunction with the troops, a detachment of three Sappers took over the lights and operated them from July 27th to August 24th, when they were withdrawn.

During June and July, as more troops were arriving from India, and more extended operations by the military against the rebels were being arranged, the officers of the company were kept busy on reconnaissances of communications and water-supply in the disturbed areas of Thayetmyo, Allanmyo, Henzada and, later, in September, Pegu. The importance of reports of such reconnaissances cannot be overstressed, as once it has been committed to paper that such and such a road can be made passable for mechanical transport, or that such and such a river can be bridged with so much labour in so many days, it must be realized that on this information the plans of future operations may be based. One of the main factors in engineering work is the supply of material, and it is always worth while spending a little longer on a reconnaissance in order to obtain an accurate forecast of the probable time it will take to obtain the requisite stores, rather than to give a figure, rendered most deceptive by the qualification, " provided all materials are at the site." This is of particular importance in small wars or operations in uncivilized countries where the blessed presence of the " R.E. Dump at X where all materials and transport are available," so helpful in one's (F) examination, is conspicuous by its absence. *Quot homines, tot sententiæ*, it is also better that the officer who carried out the reconnaissance should be, if possible, the officer in charge of the work.

The number of British officers in the company was increased from the peace establishment of three to the war establishment of five,

one officer arriving on July 25th and the other on August 4th. A sixth officer joined on September 2nd, as a replacement for one who (fortunately only temporarily) had to go to hospital, thus the unit luckily had six officers for most of the operations, and with sections widely distributed as they came to be, and with a depot to be maintained in Mandalay, they proved none too many.

By the end of July, there was one district which, for lawlessness and cessation of civil administration, was outstandingly the worst; the police were to all intents and purposes besieged in their stations, village headmen had either fled or been murdered, and the only law was that of various rebel *bohs*. This was the portion of the civil district of Thayetmyo lying to the west of the Irrawaddy (maps I and II). The operations in this area will be dealt with in the succeeding sections.

4. THE OPERATIONS IN THAYETMYO WEST MILITARY AREA, AUGUST 1ST, 1931, TO NOVEMBER 30TH, 1931.

(See Map II.)

The portion of the Thayetmyo civil district to the west of the Irrawaddy is hilly and covered for the most part by close jungle, rising in the west to the ridge of the Arakan Yomas (4,000 to 5,000 feet), which are precipitous and densely forested.

The road from Thayetmyo to Kyaukkyi (22 miles) was metalled and bridged; from Kyaukkyi to Mindon the road had been commenced and metalling laid in places, but there were few bridges, and none of them capable of carrying thirty-hundredweight lorries. The Pani and Mindon *chaungs* were unbridged.

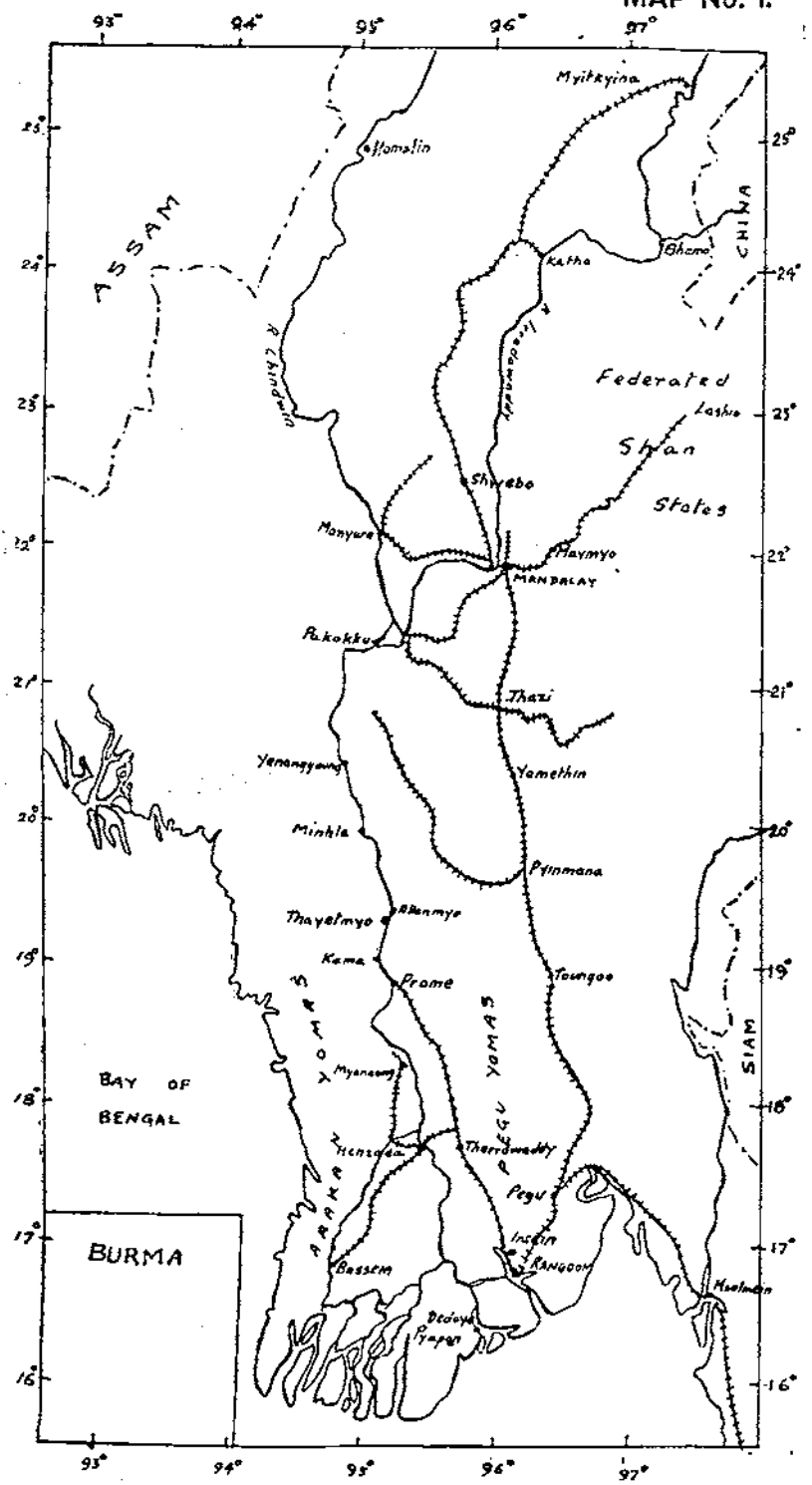
The old "outer frontier road" from Yenanman to Yegyansin *via* Myothit, Shandatgyi and Sangyi, and the "inner frontier road" from Yenanman to Thayetmyo *via* Linke and Monnatkon were unmetalled, unbridged, badly graded cart tracks except for the three miles joining the southern end of the inner frontier road to the main road Thayetmyo to Mindon, which were metalled. In addition, there were numerous cart tracks joining up villages, but, except for the road Thayetmyo to Kyaukkyi, none of the routes in the area were fit for any traffic except country bullock carts or pack animals.

The district lies on the border between the wet and dry zones, and rain is of almost daily occurrence from May to October.

Thayetmyo itself was the frontier station of Lower Burma before the war of 1885-87, and was a military cantonment up to within a few years of the outbreak of the Great War, and again during and for a few years after it, when a concentration camp for Turkish prisoners of war was situated there.

The objects of the operations were to prevent the rebellion from spreading northwards, to enable the civil administration to function again, and to break up rebel gangs and capture or kill the leaders.

MAP No. I.


93°
94°
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17°
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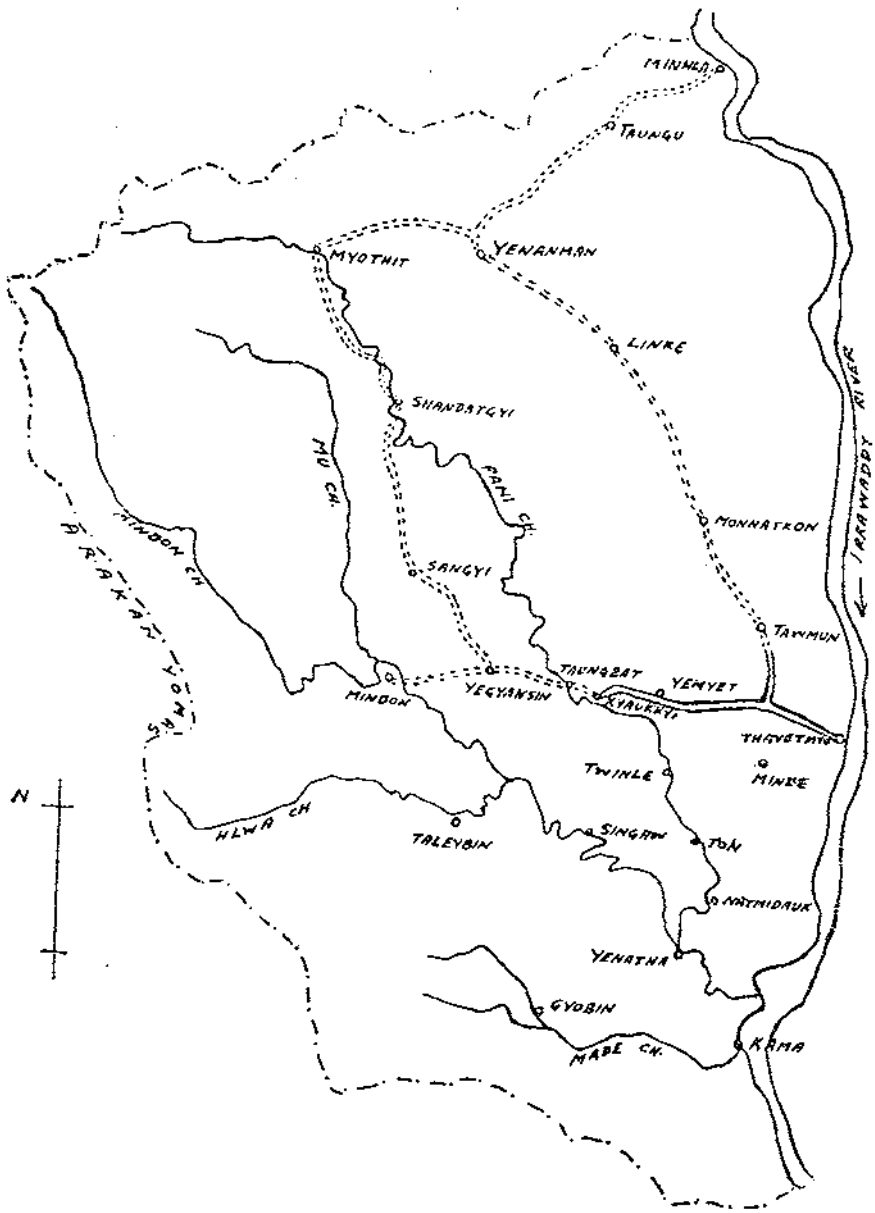
Myitkyina
Homalin
ASSAM
CHINA
Katha
Bhamo
R. Chindwin
R. Irrawaddy
Federated
Shan
States
Lashio
Shwebo
Monywa
Maymyo
MANDALAY
Pakokku
Thazi
Yenangyaung
Yamethin
Minhla
Pyinmana
Thayetmyo
Prome
Toungoo
Kama
Myanaung
Henzada
Thonzwaddy
Pegu
Insein
RANGOON
Bassein
Bogalay
Pyapon
Moulmein
SIAM
ARAKAN YOMAS
PEGU YOMAS
BAY OF
BENGAL
BURMA

The general scheme was that for the first part of the operations, troops should occupy posts with detachments of one or two platoons,

MAP No. II.



and operate on local information against rebel camps and gangs in their immediate neighbourhood. After this phase, two forces were to march down the "outer" and "inner frontier roads," halting for ten days at each post on the way, the increased garrisons then being

able to operate in the country around, " showing the flag," disarming villages, and effecting the arrest of any " wanted " men still at large. Whilst this was in progress, the garrisons in the area south of the Mindon road kept up a continuous pressure on the rebels in that area, for this purpose several temporary posts (occupied for ten days or a fortnight only) being established, in order to reach every part of the country. On the return of the columns, similar action was taken in this southern area.

The troops engaged in the operations were :—3/16th Punjab Regiment; 2½ coys. 3/6th Rajputana Rifles; 2 coys. 1/17th Dogras; 1 coy. 2nd Manchester Regt; 14 (Field) Company, Q.V.O. Madras Sappers and Miners (less one section); No. 1 Company, 1st (K.G.O.) Bn. Madras Pioneers; No. 28 Field Ambulance; No. 3 Indian General Hospital; A wireless section, and the usual accompaniments of supply and transport, making a total of about 2,500 troops in the area.

The Field Company, less one section (which remained in Mandalay as a depot and to supply the detachments at Shwebo and Gohteik), left Mandalay by river at dawn on August 2nd, and reached Thayetmyo on the afternoon of August 4th. The O.C. Company became the O.C.R.E. in the area, and in addition to his own company had at his disposal one company Pioneers (about 200 men), and the resources of the Public Works Department for work on the provision of accommodation and semi-permanent water supply.

Thayetmyo had old associations for the Madras Sappers, as 14 Company had worked on the defences there between 1879 and 1882, and 11 and 12 Companies had been stationed there during the rains of 1894-95-96, when road and other engineering work in the Chin Hills became impossible.

5. Engineering Operations, Thayetmyo, August 1st to November 25th, 1931.

The work in connection with the operations consisted of :—

(*a*) the provision of accommodation and water supply for the garrisons of all outposts, twenty in number;
(*b*) the provision of accommodation and water supply for the garrisons and concentrations at the main bases of Minhla, Kama and Thayetmyo;
(*c*) water supply and general engineer assistance to the columns operating through the country; and
(*d*) the making of the road Thayetmyo-Mindon passable by 30-cwt. lorries and 6-wheeler ambulances as far as Yegyansin, 31 miles from Thayetmyo, and 9 miles beyond Kyaukkyi, where the existing metalled road ended.

As items (*a*) and (*b*) were carried out entirely through the agency of the Public Works Department, no further mention of them will be made in this article.

Each of the columns was accompanied by a sub-section of Sappers (about twelve men). One or two canvas 500-gallon tanks and one 600-gallon trough, filled by lift-and-force pumps, were erected at each of the twelve halting places; improvements to tracks and extemporized bridging were carried out, and on occasions when there was no other work, the sub-sections functioned as infantry. The party with the western column put a light timber footbridge 200 ft. long across the Pani *chaung* at Shandatgyi on September 30th. This was carried away by a flood during the night, but was repaired next day as soon as the water had gone down sufficiently, and the whole column crossed before night. (See Photograph 2.)

Other engineering activities in the area included the installation and running of a mechanical pump for the water supply of Thayetmyo; the erection of portable searchlights on patrol launches; the analyzing of locally-made bombs captured from the rebels, and the laying of booby traps. The rebels possessed very few factory-made guns, but they constructed with great ingenuity a vast number of *Shomi* (*i.e.*, matchlock) weapons, the barrels of which consisted of piping of varying diameters looted from a number of sources. At Padaukpin, ten miles from Thayetmyo, there was an oil-field which proved a veritable Woolwich Arsenal for the rebels, until a military post was established there. On August 11th this post was withdrawn, and four booby traps, with Mills bombs as prime movers, were laid under very inviting heaps of $\frac{3}{4}$-inch piping (a most desirable size). Naturally the labour on the oil-field had to be warned not to touch any piping, and this warning was no doubt conveyed to the rebels. Although no actual victims resulted, the desired end was achieved in so far that all stealing of pipes ceased from that date.

Work on the Mindon road commenced on August 10th, and lorries were able to reach Yegyansin on September 12th. Five timber bridges with spans of from twenty to forty feet were constructed, all timber, except that required for decking, being felled at or near the site of the work, whilst dogs and spikes were made up in the field. It was found that, including all felling and hauling of timber and making of fastenings, the rate of work was about three men days per foot run of bridge. (See Photograph 3.)

The nine miles of roadway were made passable by the Pioneers, who laid over 15,000 running feet of corduroy, in addition to over 120,000 c.ft. of excavation and 2,300 running feet of revetted side drains. (See Photograph 4.) In corduroy work the rate was approximately four yards per man per day when timber had been previously collected at the site of work, and approximately one yard per man per day when timber had to be cut and carried before laying.

An average of 5·5 poles, three to four inches in diameter, were used per running foot of roadway, including bearers, surface and ribands, and 6·5 poles per running foot in bad places, where extra transverse poles had also to be laid.

The most interesting item of work was the establishment of a crossing over the Pani *chaung* at Taungbat, and this is described in the succeeding section.

6. The Crossing of the Pani chaung.

The Pani *chaung* was a river with a normal depth of 3 ft. 6 in. in August and September, but liable to flood to a depth of 17 ft. (it actually rose to 14 ft. on September 22nd, 1931). The width varied from 200 ft. to 350 ft. The bottom scoured very rapidly, and during floods very large timbers and trees were carried down by the current, whose normal velocity was 3½ to 4 m.p.h., increasing during a spate to 7 m.p.h. For these reasons any trestle bridge was out of the question, the only possibilities being a high-level bridge with long spans carried on masonry piers or piles. For a rapid operation, and taking into consideration the existing limitations in the supply of materials and the scarcity of transport, it was decided to instal a causeway to enable mechanical transport to ford the river during normal times, with a flying bridge for use during floods.

At the point selected for the crossing, the river was 220 ft. broad with a normal depth at the deepest point of 3 ft. 6 in. By cutting through a sandbank 2 ft. deep and 60 ft. wide, which lay near the west bank, the waterway was widened. A road formation was then made across the stream, with a depth nowhere more than 1 ft. 6 in. below normal level. This was done by placing two revetments 20 ft. apart on either side of the centre line of the road, and filling between with shingle. The revetments were made of 3-inch posts, driven 3 ft. into the bed, interlaced with hurdling of split bamboos, and supported inside and outside by walls of sandbags filled with shingle. (See Photographs 5 and 6.) On this formation a roadway 12 ft. wide between ribands was laid, made up of corduroy mats 6 ft. long of 3-inch " Pyinkado " poles. (Pyinkado is a wood which has a considerably higher specific gravity than water, and therefore the mats had no tendency to float.) (See Photograph 7.) Each mat was picketed down by six posts driven 3 ft. into the bed, and further held by an attachment in two places by No. 4 S.W.G. galvanized wire to substantial anchors, of which there were three for the whole causeway, about 90 ft. upstream. Each anchor was made of eight 6 to 8-inch diameter poles driven on the circumference of a 4-ft. diameter circle, interlaced with hurdling of split bamboo and with road-metal filling inside. After the anchor wires had been put round, a wall of sandbags filled with 1 : 3 : 8 mixture cement concrete

was built round the anchors from 1 ft. below to 4 ft. 6 in. above bed level. The scour marks at 45° on both sides below the anchors were also filled with similar sandbag walls.

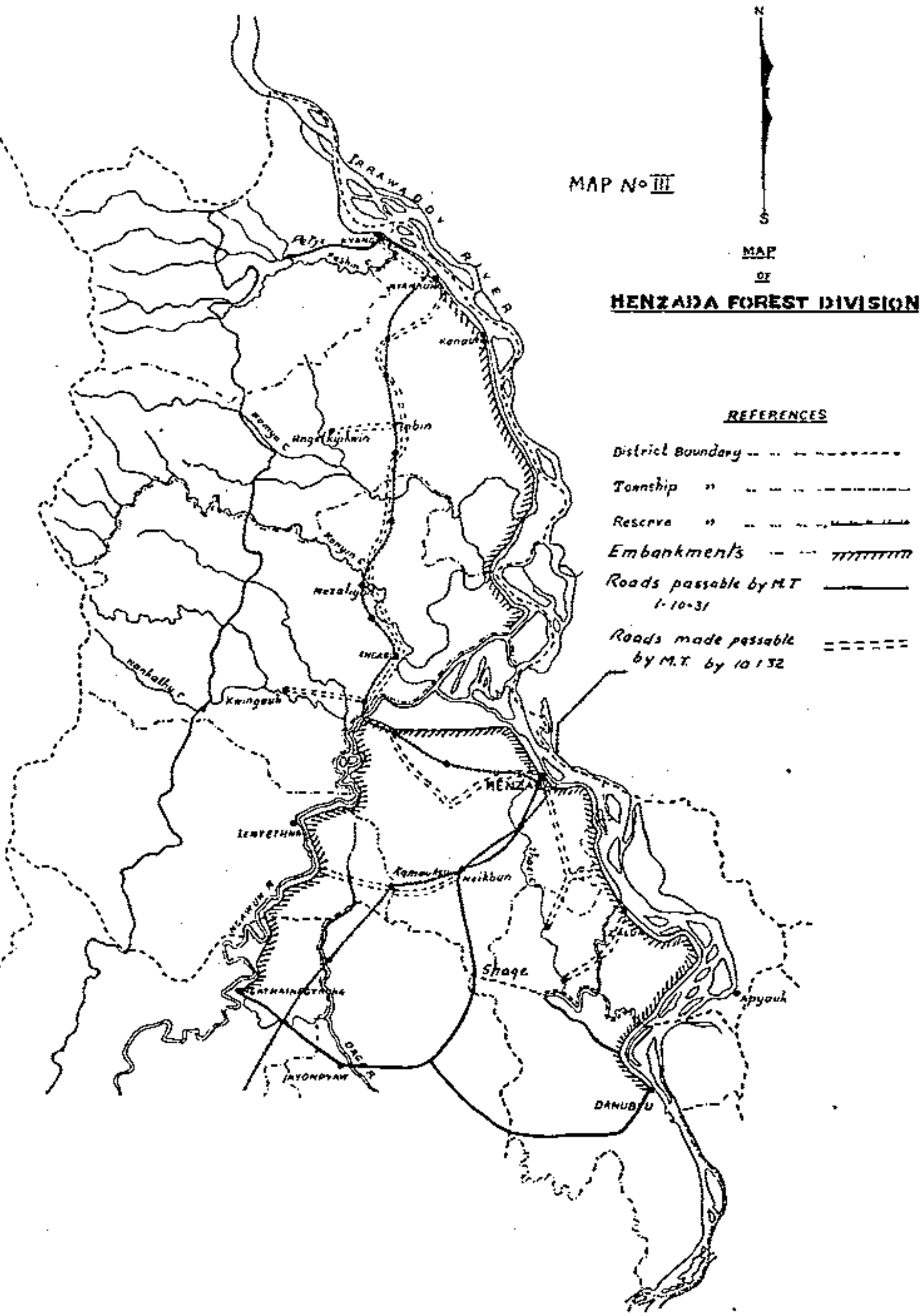
Excluding cutting and corduroying the approaches through the river banks, the work of construction occupied 17 working days, with an average of 25 men employed daily. Luckily no heavy falls of rain occurred during the progress of the work, and the causeway was completed on August 31st and in daily use until September 18th. After this date, several heavy spates occurred, and up to October 31st the causeway was impassable on fourteen days. At first there was a slight tendency to scour, and sandbags were occasionally washed out, but the trouble was never serious and caused no inconvenience. Contrary to the prophecies of the local savages, bullock and mule carts, as well as M.T., used the causeway without mishap. (See photograph 8.)

About 100 ft. upstream of the causeway a 3-inch steel-wire cable was suspended on two sheers, 25 ft. high, about 600 ft. apart. A raft was made of twenty-eight 80-gallon steel drums, weighing 192 lbs. each, purchased in Rangoon. Fixing was by G.I. wire lashings supplemented by spikes and straps. The raft was joined to a traveller running on the cable by a sling of 2-inch steel-wire rope made fast to bollards on the upstream end of each pier. The raft was provided with a pair of landing bays, 30 ft. long, for each bank. When the water was rising in flood or falling again afterwards, there used to occur an awkward interlude when there was still too much water to allow vehicles to use the causeway and insufficient water to float the raft on the road alignment, but these conditions rarely lasted for more than a few hours. The handling of the raft calls for little mention, and after a little practice the men of the Pioneers to whom it was handed over for maintenance became expert in working it in the heaviest floods. (See Photograph 9.)

7. THE OPERATIONS IN HENZADA.

(See Map III.)

Except in the west, where the country rises to the Arakan Yomas, the Henzada district is a flat alluvial plain which from the commencement of the rains until December consists of either flooded rice fields or swamp. Apart from the railways the only communications during the wet season of 1931 were the river embankments, which are narrow, and in many places present great difficulties to drivers of mechanically-propelled vehicles, and the metalled roads (*a*) Kyangin to Petyi, and (*b*) Henzada-Neikban-Shage to Ngathainggyaung *via* Kyonpyaw or to Danubyu. All other roads were impassable by M.T., due either to their being unmetalled and very often on a level with,


MAP No III
N
S
MAP
OF
HENZADA FOREST DIVISION
REFERENCES
District Boundary
Township "
Reserve "
Embankments
Roads passable by M.T 1-10-31
Roads made passable by M.T. by 10/32
IRRAWADDY RIVER
HENZADA
Shage
Apyauk
DANUBYU
Kwingauk
Nankathu C
Neikban
Zalun

or lower than the surrounding country, or to the fact that, owing to neglect over a long period, the surface had broken up and many of the bridges were unsafe. Once the rainy season is over the country rapidly dries up; existing tracks can without much difficulty be opened up for M.T., and it is often possible to move freely over the cut paddy fields and to avoid unsafe bridges by improvised diversions. (See Photograph 10.)

One company of Pioneers arrived in the area in August, but could make little headway against the sea of mud, and it was withdrawn until the first week of October. The section of the Field Company which had remained in Mandalay when the rest of the unit went to Thayetmyo, arrived on October 4th, to be joined at the beginning of November by the section which had returned from Thayetmyo to Mandalay, and another Company of Pioneers.

The object of the Engineer operations was to open up a number of roads for use in the dry weather to enable troops concentrated at central points to be moved rapidly by mechanical transport to disaffected areas or to operate against rebel gangs.

By the first week in January the technical troops had opened 136 miles of road, the work in addition to embankment-making, road-dressing and repairs to over thirty existing bridges, included the establishment of three fords, the construction of five new timber bridges, and the widening of two reinforced-concrete culverts.

The timber bridges, as in Thayetmyo, were constructed from timber felled at the site, and the same rate of work, *i.e.*, 3 man days per running foot, was obtained. (See Photograph 11.)

The fords presented far fewer difficulties than did the one on the Pani *chaung*. The currents were sluggish; the water level was falling daily, and by the middle of December was sufficiently shallow to allow a car to be driven through; the bottoms were of fairly coarse gravel, capable of standing up to normal traffic. At the Kanyin *chaung* the experiment was tried of laying a corduroy surface of bamboos. This was not satisfactory, as the bamboos (*a*) became very slippery when wet, and (*b*) being of less specific gravity than water, had a tendency to float, and when weighted down at the ends by heavy timbers, the scour set up caused deep holes to form under the corduroy. The Mamya *chaung* having a winding course, had a tendency to form channels, some of which threatened to be too deep to allow lorries to drive through them. This was obviated by constructing a "bed-level bund" across the stream, consisting of logs of wood (piles from an old burnt-out bridge), buried in the bed in a line eight feet on the downstream side of the centre line of the roadway. The logs were buried so that their surfaces were flush with the average bed level, and large stakes were driven on the downstream side, five feet into the bed, to prevent "rolling." A line of sandbags placed just upstream of the bottom edges of the

1.—The road to Mindon, August, 1931.

2.—Footbridge across the Pani *chaung*, Shandatgyi, September, 1931.

3.—Single-span bridge on the Mindon road.

A Field Company in Burma, 1931 1-3

4.—Pioneers at work corduroying the Mindon road.

5.—Commencement of the causeway across the Pani *chaung*.

6.—Constructing the causeway.

A Field Company in Burma, 1931 4-6

7.—Making up corduroy mats for the causeway.

8.—The finished causeway.

9.—The raft loaded with a bus and pioneers.

A Field Company in Burma, 1931 7-9

10.—A typical road in Henzada after the rains.

11.—Reconstruction of Kamauksu bridge, October, 1931.

12.—Cart track in the Pequ Yomas, near Prome, December, 1931.

A Field Company in Burma, 1931 10-12

logs prevented scour under them. The silting up of the gravel on the upstream side of the " bund " prevented channels from forming, and the fact that there was no obstruction to the flow of water precluded any chance of scour.

The two sections of Sappers left for Mandalay on New Year's Day, 1932, to be followed a week or ten days later by both companies of Pioneers.

8. The Engineer Work in the Prome Area, Nov. 25th, 1931, to January 4th, 1932.

Towards the end of August the situation around Prome, and on the Prome-Allanmyo border, again deteriorated. Towards the middle of November, Thayetmyo West having been completely pacified, the centre of gravity of military operations shifted to Prome. The section of Sappers and the company of Pioneers in Thayetmyo moved across to Prome on November 25th, the former being employed in the Paukkaung and the latter in the Ngapaw areas. The work here was the opening up of tracks into the Yomas to enable posts to be maintained by bullock cart transport instead of by coolies, and rapidity of work was of more importance than the accurate laying out of a route which might later become a permanent line of communication.

Between December 8th and 23rd the section constructed two tracks, one from Nyaunggyon to Natyedwin, a distance of 6½ miles, and one from Chaungywa to Taungbyauk, 5 miles. The work was all through hilly country covered with jungle varying from open woodland to dense forest. (See Photograph 12.) Excitement was supplied by occasional raids on neighbouring villages to arrest " wanted " men reported to be in them, and by a tiger who patrolled one of the newly-constructed tracks nightly, but was too cunning to succumb to the temptation of a tied-up ration goat.

The section left Prome on January 4th, and reached Mandalay on the 13th, the whole Company being reunited after just over five months' absence from their lines.

FIXING THE POSITION BY ASTRONOMICAL MEANS OF ROYAL AIR FORCE LANDING-GROUNDS IN SOUTH ARABIA.

By MAJOR R. E. FRYER, R.E.

IN the latter part of 1931, the Royal Air Force in Aden asked that the position of several new landing-grounds in the Aden Protectorate might be accurately fixed, with two objects in view, namely :

(1) The finding by any pilot of these landing-grounds by setting course and distance from Aden, this not being then possible, as their positions on the map were known to be very inaccurate.

(2) The use of the new positions as control-points, for some form of air survey at a later date.

In February of 1932 I was sent out from England to do this work. Although the actual survey work presented no very great difficulty, the project in general presented some interesting and novel features. As this class of work is increasingly likely in the future to be carried out by Sapper officers, it may be of general interest to describe it in some detail.

The whole region known as the Aden Protectorate, which stretches from the coast opposite the Straits of Bab-el-Mandeb to a point 400 miles East of Aden, has an area of about 9,000 square miles, and is administered by the Colonial Office, the civil administration only coming under India, and the military command under the Air Force.

Aden, with its mixed population of about 56,500, was annexed to the British Empire in 1839, when almost all traces of its former prosperity and importance as a commercial centre, dating back to many years B.C., had disappeared. It again attained prosperity as a coaling port, its importance becoming greatly enhanced since the opening of the Suez Canal in 1869, and is now also an important *entrepôt* for trade with Arabia.

The frontier was demarcated in 1902-04, the treaty between the British and Turkish Commissions being signed in 1905. It ran from Turba on the Red Sea (see map) to the Wadi Bana at Qa'taba, and thence N.E. into the desert. In the Great War the Turks approached Aden, occupying Lahej and Sheikh 'Othman, a place visited by many people landing at the port. The Imam of Yemen

is supposed to conform to the 1905 convention, but some encroachments have been and still are the subject of dispute.

Only a small part of the Aden Protectorate has ever been accurately mapped. This mapping is almost all in the western part, and was done by the Survey of India on $\frac{1}{2}''$ and $\frac{1}{4}''$ scales. The rest of the Protectorate in the east and north has never been surveyed, and the largest scale map available is the War Office 1 to 1 million, and also the Survey of India 1 to 1 million (about 16 miles to 1 inch).

The inaccuracies in the 1 to 1 million map were not so evident in the days of army control in Aden, as the troops could not cover large distances; but now that the Royal Air Force flies daily over the Protectorate and has established landing-grounds, these inaccuracies become much more obvious and embarrassing. They are not to be wondered at, as the only materials on which much of the topographical detail of this map is based are travellers' and explorers' routes.

Modern exploration in this region may be said to have begun in 1761-4, when a Danish expedition entered the Yemen from Mocha on the Red Sea, then a great coffee port. Expeditions by explorers of many nations have continued right down to the present day, culminating in the crossing of the Rub' al Khali, or Empty Quarter, first by Bertram Thomas, and then by Philby, within the last year or two.

In the particular country round Aden in which I had to fix these landing-grounds, a political officer from Aden named Wyman Bury had, in 1903 and 1904, done important work. His wanderings up to Dhala, and later across the Kaur watershed to Yeshbum, are well described in his book, *The Land of Uz*. He started with the idea of doing an extensive survey with Indian surveyors, but unfortunately in a fight at Mis hal (one of the landing-grounds fixed) one of his surveyors was killed. The rest refused to continue, and returned to Aden *via* Shuqra. Wyman Bury went on alone, doing most excellent work, and made a very good map.

Most people who have merely landed for a short time at Aden are surprised to hear that within a few miles the flat sandy plain gives way to foothills, and beyond these to the mighty cliff known as the Kaur. This outstanding feature rises 6,000 to 7,000 feet, and even higher in places, the upper 3,000 feet almost vertically. Some of the ground on the top of the Kaur is fertile and cultivated. Parts of it are very broken and precipitous, but eventually in the N.E. the hills merge into the great desert of the Rub' al Khali. It is extremely grim country to fly over, with no possible landing-places except those cleared and prepared by the Royal Air Force. It says a very great deal for the skill of the pilots and the reliability of British aircraft engines that the Royal Air Force are able to fly about daily over this sort of country.

The climate at Aden is hot and steamy, with little or no rain. Up country it is very much hotter by day and cooler by night. In March, when I was observing at Nisab, the temperature was about 100°F. by day and dropped to about 60° just before dawn. In Aden it was about 85° and 76°, but the atmosphere was far more humid and unpleasant. Night frosts are quite common in the hills in the cold weather, with scorching sun by day.

Although this work had been discussed between the War Office and the Air Ministry for some time, it was not before February 3rd that I received orders to leave London on February 18th, and to have all stores ready to leave on February 11th.

The stores I decided to take were as follows :—

(1) The new Tavistock theodolite (Cooke, Troughton, & Simms, see photograph).
(2) A spare 5" micrometer Cooke, Troughton, & Simms theodolite, most kindly lent at the last moment by the Director-General of the Ordnance Survey, Southampton.
(3) Mean time and sidereal time chronometers by Messrs. Mercer.
(4) An R.P. 11a Marconi wireless set with frame aerial, complete with 2 sets of inert H.T. and L.T. batteries.
(5) A plane table with all its gear (alidade, etc.).
(6) A 100-foot steel tape.
(7) 2 aneroid barometers and 2 thermometers.
(8) A survey umbrella.
(9) The usual stationery, G.S.G.S. astronomical Forms 29 to 36, and Close's *Textbook*, the Surveyor's bible.

Of the above, nearly all were War Office stores, and were lent to the Air Ministry for the job, and I was responsible for their safe return. All did return except one thermometer, which I sat on.

These stores, with the exception of (1) and (3), which were not ready by February 11th, were taken by lorry from the War Office to the R.A.F. depot at Kidbrooke. They were there crated ; when I went to inspect them, I was rather horrified to find them marked " Capt. Fryer's personal baggage." In order to make sure there was no hitch, I went personally with the R.A.F. lorry to Tilbury Dock in a snowstorm on February 10th ; this was the only certain way to ensure that all stores would be loaded on the P. & O. *Strathaird* sailing next day.

The following week was spent in settling various points and in trying out the Tavistock theodolite, which I had never used before. Unfortunately the weather was intensely cold and cloudy, and I did not have much success.

I left Victoria by the P. & O. special train on Thursday, February 18th, and sailed from Marseilles on February 19th, reaching Aden on Sunday morning, February 28th. On the voyage I spent a good

deal of time preparing my star programmes and rating the chronometers. The latter was made possible by the use of the ship's wireless, thanks to the courtesy of the Marconi officials; one of these on the *Strathnavar* was an ex-Sapper. The *Strathaird* was on her maiden voyage, and all her wireless gear was of the most modern. All the same, the wireless time signals were no easier to pick up than they were with the set I used on land.

In all classes of latitude determinations it is essential to have a programme prepared beforehand (see *Notes on Field Astronomy*, 1932, pages 81 to 83).

I worked out a programme of all possible stars (about 70) from dusk to dawn, and used almost all of them at one time or another.

On Monday, 29th February, I unpacked all my stores at the R.A.F. Squadron, and was able on Tuesday to hear the 8 a.m. wireless signal from Rugby. This was extremely gratifying, as all the wireless fans at Aden scoffed at the idea that I should be able to do so. Incidentally, I did not hear any more until I was out on the job owing to terrible atmospherics due to thundery weather up country. I tried out the Tavistock theodolite on two nights at Aden with no results, owing to very high wind and dust on both nights.

After a conference on Monday with the Air Officer Commanding it was decided that I should fix the position of the following landing-grounds:

(1) Laudar.
(2) Mis hal.
(3) Nisab.
(4) Beihan.
(5) Ahwar.
(6) A place somewhere near where the Wadi Maifa'a runs into the sea. (This was not fixed owing to the difficulty of landing at this spot, and is not shown on the map.)

It was agreed that aircraft for carrying all my stores, food, etc., should be allotted to me, and also that F.-Lt. A. R. M. Rickards, O.B.E., A.F.C., R.A.F., who knew the country well and could speak Arabic, should accompany me. Captain T. A. N. Bent, the R.E. officer in Aden, also came with us on nearly every occasion, and performed most excellent work as a booker and an indefatigable plane-tabler. Rickards did all the camp and food *bandobast*, and obtained full marks, as we never ran out of anything, not even beer!

On Wednesday, March 1st, I did a reconnaissance flight with Rickards in a Moth machine lasting 2½ hours, landing at both Laudar and Mis hal. I decided that we would fix the centre of the white stone circle of each landing-ground, and that we would also make a plane-table sketch of the vicinity of each one. This

would assist pilots flying to the landing-grounds for the first time, and might also assist any ground personnel.

I was very sick indeed on this flight, both in the air and on return. It is almost unbelievable how a small machine can be thrown about in bumps in that hot atmosphere, without coming to pieces in the air. I may say I never went in a Moth again, and also that I was never sick again.

I decided to go to Laudar on Saturday, March 4th. I was allotted three aircraft, and we loaded them at Aden at about 6.45 a.m. The machines were Fairey 3F, with a cruising speed of about 100 m.p.h., and a total flying duration of about five hours. These machines have bomb-racks of length 2′ 3″ and width 1′ 6″ and depth about 1′ 6″ under each wing, and a large rear cockpit, length 5′ 2″, width 2′ 10″, and depth 2′ 9″. The normal fuel-capacity is 137 gallons, the average consumption being 25 gallons per hour. All the same, when I saw all the stores, beer and three large officers on the tarmac, I never thought we should get everything loaded. It is essential that the R.E. officer should carefully check all his stores, as the R.A.F. is only concerned with loading the machines correctly. Despite most careful checking, on one occasion an important store was not loaded, as no one thought I wanted " that old sack," in which the said store had been packed.

For those officers who have to do much flying I strongly recommend the purchase of goggles and a helmet with earphones. The R.A.F. can and does lend them, but it is much better to have your own. Another point is the fitting of your parachute. Don't be diffident about asking how this works, as your life may depend on it. Make sure also of getting the straps adjusted to fit properly, as this makes a long flight far more comfortable.

We left Aden at 7.30 a.m. and arrived at 8.37. I must here relate the sad story of the S.T. chronometer. The M.T. chronometer, by the way, stopped in the Red Sea and refused to go again. Both had been treated by me with the utmost care since I left London. When flying, I carried the instrument on my knee to save vibration. I was in the rear cockpit with Rickards, the pilot being a pilot-serjeant. Just as we were going down to land, Rickards noticed that the landing-ground was covered with camels. He stood up to shout " Camels " to the pilot, who had not seen them, and in the act his earphones caught in the chronometer on my knee and it slipped on to the floor of the machine. This shock altered the rate of the chronometer from losing about 1 second a day to about 55 seconds, but this remained very constant.

The Tavistock theodolite has a very poor box for aircraft-transport, and I found it impossible to give it a better place than the floor of the machine. The wireless set always travelled in the bomb-racks and suffered no ill effects. The H.T. battery, however, which

Photo 1.—Beihan, looking N.E. down the wadi towards Sailan and the Rub' Al Khali.

R.A.F. Official Photograph (Crown Copyright reserved).

Photo 2.—Jibla, one of the many towns tucked into the hills, showing cultivation in the foreground.

R.A.F. Official Photograph (Crown Copyright reserved).

Fixing the position by astronomical means 1-2

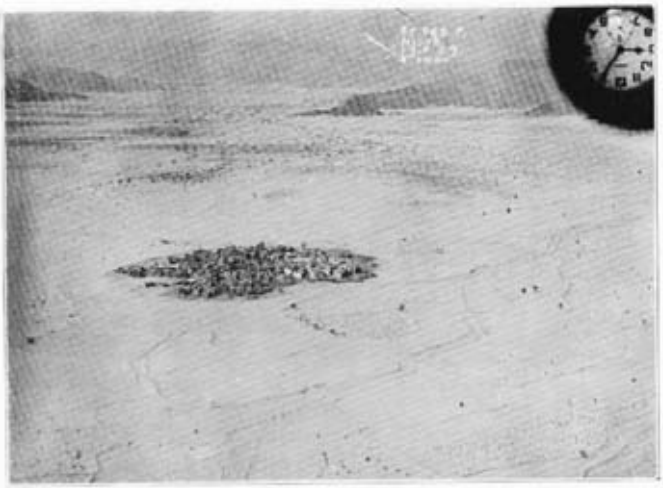


Photo 3.—Nisab, looking west. The L.G fixed is close under the rock in the extreme top right-hand corner

R.A.F. Official Photograph (Crown Copyright reserved).

Photo 4.—Al Qara, about 6,000 feet. A landmark flying from Aden to Beihan.

R.A.F. Official Photograph (Crown Copyright reserved).

Fixing the position by astronomical means 3-4

Photo 5.—Types at Mis hal, showing the complete armament. Note the sheep's skulls protecting the butts

Photo 6.—"Prepared to receive cavalry" at Mis hal. Sultan's son in foreground

Fixing the position by astronomical means 5-6

Photo 7.—The head Sheikh at Beihan, taken just before going on a pilgrimage to Mecca.

Photo 8.—One of the leading men at Beihan. He gave me his jambiya in exchange for cigarettes.

Fixing the position by astronomical means 7-8

Photo 9.—The "Tavistock" in use at Laudar. Note the military bearing of my carriers.

Photo 10.—Our abode at Laudar. (The bathroom, kitchen, and lavatory waste is clearly visible.)

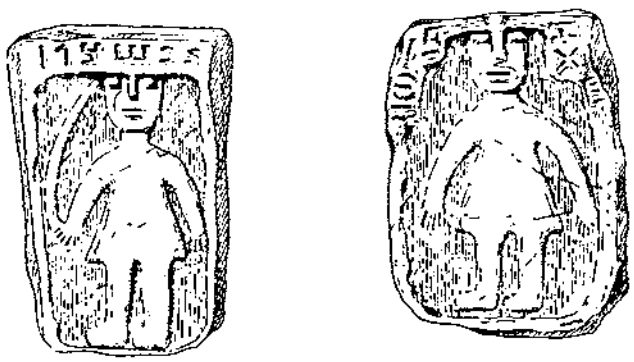
Fixing the position by astronomical means 9-10

Photo 11.—The flight that brought us to Mishal. Unloading the gear.

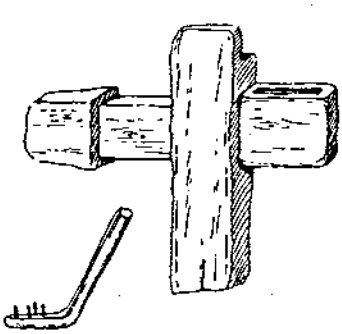
Photo 12.—A very venerable old Sheikh at Nisab. Rickard's tent (?) behind

Fixing the position by astronomical means 11-12

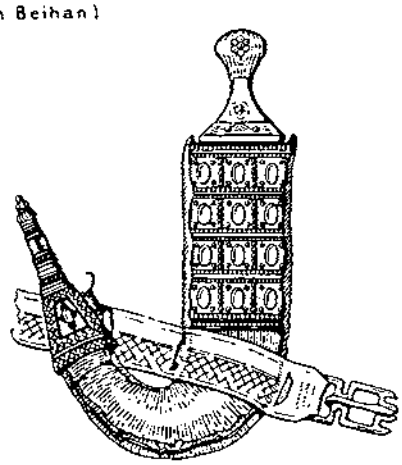
MARIA THERESIA DOLLAR
The current coin of the Desert.
actual size.



EXAMPLES OF HIMARITIC SCULPTURE.
(Fakes, from Beihan)

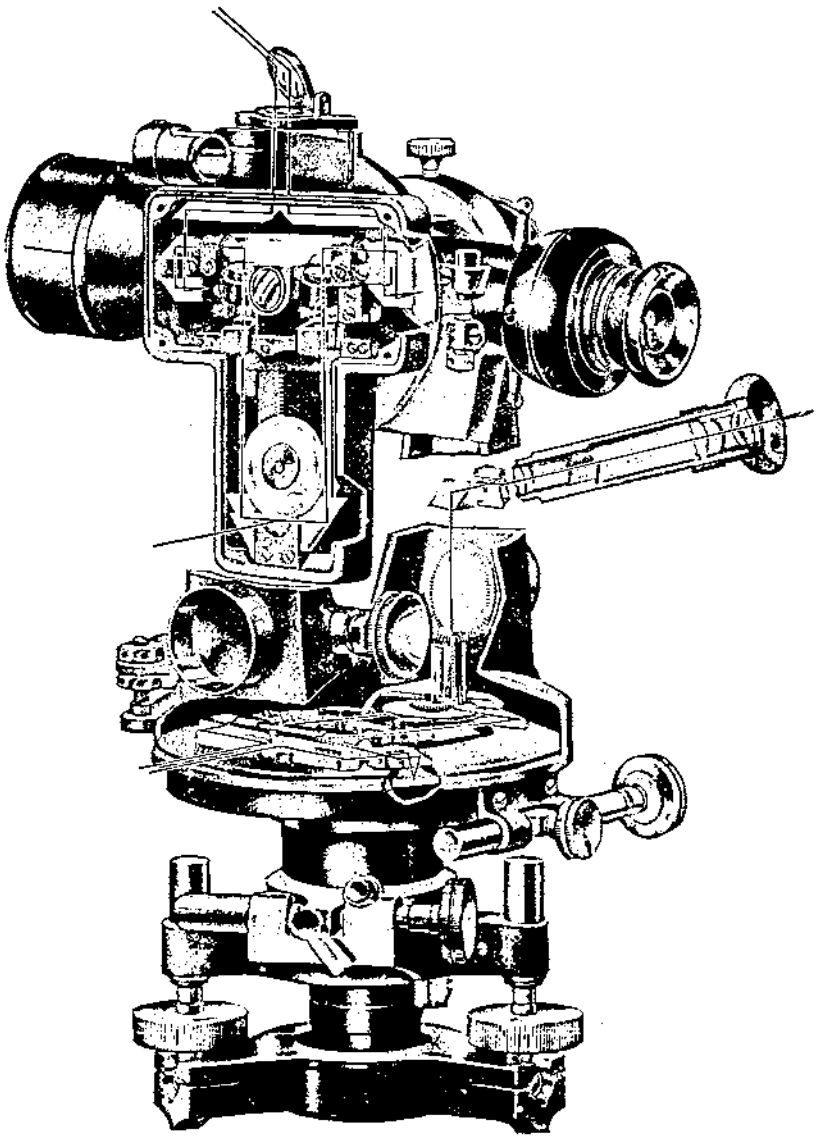


WOODEN ARAB LOCK.



JAMBIYA OR CURVED KNIFE
(Worn by all.)

"TAVISTOCK" TRANSIT THEODOLITE.



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A British theodolite in which all observations are made from one position. The divided circles, made of glass, are read by internal optical micrometers to one second of arc. Readings are taken simultaneously on opposite sides of each circle and automatically meaned, centring errors being thereby incidentally eliminated.

consisted of several inert cells coupled together, nearly always after a flight had loose connections due to vibration.

At Laudar we lived in the local sheikh's *dar* or house, which was about one mile from the landing-ground. I soon found this a great disadvantage for time-signals, etc., and at all future landing-grounds we invariably camped or lived on the landing-ground itself.

The night of the 5th March was cloudy, after a thunderstorm, and although we were up on and off all night, nothing was achieved. We did, however, measure a base of about 1,200 feet with a 100-foot steel tape, in the approved style, once in each direction, with an error that was surprisingly small, as the tapemen were totally untrained Arabs. Bent, then as later, was indefatigable with his resections and intersections, and walked miles in the heat of the day. Rickards also was not idle, as he had about 100 Arab coolies at work all day clearing the landing-ground.

Sunday, 5th, was nearly as bad for clouds, but it was on this night that I confirmed my suspicions that the Tavistock theodolite was not working properly. It was possible in some pointings on a star to get two readings, both of which appeared equally good. I was unable to put the trouble right, and did not use the instrument again. This was very disappointing, as I had brought it out specially for the job, and electric lighting and easy reading make it delightful to use at night.

As machines could not stay out on the landing-grounds all night, due to difficulties in protecting them, they always returned at once to Aden, leaving us three officers on the job. On Monday, 6th, I returned by air to Aden, it having been agreed that aircraft should call for us on this day. I got out my spare theodolite, which was an old 5″ micrometer C.T. & Simms, packed in two heavily-padded leather boxes, which were most suitable for air-transport. This theodolite is well known to all R.E. officers, and will bring back memories of hectic nights outside the S.M.E. observatory, and the well-known formula, "Stand by, coming up—D—— that cursed light."

The Tavistock theodolite is the new Service instrument, and gives readings to the nearest second, meaning face right and face left in one operation. The lighting is excellent, and is worked by an electric battery and a rheostat, and the weight is only 11 lb. The cost at present is £96.

The wireless set was the standard 4-valve Marconi time-receiving set used by the War Office for some years. It is operated by inert H.T. and L.T. batteries and a frame aerial, and it worked without a hitch. At times the signals were so good that I had to tone them down. Especially was this so with Nauen, the German station, which signalled at admittedly the best time, 3 a.m. L.M.T., while Rugby at 11 p.m. was the poorest.

No wireless time-receiving set has, I think, ever been used in this part of Southern Arabia before, and I fancy that this is the first time that complete survey-gear for finding latitude and longitude has been transported by air. The Arab sheikhs who listened to the signals from England were highly thrilled, but they liked the ticking of the chronometer best. They would listen intently with wonderment written all over their faces, and then would smile and say, "*la illah il Allah*" ("There is no god but God").

The S.T. chronometer was a standard Mercer instrument ticking half-seconds and seconds, and missing a beat at each complete minute. It had seen much use on gravity survey, but worked well. I started it at Marseilles on February 18th to read Greenwich sidereal time, and it maintained an excellent losing rate of about 1 second per day, until the unfortunate incident previously described. I kept the chronometer going the whole time, as I wished to observe its behaviour after transport by air. I carried it always on my knee on these occasions, and was unable to detect any marked change in its rate even after long flights. It was finally stopped on April 3rd after 45 days' non-stop running.

All important time-signals are now sent on continuous wave on a wave-length of about 19,000 metres. The stations I used were as follows:—

Station.	*Wave-length.*	*Aden Time of Signal.*
Rugby	18,750 ..	12.55 p.m.
		20.55 p.m.
Bordeaux	18,900 ..	11.01 a.m.
		23.01 p.m.
Nauen	18,130 ..	15.01 p.m.
		03.01 a.m.

These were very useful times for star work, giving good brackets 9 p.m. to 11 p.m., with Nauen at 3 a.m. always very clear. Much useful information about time-signals and receiving sets is given in *R.G.S. Technical Series No.* 3, by Mr. Hinks, last published in 1929.

The type of signal I received is known as the rhythmic, and consists of 306 dots or 305 gaps sent in exactly five minutes of mean time, with 61 intervals equal to one minute of mean time. For ease in identification, dots number 0, 61, 122, 183, 244 and 305 are lengthened to 0·4 seconds, and are usually called bars. This has the great advantage that when signals are badly heard any bar at a precise minute will give a useful signal. The principle of this type of signal is the comparison of the ticks of the observer's chronometer with the wireless dots spaced at exactly equal intervals of time apart, each interval being nearly but not quite a second. If the seconds-hand of the chronometer be watched by eye or listened to with one ear, and if the wireless dots also be listened to, a time "vernier" will be

established, and it will be possible to get four or five coincidences of the wireless dots and the chronometer seconds-hand. As the Greenwich time of the first and last bar of the wireless signals is known, it is only a matter of proportion to calculate the Greenwich time of any dot coincidence.

Different observers have different methods of obtaining these coincidences, each thinking his own method is the best. Several such methods are described on pages 100 *et seq.* in *Notes on Field Astronomy*, 1932. The method I used was first used on a gravity survey in 1931, and I found it extremely successful. In this method the observer looks vertically down on the chronometer with the wireless dots sounding in the earphones. A little practice will enable him to estimate the coincidence of a wireless dot with the "flick" of the seconds-hand of the chronometer. There is a belt of about six dots, all of which appear to be coincident, but this does not matter. As soon as the wireless dots begin, the chronometer is watched intently until the estimated first coincidence occurs. The reading of the minutes-hand and seconds-hand of the chronometer is immediately written down. On looking back at the chronometer it will be found that the wireless dots and the seconds-hand are still nearly coincident. The observer continues counting the wireless dots, assigning to the dot the number indicated by the seconds-hand of the chronometer, and then continuing to count wireless dots until the next bar is reached; the number of the bar should then be noted down. This completes one coincidence, and the observer can then begin to concentrate on the next. The results then appear as follows:

Date .. .. .. 21st March, 1932.
Station .. .. Beihan.
Signal and Time .. Rugby 17 hr. 55 min. (G.M.T.).

H.	*M.*	*S.*	*Count to Bar.*	*Bar number.*
5	36	44	.. 59 ..	1
	37	55	.. 59 ..	2
	39	7	.. 60 ..	4
	40	17	.. 60 ..	5

To obtain the chronometer error, all coincidence times must be referred back to the time of the first wireless dot. The working of this is shown on Table 1.

If the signal is sent correctly and the coincidences are observed correctly, then they should be 72 seconds apart on a S.T. clock. This magic figure should not be allowed to bias the results. It is interesting to note that an error in judging the time of the coincidence of 1 second in the same sense throughout only affects the answer by 0·0137 seconds; if only one coincidence is wrong, the difference in the results is only 0·003 seconds. Unless obviously

TABLE I.

Date: 21/3/32. *Station:* Beihan. *Signal and Time:* Rugby, 17 hr. 55 min. *Chronometer:* Mercer Sidereal.

1	2	3	4	5	6	7	8	9
Chron. time of coincidence.			Count to Bar.	Bar number.	Dot intervals between coincidence and next bar. (Col. 4—Col. 3).	Dot intervals between coincidence & first dot. (Bar number—Col. 6).	Time between coincidence and first dot.	Chron. time of first dot. (Col. 2 & 3—Col. 8).
H.	*M.*	*S.*					*M.* *S.*	*H.* *M.* *S.*
5	36	44	59	1	15	61 — 15 = 46	46 x ·9863 = 45·37	5 35 58·63
	37	55	59	2	4	122 — 4 = 118	1 56·38	35 58·62
	39	7	60	4	53	244 — 53 = 191	3 08·38	35 58·62
	40	17	60	5	43	305 — 43 = 262	4 18·41	35 58·59
							Mean	5 35 58·61

To calculate the chronometer error:

	H.	M.	S.
G.S.T. of G.M.M. (21st March, 1932)	11	53	11·13
P.M. signal add 17 hr. 55 min. in S.T units	17	02	47·56
		55	09·04
∴ G.S.T. of 1st dot =	5	51	07·73
But Chron. time of 1st dot =	5	35	58·61
∴ Chron. is slow		15	09·12

faulty, results should not therefore be discarded, as the mean result will not be far wrong, and is just as likely to be right as any complicated method of adjustment. A complete example is shown on Table I.

If the R.A. and Decln. of a star and the L.T. be known, then an observation of its altitude at the instant of upper or lower transit will give a value for the latitude.

There are, however, several limitations to this as a practical method of observing in the field, for the following reasons :—

(1) The direction of the meridian must be accurately known, and this is not easy to determine.

(2) The L.M.T. or L.S.T. must be known accurately by means of wireless time-signals.

(3) With a single observation to a star it is impossible to eliminate the collimation error of the theodolite. If, however, a north star is observed on F.L. (say), then an observation to a south star also on F.L. will give a reading which is as much too great (say) as the former reading was too small. Hence the true latitude can be obtained by taking the mean of a determination to a north star and a south star.

If these limitations can be overcome, then the method is easy to observe and compute, no logs at all being required for computation.

For high latitudes it is possible to find the meridian by computing the azimuth of Polaris. In the low latitude of Aden, the following method was adopted. A star of fairly large magnitude was chosen with a convenient time of transit at the beginning of the night's work. Several readings both before and after transit were taken on both circles of the theodolite. It was found that for about one minute of time before and after transit it was impossible to detect any rise or fall in the star's altitude.

The sequence of work then is as follows :—

(*a*) Prepare the programme of stars as already stated.

(*b*) Obtain by wireless signals the error of the chronometer.

(*c*) Set up, observe large star, note H and V readings at transit and note time by chronometer. The horizontal reading at the moment of greatest altitude (best obtained from a graph) will give the correct setting for the meridian. A comparison between the time noted at transit and the R.A. of the star will give the error of the chronometer on L.S.T.

(*d*) Observe north and south stars at transit on *same* face.

(*e*) Compute latitude from the simple formula $\pm\lambda = \pm\zeta \pm\delta$ correcting each observation for refraction.

(*f*) Pair north and south stars of about the same altitude.

The above method, although not perhaps of great accuracy, gave very good results, and was used at all stations. The usual method of circum-meridian altitudes was also used as a check. The difficulty was to get enough north stars to pair with south. The ease of computation compared with the more rigorous circum-meridian method is very marked indeed.

On Wednesday, 9th March, I returned by air to Laudar with the old 5" micro-theodolite, and on that night and the next was able, despite clouds, to complete my observations. Our reception on arriving was rather amusing after the initial shock of it. A *feu de joie* was fired, and bullets whistled all over the place; then the local sheikh or sultan came up and shook hands. All the *askaris* or soldiers of the tribe were armed with serviceable rifles or carbines of every description and make, but the majority were British. Nearly everyone possesses also a *jambiya*, or curved knife, which he wears round his waist with his cartridge-belt (see illustration). At Laudar there were two men who had been to Aden and had served with the local levies; having some idea of discipline, they were most useful men. Note how nicely they stand to attention for their photographs. (Photo 9.)

On Friday, the 11th, three aeroplanes came up from Aden and moved us to Mis hal, about 15 miles. Here—after my experience with clouds at Laudar—I decided to spend four days. As it happened, the nights of the 11th and 12th were both good, and I completed the observations. The local sultan was a truculent man, but had a most entertaining son, with whom I made great friends; we frequently landed at this landing-ground. We had tents of a sort here, brought up by camel from Aden; so we lived in more comfort. On Sunday, 13th, we had an early night, as we had been up practically all night for four nights running. Rickards had some trouble with the coolies working on the landing-ground. He said 8 annas was his rate for a day's work. The local T.U.C. would not agree to this, and they spent the whole morning till mid-day arguing before any agreement was reached. Rickards now said that the pay was 4 annas for the rest of the day, and after further arguing they agreed. When paid in the evening, those who got one four-anna piece thought they were very hardly treated compared with those who drew four one-anna pieces. Many had never seen money before, being only accustomed to a system of barter.

On Monday, 14th, three aeroplanes moved us to Nisab, about 100 miles. This meant flying over the Kaur, and some very grim country beyond. We camped on the landing-ground; it was a hot day, the temperature just reaching 100°F. in the only little tent we had. Our *feu de joie* here was fired by one man, who had run miles, and arrived in a breathless condition putting a round (live) into the breech.

On both 14th and 15th we were up all night and were much

bothered by high cirrus cloud. However, we just managed to get enough observations. There was a very distinguished-looking old sheikh here (see Photo 12). One of his sons used to sit on my camp-bed and stroke the blanket, which was no doubt a wonder to him.

On 16th we left for Aden, which we reached in 1 hour 27 minutes. The 17th and 18th were spent in working out computations, of which I now had legion, and in enjoying a well-earned rest.

We left for Beihan (Photo 1) on Saturday, 19th, and took 1½ hours on this flight, which was over some very grand high country; one village, Al Qara (see Photo 4), perched on the top of a hill, was very remarkable. As Beihan lies right on the supposed boundary indicated on the 1 to 1 million map, I decided to spend four days there in order to improve the chance of getting good results. It was lucky that I did so. On the 19th there was a thunderstorm and it rained nearly all night. The Wadi Beihan, which is very wide here, came down in spate next morning. All this water runs to waste in the great desert Rub' al Khali, and by next morning the wadi was dry again. Both 20th-21st-22nd were cloudy at times, and it was only by staying up all night that I managed to get enough observations—a very tiring job.

We lived in a very grand *dar* at Beihan, but it was full of bugs, as indeed were all the houses we slept in. Being fresh from England, I was bitten worse than the others, and as the sandflies were also troublesome, I spent most of my time scratching, a source of great amusement to the native inhabitants of the house. Flies were also very bad everywhere. There were so many on the food, drink, etc., that it was difficult to avoid eating them, and quite impossible to do anything about it.

Observing here one night I had as many as 70 Arabs, armed to the teeth, sitting round the theodolite. They would attempt to imitate my calling out angles, and became very good at calling out "Coming up—Oopp." They thought I was photographing the stars, and it seemed to us a good plan to foster this belief, as the tribesman is suspicious of instruments, especially of those that tick, and therefore probably have *jinns* or devils inside them.

We established quite definitely the fact that Beihan is well inside the Protectorate, although it is known that the Imam of Yemen maintains that it is inside his country. One man at Beihan (shown in Photo 8) was most inquisitive, and asked intelligent questions about England; he insisted on showing me his prowess at writing Arabic by giving me examples in my angle-book. He also gave me his *jambiya* in exchange for cigarettes. Many of these knives are very ornamental. They are said to be made by local cutlers in a town on the borders of the Hadhramaut.

Here also are to be found Himaritic remains, and Rickards went miles to take a photograph of inscriptions on a rock. I acquired

two stones with figures and inscriptions all complete. Alas! the British Museum tells me they are forgeries. It is indeed a sign of the times when a factory for forgeries of this nature is found in these remote corners of the world, where probably only half a dozen white men have ever been before.

The currency used in this part of Arabia is interesting. It is not the rupee, the standard British currency of Aden, but the Austrian Maria Theresa dollar, worth about 1s. 4d. (see illustration). The history of this coin is that in the eighteenth century it was the popular currency of the Levant, whence its use spread through Arabia and Abyssinia and as far as Madagascar. The Arabs liked it, and have always insisted on having it. Some 15,000,000 are still struck annually in Vienna, and the coins have or had a good ring. This and the figure of the Empress (1717-1780) are supposed to be reasons for its popularity. Attempts by the British, Abyssinians and Italians to oust it have always failed.

We returned to Aden on the 23rd March, and the whole population complete with band turned out to see us off. It is a difficult job to keep these Arabs out of the revolving propellers of aircraft. They want to poke their noses in everywhere and to handle everything. The objection to stopping the machine is that it is often extremely difficult to re-start, as we knew to our cost on several occasions.

From 24th to 30th March was Easter leave week, and I was left alone with my comps. It is most trying to compute in Aden in the heat, and when you use the fan, all your papers blow away.

On the 30th we left for Ahwar, some 120 miles along the coast, quite a different type of place from the others, all of which were about 3,000 feet up. However, we had two consecutive cloudless nights for the first time on this work. The only hitch was that I lost my way from the centre of the landing-ground to our tent, where the wireless set was. I found it only just in time to get the 11 p.m. Rugby signal. Needless to say, all our bodyguard of *askaris* were fast asleep and had forgotten to display the light as ordered.

We had returned to Aden on April 1st, and on the nights of 1st, 2nd and 3rd I worked at Tarshyne Fort, one of the trig. points of the Aden triangulation whose position was required.

On the 2nd I did a 4-hours reconnaissance flight with Rickards in glorious visibility. We flew over Bani Baq-Beidha (held by Yemen)—Laudar—Habban—Yeshbum—Mis hal (landed)—Aden. On Monday, the 4th, I lectured to the Fortress Company, R.E., in the morning, and to the Command in the evening. I also took all my stores to be packed.

On Tuesday, 5th, I completed another 2½ hours' reconnaissance flight in poor visibility, but over wonderful and awe-inspiring country *via* Lahej — then west towards Mocha — Museimir — Dhala'—Qa'taba—Awabil Fort—and back to Aden.

On Wednesday morning I said good-bye, and sailed at 5 p.m. on the P. & O. *Strathnaver*, the sister-ship of that on which I travelled out.

On my way home I stopped at Cairo for a fortnight, where the R.A.F. were carrying out air survey experiments, and also flew over to Ramle (Palestine) and thence up to Jerusalem. I arrived back in London on Saturday, April 30th, having been away just over 11 weeks.

All the computations were completed at the War Office, and the results are appended, showing the difference between the map fixings and mine. Now that it has been decided to carry on with the mapping of Aden, these positions will be invaluable, so that both the objects given in the opening of this article will be achieved.

The lessons learnt are all old, but will bear repetition:

(1) Most careful organization of stores before leaving London. In a one-man job of this nature where speed is essential, it is imperative that nothing should be forgotten. Adequate provision of spares must be taken. In this case I should have been completely defeated if I had not had two theodolites, to say nothing of the chronometer. No such things existed in Aden.

(2) Make sure that you are provided with definite orders from home as to what you are to do. This prevents unpleasantness when you arrive and enables you to carry out your reconnaissance and to make your plans with all possible speed.

(3) Make sure that you are clear as to what you want to do before you start. Do all in your power to foster the good relations that already exist between the R.A.F. and the Sappers. I have nothing but praise for the efficiency with which the R.A.F. managed my trip in England, Aden, Egypt and Palestine.

Lastly, if anyone wishes for further information on any of the methods used, I shall be most happy to give them. Of books on Arabia there are many; but I recommend *Arabia Felix*, by Bertram Thomas, and no doubt Mr. Philby will shortly be supplementing his recent articles in *The Times* by a book describing his remarkable journey across the Empty Quarter or Rub' al Khali. Arabia is a most fascinating country, and I can easily understand how it is that people get bitten with the idea of exploring it.

I am indebted to Squadron-Leader Rickards for some of the photographs published, and to Mr. Williamson for the excellent drawings of the coin, locks, etc.

TABLE II.

A FEW FIGURES IN CONNECTION WITH THE JOB.

Total distance travelled: 10,270 miles by land, sea and air.
Total cost: Just under £200, or about £33 per station observed.
Flying time in Aden: 20 hrs. 44 mins.
Egypt: 4 hrs. 43 mins.

Total: 25 hrs. 27 mins.

Approximate number of stars observed for: Latitude: 145, Time: 88
or not less than 2,000 pointings on stars.
Wireless signals observed, 66, made up as follows:—

Rugby	28
Bordeaux	28
Nauen	10

Number of days in Aden: 39.

Place.	*Old Latitude.* ° ′ ″	*Old Longitude.* ° ′ ″	*New Latitude.* ° ′ ″	*New Longitude.* ° ′ ″	*Diff. in miles from old position.*
Laudar ...	13.54.45	45.57.05	13.52.58	45.52.05	6
Mis hal ...	13.43.00	45.50.00	13.39.26	45.48.47	5½
Nisab ...	14.36.20	46.24.40	14.30.57	46.24.50	7
Beihan ...	14.55.35	45.38.45	14.48.41	45.43.48	9
Ahwar ...	13.27.35	46.38.50	13.32.05	46.43.20	5½

ANNUAL TRAINING OF RAILWAY COMPANIES

at the Railway Training Centre, Longmoor.

By CAPTAIN G. A. PALMER, R.E.

THIS paper has been inspired by Captain Gayer's article in *The R.E. Journal* of September, 1932, on the training of field companies. Many Sappers have never been to Longmoor, and possibly to some of these a brief outline of the training problems of railway companies may be of interest. Other functions of the Railway Training Centre such as instruction of young officers, study of transportation problems, and experimenting with plant and equipment, are outside the scope of this paper.

ORGANIZATION.

There are two regular railway companies in peace, the 8th and 10th, each of 4 officers and about 180 other ranks. In addition there are eight companies of the Supplementary Reserve; 150th, 151st and 152nd Railway Construction, 153rd and 154th Railway Operating, 155th Railway Workshops, 156th Railway Stores and 157th Docks. These are found by the four civil main-line railways and come to Longmoor each summer for a fortnight to learn to apply their expert railway knowledge to military problems and to pick up or to refresh their memories in the rudiments of soldiering.

The technical training weapon of all the above companies is the Woolmer Instructional Military Railway but, unlike other weapons, a railway cannot be greased and put away in store for six months in the year. It is inevitably a transport agency, and however much this latter function may be subordinated to training requirements, it cannot be entirely suppressed. This means that the railway cannot be closed down completely. Now to enable a railway to function, the co-operation of all its departments is required—engineering, operating, locomotive sheds, workshops and stores—and therefore even a very little traffic makes a big demand on man-power. This demand is almost continuous throughout the year (even on Sunday afternoons) and has a considerable effect on the training programme.

The training of the Supplementary Reserve companies will not be further considered here, but they have been mentioned so as to show that the construction of a training programme is complicated by the number of different types of unit whose training requirements differ widely.

SUBDIVISION OF THE TRAINING YEAR.

As with field companies, the training year is divided into two periods, approximately as follows :—

1st October to 28th February .. Individual Training.
1st March to 30th September .. Collective Training.

INDIVIDUAL TRAINING

1st October—28th February.

The subjects to be dealt with in the individual training period are :—

1. Trade Training.
2. Individual Military Training.
3. Educational Training.
4. Output from Workshops.

In addition time has to be found for leave. In order to get through the programme it is essential for everyone to go on leave at once so that for the rest of the time units are as far as possible 100% effective. In practice 20th December to 20th January has been found the most convenient period.

Trade Training and Output from Workshops.—These two subjects are linked together and during the period 1st October to 20th December are given priority over all other forms of training. All men of workshops trades of both companies are sent into the shops and a general programme of repairs and annual overhaul of locomotives, rolling stock and plant is undertaken to get the railway into trim for next year's collective training. Special classes in railway trades are run in both the Signal School and out on the line : in these classes pioneers are taught a trade and the old hands are given opportunity to improve their rating. It must be remembered that it is unusual for a man to enlist in the Corps as a railwayman and the majority of them have to be trained from pioneers at Longmoor. A short course is arranged for N.C.O's of the 8th Company of all trades to teach them how to take charge of men on railway construction jobs. Almost the only tradesmen on the Railway Training Centre establishment for whom no facilities exist are those of the building trades (other than carpenters) and except for these there is little reason why any man of average aptitude and diligence should not improve his trade rating before the Christmas furlough period.

Individual Military Training.—Every Saturday throughout the winter is devoted to military training and company commanders refresh their men in drill, rifle, bayonet and anti-gas training, and route marches. Periodical parades are held by the Commandant for regimental ceremonial drill.

After the Christmas furlough, cadre classes are run under centralized arrangements for senior and junior N.C.O's. Only four or five weeks are available, and all N.C.O's cannot be spared simultaneously as the railway (including its workshops), though no longer given priority as before Christmas, still opens its insatiable maw and demands men for routine railway work and for repairs and stage-setting, jobs which must be completed before the summer training begins. Under these conditions it is extremely difficult to decide on a satisfactory type of cadre class and after some experience it is thought that the following assumptions must be made. Firstly, that field works must be kept out of the curriculum : its inclusion results in a syllabus too crowded to enable any subject to be dealt with thoroughly, and the average N.C.O., having been whirled through his two or three weeks floundering in a sea of manuals and notebooks, emerges from the course knowing a little of everything and nothing too well. Secondly, it must be assumed that every N.C.O. joins the class with at least the knowledge expected of a good all-round Sapper: the whole time can then be devoted to teaching him the duties of an N.C.O. It may be thought that this can be taken for granted, but in the writer's experience it is very far from being the case. The proposal to run a special drill and duties class for backward N.C.O's at Chatham before Christmas should prove a great help in this respect, and when these N.C.O's join the cadre classes in the spring they will not be so likely to hold the better men back.

Two separate classes are run, one for senior, and one for junior N.C.O's. The syllabus comprises drill, weapon training, map reading, reconnaissances and reports, with quickeners in the form of physical training and bayonet fighting. It is essential to have a pool of N.C.O. instructors trained at Hythe, Porton and the Physical Training School, and it is highly desirable that a Hythe-trained officer should be available.

During the winter, opportunity is taken to send officers and N.C.O's away on courses : rifle and A.A. light automatic at Hythe, anti-gas at Porton, drill and duties at Chatham, physical training at Aldershot, and education at Shorncliffe. Each company has its authorized quota of N.C.O. instructors and is responsible for applying for vacancies.

Educational Training—Now that the majority of recruits leave Chatham with at least a third-class certificate of education, the burden on units is appreciably less than it used to be. A subaltern who has been through the School of Education at Shorncliffe is appointed Regimental Education Officer, and assisted by Shorncliffe-trained N.C.O's coaches all third-class men for the second-class examinations in November and March. It is voluntary for men to sit for the first or special certificates and coaching for these is in the hands of the Army Educational Corps.

COLLECTIVE TRAINING

1st March—30th September.

General—Engineer Training, Vol. II, Sec. 18 lays down that the collective training of railway companies shall be subdivided as follows :

Military Training	...	...	... 4 weeks.
Field Works (less bridging)	...		... 2 weeks.
Railway Training	...	...	... the remainder.

The first two are carried out under the Chief Engineer, Aldershot Command, and the last under the Inspector of Railway Troops, War Office.

The total period available for collective training is seven months. One month may be written off to allow for Easter, Whitsun and August leave, the King's Birthday, R.E. Week, rifle meetings, etc. and we are left with six months or 26 weeks.

Throughout the year guards and piquets and all garrison and regimental duties and fatigues are carried out by one company known as the Duty Company, while the other company is left free to train at full strength. Companies take turn as Duty Company to suit the training programme and though the periods are not of stereotyped length, it is arranged that each company does a total of six months in the year as Duty Company. This means that only one company is on collective training at a time and therefore twice the total time is required to get both companies through the programme : that is, eight weeks for military training and four weeks for field works. Collective railway training is only carried out by the 8th Company as being the active service company, and eight weeks is allotted for this. This accounts for a total of 20 weeks.

But we have not yet considered the Supplementary Reserve companies who each spend a fortnight at Longmoor. Some companies can be paired together but others cannot, and an absolute minimum of twelve weeks is required to fit them all in even if things go particularly smoothly. We therefore have to fit into our total of 26 weeks' training 20 weeks for regulars and 12 weeks for supplementary reservists ; this involves a six weeks' overlap.

The most satisfactory solution is to start military training as early as possible and let the overlap take place during the field works course and the tail-end of the 8th Company's collective railway training. In practice the programme works out something like this :—

March—8th Company	...	...	... Military Training.
April—10th Company	...	...	... Military Training.
May and June—8th Company	...		... Railway Training.
July (first fortnight)—10th Company			... Field Works.
July (second fortnight)—8th Company			... Field Works.

June to mid-September—Supplementary Reserve Companies.

It must not be thought that while a company is Duty Company it has nothing else to do but find regimental employ and fatigues. There is always plenty of work to be done in the various departments of the railway, and while the Supplementary Reserve are in camp, drill and musketry instructors must be found and the stage has to be set for the various schemes on the railway to be carried out by Supplementary Reserve units.

Collective Military Training.—Four weeks.—This comprises squad, section and company drill, bayonet and anti-gas training, preliminary musketry, route marches and company schemes for the first three weeks. The last week is spent on the ranges firing the annual course. Companies then change round and repeat. Alternatively, each company carries out its three weeks' training consecutively and then both go on the range together for the last fortnight. Both systems have advantages and disadvantages.

Field Works Course.—Two weeks.—This usually consists of the more elementary types of field works: railway companies get plenty of practice in advanced field engineering during their railway training when they handle steam-diggers, pile-drivers and cranes and carry out heavy bridging and reinforced concrete work. The field works course is therefore restricted to knotting and lashing, use of spars, field defences, demolitions and light bridging and rafting. At the end of the course the Q.I. examination is held regimentally.

In 1932 the Supplementary Reserve camps were cancelled under the national economy scheme and the opportunity was taken to get both companies away together to a field works camp near Reigate in July. This involved a three days' march each way, erection and dismantling of the camp and a three weeks' field works course. A part of the R.E. Band accompanied the unit on the return march from Reigate to Longmoor, and greatly helped to keep up the spirits of the troops.

Collective Railway Training.—Eight weeks.—In 1932 this took the form of an active service project for the 8th Company. Through the acquisition of the necessary land an extension of the railway to Liss became possible, and this enabled a scheme to be put in hand which included surveying, clearing the ground, excavating cuttings, forming embankments and bridging five streams.

Active service conditions were simulated as far as possible and all estimates for plant, tools and materials had to be made out beforehand and any further supplies could only be obtained after indenting on an imaginary depot several days' journey away. The company operated its own construction trains and in every way carried out its war-time role of a Railway Construction and Operating Company.

This kind of work is the culminating point of previous elementary technical training. The 8th Company is working on the permanent

way for a large part of the year. The eight weeks' collective training are distinctive in that during those weeks the company has no other demands to meet for labour or duty of any sort and the O.C. can train his company as a unit.

The full strength is, however, only three sections. The fourth or survey section trains separately in its own role as a section of a Railway Survey Company. In addition, this section goes on a Survey Tour during September to Salisbury Plain or somewhere suitable for training in the location and setting out of a railway line in virgin country.

Miscellaneous.—At the end of the summer a Transportation Exercise is usually held for all officers in some suitable part of the country away from Longmoor. This lasts three or four days and a number of Staff College students or graduates are invited to attend to study the problems of the Q (Movements) Staff in war.

Any chance of co-operation with the other arms in entraining schemes and so forth is taken throughout the year and railway-trained officers are often required to take part in administrative exercises in the Aldershot and other Commands.

GENERAL.

As railway companies are affiliated to the general Corps roster any N.C.O. or man may find himself suddenly posted to another branch of the Corps. Similarly officers are liable to general R.E. duty, and in the past two years officers at Longmoor have been posted to Field and Fortress Companies, the Training and Survey Battalions, Territorial Adjutancies and Works Services. It is, therefore, a cardinal principle of training that all ranks besides being railwaymen must be general service sappers. The two to a certain extent conflict and it is almost impossible for any but a superman to be completely efficient in both lines but it is a case where the best is the enemy of the good.

It is hoped that this article will show that Longmoor is doing its best to maintain a fair balance between the two sides.

REINFORCED-CONCRETE CONSTRUCTION ON HONG KONG ISLAND.

By MAJOR W. A. F. KERRICH, D.S.O., M.C., R.E.

1. The humidity of the climate of Hong Kong, and the activities of the white ant, make reinforced concrete a particularly suitable building material for this colony; and it is being widely used both in civil and W.D. practice.

Photographs Nos. 1 and 2 show a two-story block of eight "B" type (convertible) married soldiers' quarters, which has recently been completed on Kennedy Road. The block has a north aspect overlooking the harbour, with the ground falling sharply away in front, while the road runs along the back or south side. Photograph No. 1 shows the south and east sides, and Photograph No. 2 the north side.

The type of construction is the same as that used for the majority of recently-built civilian houses.

The building is a monolithic structure, the roof and upper floor being reinforced-concrete slabs, supported by a framework of reinforced-concrete beams and columns. The brick walls are merely filling, and do not carry the weight: inspection of the photographs will show the reinforced-concrete "skeleton" sticking through the brick "skin."

The roof is waterproofed with a bituminous felt, a product of the Texaco Oil Company, and there are no expansion joints in it.

The Texaco covering is laid to the following specification:—

(1)	Texaco Roofing Cement No. 10 poured	35	lb.	per sq.
(2)	Asphalt Saturated Felt	15	,,	,, ,,
(3)	Texaco Roofing Cement No. 10 poured	35	,,	,, ,,
(4)	Texaco Roofing No. 2 (two-ply)	40	,,	,, ,,
(5)	Texaco Roofing Cement No. 10 poured	35	,,	,, ,,
(6)	Sand finish.			

To keep the top story cool a further layer of flat Canton tiles ($14\frac{1}{2}''$ x $14\frac{1}{2}''$) has been added; the edges of these tiles being supported on bricks on edge, thus giving an air space of $4\frac{1}{2}''$ between the tiles and the roof proper.

Floors are covered with floorboards nailed to breeze concrete on top of the concrete floor proper, except the verandah, scullery and

bathroom floors. Critall metal doors and windows are used throughout.

Photograph No. 3 shows a reinforced-concrete bridge connecting the top floors of two adjacent barrack blocks, which are in use by Headquarters, China Command, as offices. The salient feature of this bridge is the fact that it is carried on a row of single reinforced-concrete columns; which, it is thought, gives a more pleasing effect than the usual two-legged trestle type of support.

Below the bridge can be seen a covered way for use in wet weather, of the type common in Hong Kong, having brick piers supporting a wooden roof with a covering of curved "Chinese" tiles, laid double.

Photograph No. 4 shows how a covered way of similar type, the roof of which required renewal, has been rebuilt in reinforced concrete, re-using half the number of brick pillars. This is a good example of the plastic properties of the material; and was extremely unpopular with the contractor who had to erect the centering and bend the rods to shape.

Photograph No. 5 shows the new reinforced-concrete steps and balcony to the 40th Company R.E. offices.

Photograph No. 6 shows a reinforced-concrete staircase of the more usual "slab" design. This gives access to a Serjeants' Mess, and the spaces between the handrails have been filled in with X.P.M., rendered both sides, at the request of the mess members, who thought that ladies attending social functions in the mess would prefer to have it so.

2. A lot of reinforced concrete work besides that illustrated by the photographs has been done recently in the old barracks on the island, financed from the Part III Major item, "Renew Roofs and Floors."

The floors are a simple problem, the only feature that calls for special comment being the surfacing.

Barrack-room and similar floors are given a granolithic surface; while in quarters, etc., where a wood surface is required, it is usual to lay hardwood blocks on top. It is interesting to see the logs from which the blocks are manufactured being sawn by hand into scantlings with pit saws, and the scantlings further reduced by hand, till the required number of blocks is produced, each differing in size from all the rest.

A most irregular floor surface naturally results when the blocks are laid, and it has to be laboriously planed smooth afterwards; usually to a finished thickness of $1\frac{1}{2}''$.

There is still some difference of opinion as to what is the most satisfactory type of roof. Some think that with careful supervision a plain concrete roof will be waterproof. All mixing is done by hand, either because labour is so cheap, or because the trade unions will not allow mixing machines to be used, and careful supervision is

No. 1.—"R" Type, married soldiers' quarters. South and east sides.

No. 2.—North side.

No. 3.—Covered way and R.C. bridge.

Reinforced concrete construction on Hong Kong Island 1-3

No. 4.—R.C. covered way.

No. 5.—R.C. steps and balcony.

No. 6.—R.C. staircase.

Reinforced concrete construction on Hong Kong Island 4-6

required to ensure a good mix. The aggregate is hand-broken granite, and careful supervision is again required to get it properly graded; while the sand is on the coarse side. Consequently there is always the risk of voids, and a "soft" patch that will let the rain through.

Secondly, there is the danger that the hot sun may cause cracks even in good concrete, and expansion joints are advocated by some.

A waterproof covering of Texaco (Ruberoid, Malthoid, etc.) overcomes all these difficulties, but it is an additional expense.

Again, not everyone is convinced that a flat concrete roof, even with an air space and Canton tiles, is as cool as the old-fashioned wooden-pitched roof with double Chinese tile covering. An experimental type is being tried in which the wooden trusses, purlins, and rafters have been replaced by similar members in reinforced concrete, and the Chinese tile covering has been retained.

Lastly, a "flat" roof has to have some slope to throw off the water (at least 1/30 is recommended). If the slab is tilted, the ceiling below has a similar slope, though there appears to be but little real objection to this. A different design has been seen locally in which the slab is flat, but a covering of breeze concrete is laid on top, thicker in the centre than at the eaves, thus giving the necessary slope. In this type the Canton tiles and air space are dispensed with, the breeze concrete giving the necessary additional protection from the heat of the sun. Such a roof is now in the course of erection by us.

3. The S.M.E. *Reinforced-Concrete Manual*, which is based on the L.C.C. Building Regulations, is found in practice to produce structures a good deal heavier than similar civilian structures that are going up in Hong Kong.

It is, therefore, worthy of note that the Hong Kong Government have just published a Building Ordinance to the effect that in future the L.C.C. regulations for reinforced concrete are to be adhered to.

4. British mild-steel rods are almost unobtainable locally, steel of Continental origin being used instead. Samples sent to the Government laboratories for testing show that the latter has a higher elastic limit than the British standard specification for mild steel; but a lower ultimate strength. It is, therefore, not obvious which is the "stronger" when used in reinforced concrete; for, although the Continental steel will tear apart first, yet no building should ever be so heavily loaded that the elastic limit of the steel in the reinforced concrete is exceeded, since once this has occurred the structure will be unsafe. From this latter point of view the Continental steel is "stronger" than the British.

COMBINED RATES IN THE M.E.S.

By Colonel E. St. G. Kirke, D.S.O.

One of the first things which strikes a newcomer to the Military Works Service in India is the vast quantity of paper that circulates before anything can be, or rather is done. If he be of an inquiring turn of mind, he will at once begin to wonder how much of it is necessary, and to what extent it can be reduced without a sacrifice of efficiency.

If he be cynically minded he may give credence to the idea that somewhere hidden away out of sight is a secret society of clerks, banded together for the fell purpose of causing or creating as much correspondence as possible, so that in the fullness of time jobs may be found for the ever-increasing number of relations who pour in an unending stream from various Government colleges. This society, he will believe, is fortified by the subordinate executive staff who know that if only their superiors can be kept sitting tight in their offices, signing drafts put up by their allies the clerks and immersed in other correspondence, they will have less time to inspect, and can, in fact, almost be prevented from inspecting works in course of construction.

There is, no doubt, much correspondence relating to unimportant matters which could equally well be settled by word of mouth, with satisfaction to all concerned, and a determination to reduce it will work wonders. In the case of estimates for new works, a very great deal of time and paper can be saved by the introduction of combined rates.

The essence of all building activity is that one party, in this case the Government, wants houses, barracks, workshops, garages and the like built at a minimum cost compatible with good workmanship and material, while the other party, namely the contractor, seeks to earn a reasonable living. If this premise be granted, the problem of reducing paper-work becomes comparatively simple.

In a perfect world, and to a certain extent in civil practice at home, the purchaser would tell the contractors what he wanted built, provide them with drawings and specifications (if he did not leave this also to them) and ask them to put in competitive tenders for the finished work. The lowest tenderer would get the job, and start off as soon as possible. As, in the perfect world, no mistakes would be made, this arrangement would prove satisfactory to all concerned.

In a workaday world, however, there is a possibility of mistakes occurring on both sides, and this has led to an elaborate system of detailed estimates which, in the sum total of getting out quantities and values, checking and counterchecking both technically and arithmetically, takes up an incredible amount of time.

The question therefore arises whether, even in an imperfect world, the ideal or lump-sum contract system is altogether impossible of realization, and when it is examined the difficulty will be found to lie largely with considerations of audit, without which no large business can successfully be conducted. At the same time there is reason to believe that there is a larger staff devoted to this duty than the circumstances warrant in the case of the M.E.S., and some years ago an offer was made to reduce the clerical establishment of the M.E.S., if the Military Accounts Department would make a corresponding reduction in theirs, but the offer was refused.

The difficulty can be got over to a certain extent if a compromise is made between the lump-sum contract system and one based on detailed estimates. This compromise can be found in use of "combined rates." These were introduced into Quetta at the suggestion of the late Chief Engineer, Western Command, Brig. W. H. Evans, and proved an immediate success.

The essence of the system is that every feature of a house (for instance) is an entity, and estimated for as such, instead of being split up under various headings into its component parts. Thus a wall up to plinth level involves so much excavation, so much concrete, so much brickwork and pointing, and a damp-proof course. If the cross-section of this wall be standardized, it is clear that a running foot rate can easily be evolved, and the whole sub-plinth masonry dismissed in a line or two of the estimate. No measurements of depth or breadth are required, since these are standard, nor long sums to take out the cubic contents.

To meet the case of uneven ground a percentage was added to the running foot rate. This was done at the request of local contractors, but was, strictly speaking, unnecessary, as will appear later. All they had to do was to raise their tender by an amount which their experience would show to be enough to cover the extra work involved. The same applies with equal force to stony or unusually hard ground.

Most Government buildings in India are standardized or easily capable of being standardized, so that the walls above the damp-proof course are equally susceptible of being dealt with on a running foot basis. In short, the whole shell of the house can be dismissed in a few lines instead of taking up several pages of detailed estimate.

Now let us consider the doors and windows. Each involves most of the following:—A hole in the wall (ordinarily to be deducted from the masonry item), *pacca* jambs (ordinarily a deduction from the *kacha* masonry item and an addition to the *pacca*), sill with

throating, arch or lintel over, frame, holdfasts, joinery, glass, fastenings and paint. Nearly a dozen separate items. If, however, the door or window be regarded as a whole, to include all the appurtenances thereof, a rate can be got out either on the unit basis or per square foot. This item in the estimate can then be reduced to " so many doors and windows at so much each," *i.e.*, a couple of lines, instead of a maze of intricate calculations involving the items for *pacca* brickwork, *kacha* brickwork, masonry arches, ironwork, etc., etc. Fireplaces can in the same way be given a rate to include chimney-breast, mantelpiece, flue, flashing, chimney-pot, cowl, and stack. Result, one line only in the estimate.

Similarly roofs can be dealt with on a basis of square feet overall, as measured on the plan, not on the slope. (Measurement on the slope is an unnecessary complication which can be eliminated by adding a suitable percentage to the area as found from the plan.) The rate must include everything connected with the roof above the walls, namely trusses, rafters, purlins, hips, valleys, roofing material, whether of tiles, C.G.I. sheets, etc., and ceilings where provided

The mathematician will at once exclaim that the above system is hopelessly inexact, and in the abstract he is right, but the practical man, who is concerned with results, will ask " Does this matter ? Is not a workable basis being provided upon which contractors can readily tender for the work ? " He, too, is right, but let us for a moment examine the mathematician's case, and suppose that a meticulously elaborate and mathematically correct estimate has been worked out. Tenders are called for upon this estimate, and, judging by Quetta experience, are received varying from schedule rates to 30 per cent. or more below schedule rates.

What, then, becomes of the mathematician's exact estimate ? Clearly it contains no indication whatever of the actual cost of the work, and is therefore little better than sheer waste of time and effort, not only on his part but also on the part of all those who have to check it.

Now what can be said for the combined rate system ? In the first place it is clear that combined rates can be worked out closely to correspond with the individual rates from which they are built up, and that when once they have been worked out they stand good for all subsequent estimates. Before the Quetta combined rates were put into force, a typical estimate was worked out by them, and compared with a detailed estimate worked out from the schedule of rates. The difference was very small, and showed that the combined rate system gave a reasonably accurate " starting price " upon which contractors could, and were content to base their tenders. Obviously all that is required at this stage of the proceedings.

As regards the danger of Government not getting value for money, the safeguard lies in the competition between contractors to get the

work, the real costs of which they know far better than does any Government agent, seeing that they spend their lives in their trade, and earn their living from it. No one supposes that all the rates in the various P.W.D. and M.E.S. schedules accurately represent the cost of any particular task; nor is it possible that they should, having regard to fluctuations in the cost of materials and labour, seasons of the year, and other factors such as supply and demand. Contractors know better than anyone which rates are too high and which are too low. They are, therefore, able to balance the profitable against the unprofitable items, and make a price for the whole building. In other words, they think in terms of the whole job rather than in those of meticulous details.

(In the case of small repetition work, such as servants' quarters, the audit authorities will generally accept a lump-sum estimate, since it is an obvious waste of time to get out even a combined-rate estimate for a building, when hundreds of the same type have already been built and the cost is well known.)

By the means of combined rates, estimates for an officer's quarter and accessories can be produced in a few hours, on only a few pieces of foolscap, instead of several days and some fifty pages being required as in the case of the conventional detailed estimate. The success of the system depends primarily upon taking contractors into one's confidence, satisfying them that they are not being "done," and obtaining their acquiescence (as well as that of the Controller of Military Accounts). When this is once secured, they quickly realize the amount of trouble they are saved in the matter of checking bills, a relief which is also shared by the M.E.S. and audit staffs.

The system is not ordinarily applicable to repair work, unless, for example, the whole of a roof has to be renewed. It can, however, be adapted for use with periodical repairs, to the extent of taking plain measurements from a plan of wall, door and window areas, without any deductions or additions for every small variation encountered. This principle of simple area measurement has recently been brought into use throughout the M.E.S. with great benefit to all concerned.

To sum up, the adoption of combined rates in estimating makes for a definite reduction in office work, and enables officers to get out of doors to see that materials are good, that walls are vertical, that cement issued to a job does not find its way into the bazaar, that *kail* wood is not substituted for deodar or *shisham*, that, in short, the contractor and his agents are putting in work of the quality for which Government is prepared to pay.

CONCRETE SLAB ROADS.

By CAPTAIN J. H. D. BENNETT, R.E.

THE problem of the rapid construction of temporary roads and the rapid repair of roads damaged by enemy shell-fire and demolitions, is one that is ever present with the military engineer on service. An attempt to solve the problem by means of the slab or " corduroy " road has already been made and a description of this type of road with which every Sapper officer is familiar, would be out of place here. The disadvantages of this type of road may, however, be briefly summarized as follows :—

(*a*) It requires an enormous amount of timber—and preferably timber not necessarily square sawn but with at least one flat side.
(*b*) It requires a very large amount of labour for the preparation of the formation on which the runners and slabs are laid.
(*c*) It is almost impossible to take up and re-use owing to the damage to the timber caused by the driving and extraction of dogs and spikes.
(*d*) It becomes very slippery and difficult for M.T. to negotiate in wet weather.
(*e*) It is comparatively slow to lay.

Bearing these disadvantages in mind an attempt is now being made to evolve a type of " portable " road which would have the following advantages :—

(*a*) Be made from common materials likely either to be available or easily obtained in the field.
(*b*) Be quickly laid without much formation labour.
(*c*) Be capable of being rapidly taken up without damage and re-used.
(*d*) Give a durable and non-slip surface for M.T.

The problem has not yet been solved in its entirety and the description of the experiments already undertaken is not intended as a solution but rather to invite attention to this problem in the hope that readers may give this matter their thought.

The material selected is reinforced concrete. The sand and coarse aggregate (or ballast) can usually be found locally, cement should not be difficult to obtain, and once the type of reinforcement has been decided upon, the production of sheets of reinforcing

fabric bent to shape and spot welded presents no unsurmountable problem. Moreover, concrete will give a durable surface satisfactory to M.T.

The basic idea of using reinforced concrete is that slabs of this material of convenient size and weight and suitable strength should be made up for use as wheel tracks, and that a complete road surface for the full width should not be provided. The ends of the road slabs should be carried on R.C. sleepers so that the whole would be very similar to a railway track of steel rails on wooden sleepers.

The sleepers are made 3′ 10″ x 10″ x 3″ reinforced by two $\frac{1}{2}$″ diameter M.S. bars placed longitudinally and have a $\frac{1}{2}$″ M.S. bar inserted at the centre across their width. This $\frac{1}{2}$″ transverse bar is bent upwards at the edges of the sleeper and is of such a length that the bent-up portions project above the top of the sleeper $1\frac{1}{4}$″ each side. These projections or dowels fit into corresponding holes in the slabs, thereby providing longitudinal fixation for the slabs. A sleeper of these dimensions weighs approximately 1 cwt.

The slabs are made 2′ 2″ x 4″ thick and average 5′ 0″ in length. One side of the slab is made 5′ $0\frac{1}{4}$″ long and the other side 4′ $11\frac{3}{4}$″; the ends of the slabs may therefore be said to be tapering equally inwards. In the centre and $5\frac{1}{4}$″ from each end of the slab a $\frac{3}{4}$″ hole is left for fixing over the $\frac{1}{2}$″ dowel projecting upwards from the sleeper. The top of the slab is ribbed longitudinally so as to give a non-slip surface, and the slab weighs approximately 4 cwt. The distance apart of the wheel tracks and the width of the slabs is governed by the types of transport the road will have to carry. A distance of 3′ 3″ in the clear between tracks is the maximum admissible if the road is to be capable of use by Austin Seven scouts, and a slab width of 2′ 2″ is found necessary if heavy lorries are to be able to drive along the road at any reasonable speed. The type of reinforcement for the slab is now under consideration and will be discussed later.

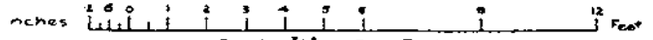
It is realized that a weight of 4 cwt. is somewhat heavy but with mechanical handling (possibly by the derrick lorry) this should not prove excessive. The slab dimensions are a compromise between keeping the units as large as possible, so as to reduce to a minimum the number required for the construction of any given length of road, and at the same time not making them too heavy for man-handling if necessary. Moreover, if the slabs are to be regarded as " bridge spans " between sleepers, their dimensions and weight are seriously affected by considerations of strength. The tapering ends of the slabs permit of them being laid either straight or on a gentle curve. When laid straight the long edges of the slabs are laid alternately on the inside and outside of the track under each wheel. (Fig. 1.) When rounding a gentle curve all the long sides are laid on the outside. (Fig. 2.)

The reinforcement of the slabs is still undecided, and a certain amount of controversy exists as to whether the slabs should be designed as "bridge" or "supported" spans. The supported span school of thought maintain that as the slabs are intended for use on soft soil and in repairs to damaged roads the sleepers, when under load, will rapidly sink into either the soft soil or loose shell-hole filling and that the slabs will thus derive support from the ground underneath them. The bridge span school are, however, of the opinion that, although not primarily intended for use unsupported, the slabs should be capable of carrying the wheel loads if the subsoil support is either not originally provided or becomes non-existent due to erosion or similar causes. They further maintain that the slabs should be able to act as bridge spans without risk of failure until such time as the sleepers sink sufficiently to allow the underside of the slabs to bear on the ground, and also that, if this state of affairs is not reached (or not reached for a considerable period) packing under the slabs would be necessary to the detriment of advantage (*b*) quick laying without much formation labour.

The first design of reinforcement consisted of six M.S. bars $\frac{1}{2}$" diameter spaced 4·20" centres with ends hooked and fixed by windlassed 14 S.W.G. wire. This failed in two ways; firstly when acting as a bridge span the slab broke in the centre and secondly the slab cracked longitudinally between two rods when traversed by a narrow-tyred heavy vehicle. In both cases the load consisted of a heavy lorry loaded with sand, back axle load 7 tons 13 cwt. 1 qr. moving at about 5 m.p.h., the slabs being made of ordinary Portland cement 1 : $1\frac{1}{2}$: 3, and 56 days old. To overcome the tendency of longitudinal cracks a further type of reinforcement was designed, incorporating transverse bars and additional longitudinal bars, but tests to destruction have proved that when made with ferrocrete and tested at seven days this type is still too weak despite the fact that the slab thickness was increased by $\frac{3}{8}$". A further type of slab has been tried using 4" mesh heavy gauge X.P.M. as reinforcement, a single sheet being placed $1\frac{1}{4}$" from the underside of the slab. Under test, however, this only gave 60% of the strength of the original type of reinforced slab. A reduction in thickness of slab to 3" resulted in a fall of 50% on the ultimate strength. A slab with the original type of reinforcement, made of ferrocrete and tested at 28 days, failed under a central knife-edge load of 70 cwt. This and the X.P.M. slabs are made of a 1—2—4 mix by volume and a water content of $4\frac{1}{2}$ gallons to each 7 c.f. dry batch, a water ratio of approximately 7%. To satisfy the bridge span school a minimum strength of 5 tons at the centre will be required. This allows 100% for impact, but only a very low factor of safety.

The tests of the original slabs under traffic showed that, even though the slabs failed longitudinally, if they were supported on the

— Reinforced — Concrete — Lorry — Track —



Scale 3/8" = One Foot

When laying straight Tracks the long side (5' 0¼") of rail is placed on the outside of the track in every alternate rail

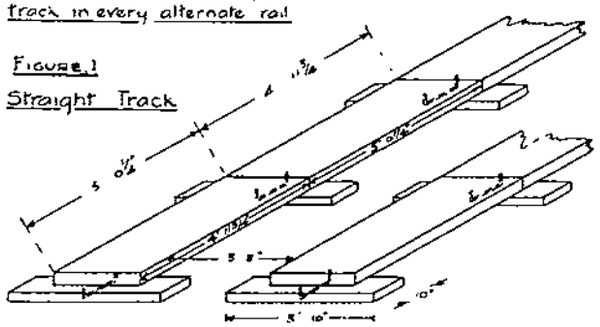


FIGURE 1
Straight Track

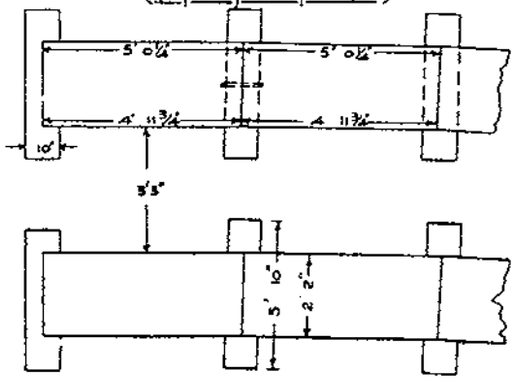


FIGURE 2.
Method of laying on easy curves
(Angle of tangent 1/52)

NOTE
On easy curves, long side (5-0¼") of every rail is on the outside of the curve and short side (4'-11¾") on the inside

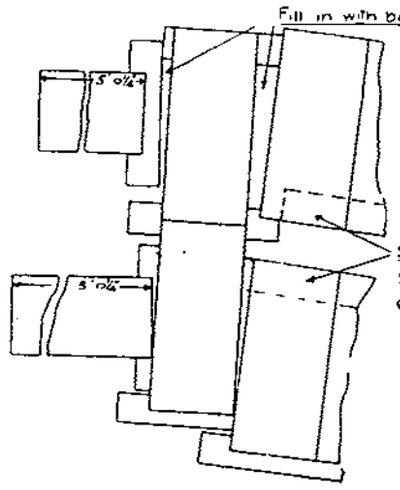
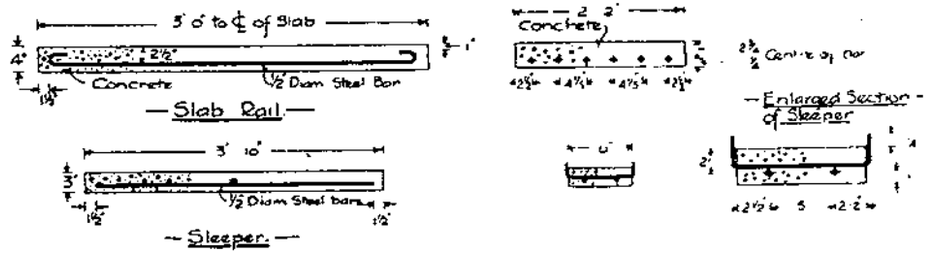


FIGURE 3.
Method of laying on Sharp Curves

Sleepers under here upside down to prevent dowel projecting up



— Longitudinal Sections — — Cross Sections

— Scale for Details — 3/4" = One Foot —

under side, they still had sufficient cohesion to be sufficiently serviceable to be allowed to remain *in situ* and to carry all forms of traffic, though it would be impracticable to take up and relay such slabs at a new site. It may be mentioned that the replacement of a broken or damaged slab is only a matter of a few minutes for four men.

The difficulties now remaining are two in number: firstly the design of suitable reinforcement without, if possible, necessitating any increase in slab thickness and weight, and secondly, the evolution of a speedy mode of laying. The former, as has already been mentioned, is in hand, but the latter is a problem requiring a good deal of consideration. We may presume that the slabs and sleepers will be manufactured some distance behind the line, though stocks may be carried at forward dumps. A 3-ton lorry will carry sufficient slabs and sleepers to lay ten yards of track. The first lorry to arrive backs on to the edge of the soft spot to be spanned, where it is off-loaded and ten yards of track laid. The next lorry then arrives at the head of this ten yards but, from the point of view of unloading, facing the wrong way round. When unloaded it has to get clear, and reversing a heavy vehicle along the track for any distance is by no means an easy matter, especially if done at night without lights or with only dimmed lamps.

Turn-outs and passing places are further difficulties, but it must be remembered that the concrete slab road is only intended as a temporary measure and that only a comparatively short length of track at any given point is at present visualized. Whether special slabs for this purpose will be required has not yet been decided, but a turn-out can be made with the stock slab and sleepers (upside down) between the wheel tracks and then taking off by the normal sharp curve method of laying. A passing point can then be made by making a reverse sharp curve followed by a straight length parallel to the main track and then rejoining the main track some distance farther on by a turn-in of similar construction to the turn-out. Failing this, a complete double track might be laid but, unless the distance is short, this would be very extravagant on material.

The concrete slab road has not yet emerged from the experimental stage, but it would appear to be only a matter of time and thought before the difficulties now remaining are overcome.

Since writing the above a slab slightly thicker than the above and doubly reinforced has been made and tested to a breaking load of five tons.

PLUS OR MINUS ?

By MAJOR J. SPOTTISWOODE, M.C., R.E.

I RECENTLY had occasion to show a number of young R.E. officers round one of my Company tool carts, and was a little shaken by one remark made: "It seems to carry more—ah—destructive than constructive tools."

As an old Field Company officer, who unfortunately just missed going to Cambridge, I felt that this indicated a false prepossession of the capabilities of a field company. It seemed to me to be part and parcel of the impression, prevalent in some quarters, that the Field Company sapper, while being quite useful at demolitions and temporary "kutcha" construction, does not appear in the picture of real useful construction.

It so happens that I am in a position to produce some figures which, I hope, may help to dissipate this idea by giving the actual results of the past year's work of the 23rd Field Company, R.E., who owned the cart in question.

The literal incorrectness of the remark can be shown by the fact that the weight of constructive tools in the cart is about 1,500 lb. while that of destructive is less than 500 lb. In numbers the preponderance of constructives is equally marked.

Before starting, it may be of interest to point out that though the establishment of the Home Field Company in peace is 127, its strength probably about 120, its working party is normally about 45, rising possibly to its maximum of 60 for an odd day or two at Bridging Camp.

Starting, therefore, in November, 1st Divisional R.E. Workshops, in which the 23rd Company had one-third share, produced goods and buildings to a value of £2,500 at the most conservative valuation that can be taken. This excluded the metal tradesmen, fitters, blacksmiths and electricians, who worked in a separate establishment and whose figures I do not know. Remember, firstly, that this was a period primarily of trade training of men, many of whom were distinctly rusty with their tools and more were starting practically *de novo*. Secondly, that time is severely cut into by military training, duties and by essential recreational training, resulting in a trade working week of 30 hours. Thirdly, that in such a small show, overheads are relatively large and several minor trades cannot be employed as tradesmen. This result, apart from the incalculable value of improved trade efficiency, can hardly be held to be anything but positive value.

Starting our Field Works period in April, we undertook a new permanent bridge over our old friend the Basingstoke Canal, to allow horse exercise parties to avoid the bottleneck of Wharf Bridge on the main London-Southampton Road. The specification for this included the faculty of being lifted for possible canal traffic by a small boy.

This, incidentally, provided several pretty problems whose final solutions were not always the original ones.

At the same time we also built part of an experimental, but still useful, road of Terolas, one of the " mix-in-place " materials of road construction now becoming popular in sparsely inhabited areas.

Our next period contains one asset and one nearly neutral figure. We constructed a length of reinforced concrete road of distinct utility, and we drove a mine and destroyed a perfectly useless m.g. emplacement.

During July, at Bridging Camp, we destroyed but little (*pace* the E.B.E.), if we made nothing permanent, except, I hope, friends in the neighbourhood. There followed a week's destruction of boot leather, a fortnight's leave and we returned once more to construction.

A 40-ft. main road bridge, carrying considerable traffic, constructed largely of wood, was rotten. Now a steel piling, reinforced-concrete viaduct is, I hope, ready to do its work for many years ahead.

One more item, of constructive destruction this time. A recreation ground is required, and to prove that even explosives have their economic value, we employ them to remove trees which are in the way and convert them to useful timber and firewood.

I have necessarily omitted innumerable odd jobs done by small parties, the constant mending and construction by our wheeler, saddler, etc., the maintenance and improvement of amenities by our regimentally employed, etc., etc., but their sum total must be appreciable.

Now I am not claiming that a Field Company would be a welcome addition to an earnest economist's heaven, or even that the foregoing is quite an average training season, but the remark that moved me to write reflected on our capabilities, and I trust that the fortuitously sharp weapon ready to my hand is sufficient to prove my point.

Even if I am sparring at a non-existent shadow, possibly some general interest may attach to a record of a year's work of intense interest to me personally.

CORRECTION.

In the concluding part of the *History of the 7th Field Company, R.E., during the War*, 1914 1918, published in the December, 1932, *R.E. Journal*, the following should be added to the list of Honours and Awards appearing on page 632:—*D.C.M.*—Sapper Elms; *Medaille Militaire*—Coy.-Serjt.-Major E. A. Baker.

MEMOIRS.

MAJOR-GENERAL SIR WILLIAM SALMOND, K.C.B., COLONEL COMMANDANT R.E.

BY the death of Major-General Sir William Salmond in November, 1932, in his 93rd year the Corps of Royal Engineers lost a comrade who was at one time one of its best known officers. During his service of 45 years in the Corps he held the appointments of Assistant Adjutant-General, Royal Engineers, 1884-89, and of Deputy Adjutant-General, Royal Engineers, 1896-1902.

Those who know of the work that was incident to those offices will realize that it entailed a very close knowledge of all things connected with the Corps, as it included the matters of organization, personnel, equipment, rosters of units, posting of officers, etc. During General Salmond's tenure of these offices it is evident from the official records that his work was very highly appreciated by his seniors in office. But to the majority of the officers of the Corps during these periods he became best known by the sympathetic hearing, the imperturbable courtesy, and unfailing tact with which he replied to all applications. Such applications, both personal and written, spattered continuously like hail on these offices—from those who did not want to go abroad—from those who did—from those who wanted better jobs (or less work), and many others of various kinds. To one and all General Salmond extended the same courtesy and well-considered decisions.

In searching the records of his early life it will probably come as a surprise to those who only knew him in his later life, how strenuously he threw himself into various sports and amusements; riding and shooting were his favourite amusements, but boat sailing and mountain climbing were also keenly and successfully engaged in. And it may be inferred from such records that had his army career been laid in a wider field than office work—he would have been as successful and well-known in this as he became at the War Office.

His one experience of active service was in the Egyptian Campaign of 1882—when he went in command of the 18th Company R.E. to the base of operations at Ismailia. There he established landing stages, piers, store depots, and condensers for the use of the troops, and though not present at the battle of Tel-el-Kebir, he was awarded

Major-General Sir William Salmond KOD,
Colonel Commandant RE

a special brevet promotion to Lieut.-Colonel. This was in addition to the medal, Star, 4th Class Order of Osmanieh, and mention in dispatches.

His brevet promotion was a special one, as Lord Wolseley informed him that he was the only officer at the base whom he had selected for such distinction in consequence of the high appreciation he, Lord Wolseley, had of his work there. Except for this period of employment on active service, the last 22 years of his army career were spent in various appointments in London.

General Salmond was born on 25th August, 1840, at York, where his father's regiment was then stationed, the 4th child of Lieut.-Colonel James Salmond of Waterfoot, Cumberland. His grandfather, Major-General James Salmond, was a distinguished soldier in the service of the East India Company, and was the first Military Secretary to the Court of Directors up to 1837, an office now existing under the title of Military Secretary to the India Office. His early years appear to have been spent in very happy surroundings, and he and his brothers took early to ponies and riding, encouraged in this by their father and his brother officers.

His education was begun at Mr. Gibson's private school at Tyrrell, near Waterfoot, and afterwards at a Dr. Heldermeier's at Worksop: then at the Mansfield Grammar School. In 1851 his father took him and his brothers to see the Great Exhibition in Hyde Park, which evidently made a great impression on him.

In 1852, while at Boulogne, he went as a day boy to the Municipal College there, and learnt the French language so well that he often referred to the great advantage he found it in after-life.

In this year 1852, his maternal grandfather, Dr. Ewes Coke, obtained for him through the Duke of Rutland a nomination for Woolwich from Lord Hardinge, then Master-General of Ordnance.

The usual course for a boy nominated by the Master-General was to join the Government School at Carshalton at about 12 years old and go to Woolwich from there. But Salmond's father, hearing that Carshalton had a poor reputation, declined to send his son there and sent him instead to a Mr. Hopkirk's school at Eltham. There Salmond went to the top of the school and having passed the entrance examination, joined at Woolwich as a cadet in August, 1855, he being then about 15 years old, and was head cadet of his batch. His time at Woolwich was very happy and he was never much bullied—although it is evident from his own notes that bullying was much in evidence. Owing to the casualties of the Crimean War there was at this time a shortage of Artillery and Engineer officers, and some of the senior cadets were given accelerated commissions. This left Salmond within the first ten of his batch, and so entitled him to a commission in the Royal Engineers which he obtained on 23rd December, 1857 (subsequently antedated to 1st October, 1857).

Owing to his youth and rather delicate physique his father obtained an extra month's leave for him before joining at Chatham, and this leave was spent in riding and hunting both with the Brighton harriers and at Leamington, where his father was then living.

He eventually joined at Chatham in February, 1858.

During his first months at Chatham, enjoying the comparative freedom after the long hours of restraint at Woolwich—he indulged his fondness for boat sailing on the Medway with his friends Micklem (afterwards Major-General) and Moysey (afterwards Colonel). He thus got seriously behindhand in the work allotted to him of "fortification plan drawing," and incurred a "red-hot" reprimand (or "taunt" as he called it) from a choleric colonel.

The effect of this "taunt" was a fit of energy and application so that the back work was quickly made good, and he was soon afterwards warmly complimented on his work and zeal; the "taunt" evidently bore fruit as there was never again any cause for another one.

From Chatham to Aldershot, under Colonel Chapman, C.B., then C.R.E., and thence to Pembroke dock for harbour defence work, where he was again able to follow his love of boat sailing.

To Gibraltar with the 33rd Company in 1861, and there he put up and set in working order the first telegraph line on this famous Rock. In his spare time, in company with two brother officers, one of whom was the late General Sir Charles Warren, he scaled the steep eastern side of the Rock in several places, a feat that had then been seldom accomplished. In one of these climbs a sudden slip nearly led to a fatal result.

Appointed to command the 40th Company R.E. at Chatham in 1867, he was temporarily detailed from there to assist in arranging and pitching the annual camp at Wimbledon for the National Rifle Association.

This was his first introduction to musketry affairs on a large scale. He was always very keen on game shooting, so that rifle shooting followed in natural sequence. Promoted 2nd Captain in May, 1868, he was then sent to Aldershot to command the 11th Company R.E., Colonel Laffan then being C.R.E. Here he first met D. Thompson, of the 67th Regiment, an Inspector of musketry, with whom he made firm friends.

Proceeding again to Gibraltar in command of the 11th Company he was offered while on leave in 1872 the appointment of musketry instructor to the Corps at Gravesend and Chatham, which he accepted and held for the full period of five years up to 1877.

It was while he was on leave in 1873 at Packington that he first met Miss Hoyle, to whom he became engaged, and the wedding took place in August, 1874.

At the end of his time as musketry instructor in 1877 he was

ordered to Dover for harbour defence work, and was promoted to major soon after.

After three years at Dover he went in 1880 to the home district in London as executive officer, and during his time there he was, in 1882, ordered to Egypt in command of the 18th Company R.E. for work at Ismailia, the base of operations (as before mentioned), and returned to the home district at the end of the year.

The following notes were made by him of his experiences in the Egyptian 1882 Campaign :—

" Next day I received orders to go to Chatham and take command " of the 18th Company ordered on active service. I had to go " down to Woolwich to inspect the timbers of a pier I was to put " up at Ismailia and to see some shears, all of which were to be " sent out ready for us. In three days we were off. We left " Chatham by train for Albert Docks at 2 a.m. . . . I was " commanding the troops on board (the *Viking*) which consisted " of my company and a company of the Commissariat and " Transport Corps. My officers were Captain Gordon, Lieuts. " Mantell, Norris and Winn. We all ceased shaving on departure, " and by the time we reached Malta, our first stopping place, we " were beginning to get a little more decent looking than we did " on the first day of our start. . . . We reached Ismailia, 20th " August, and at once landed. . . . No timbers or anything " connected with the work we were expected to do having arrived, " I was detailed to take charge of the telegraphs and railway " pending the arrival of the special companies R.E. trained for " these works. It was a case of making bricks without straw " with a vengeance, a railway to work without engines, a telegraph " to carry on without operators or appliances. The solution for " the railway was to take horses in place of engines, and as to the " telegraph, although we found a few men who could to some extent " work the instruments, it was a lame duck sort of arrangement. . . " During the week there had been pretty well every day a fight of " some sort or another at the front, but I was glued to the base " as C.R.E., and at the base I saw nothing of these fights. . . . We " were a very small force left in Ismailia and it showed a great " want of enterprise on Arabi's part in not having a shy at us from " Salahiyeh. Our preparations for him were complete enough, " Sir Owen Landon who commanded at the base, had assigned " everyone his post and we should have given him a warm " reception. . . .

" Early on 13th September came in the news of Tel-el-Kebir " and following close on this, the information that practically the " nation gave in. We at once felt that the war was over, and " accordingly Sir Owen allowed us to go off and have a look at the

"front. I got to Tel-el-Kebir the day after the fight and went "round the position. . . . Soon after orders were received for "some of the troops to go home from Ismailia, and in concert with "others I made the necessary arrangements. The troops to "return came in on the 20th September, and all arrangements "were going smoothly when suddenly on the 21st I was taken ill "with violent diarrhœa and vomiting which continuing with "great severity completely played me out, and on the 23rd I was "carried on a stretcher down to the pier, and sent on board the "*Lusitania* homeward bound."

In 1883 he was appointed Assistant Director of Works (Barracks) at the War Office.

It was in 1884 that he became Assistant Adjutant-General, Royal Engineers—and he held this important appointment for five years up to 1889. During this period he served under two Deputy Adjutant-Generals, Major-General Sir John Stokes, K.C.B., and Colonel Robert Grant, C.B. On relinquishing his appointment in 1886—Major-General Stokes made a special report to the C.-in-C., in which he said :—

"I ought to have told your Royal Highness how much I have "been indebted to . . . Lieut.-Colonel Salmond. It is impossible "to over-rate the ability, industry and loyalty of the invaluable "officer. My term of office has witnessed the dispatch of several "important expeditions to North and South Africa and the "assembly of several important committees on subjects affecting "the Royal Engineers. In these matters, as well as in the "ordinary duties of the office this officer has been indefatigable.

". . . Whatever degree of success I may have been able to "accomplish has been largely due to his industry and ability."

Colonel R. Grant says of him :—

"This is an excellent officer in every respect. One of the best "I have met in the course of my service. He has great qualifi- "cations for Staff Employment both in the field and in office. "A very good man of business, quick and decided in making up "his mind, with large and unprejudiced views and untiring "industry. His manner and tact are very good and his experience "is wide."

In January, 1884, he was sent to Brussels to inspect the rifle ranges there and remained three days. The celebrated General C. Gordon was staying at the same hotel, and as Salmond had known him in former years, they fraternized again. Gordon was then engaged

to go to the Congo for the King of the Belgians, but his heart was in the idea of freeing the slaves and he hoped to be able " to jump on the Mahdi's back," as he said, in the Bahr-el-Ghasal district which he thought to be the hot-bed and originating ground of the slave traffic.

On vacating the temporary appointment of Assistant Quarter-master-General in 1890, which he held during the absence of Sir Francis de Winton in Griqualand West, he received highly complimentary private letters from Sir Redvers Buller, then the Q.M.G., and from Sir George Harman, then the military secretary.

A short period as Colonel on the Staff Commanding Royal Engineer Home District in 1890-91, led to his appointment as Deputy Inspector-General of Fortifications (Barracks) in 1891.

The Barrack Act of 1890 had then come into force. A loan of £4,100,000 had been made for the purpose of bringing old barracks up to date, replacing hutments by permanent buildings, etc. Colonel H. Locock, then D.I.G.F. Barracks, was placed in charge of this very important work, and Salmond took his place in the War Office.

There is little record of his work during these years 1891-96, but he regularly spent his leave in shooting and hunting—paying visits to his numerous friends in Scotland and in England.

In 1896 he succeeded Major-General J. H. Maitland as Deputy Adjutant-General, Royal Engineers and carried out the duties of this office till the 30th June, 1902, when he retired. He was the last officer of the Corps to hold this appointment and, on his relinquishing it, the appointment was redesignated Assistant Adjutant-General. He was promoted Major-General in 1898. During his tenure of this office the responsibility of providing a sufficiency of the Engineer arm in the South African War devolved on him. Many technical units had to be organized and sent out, all such needs were adequately met by him and these Engineer units proved fully efficient.

To give some idea of these requirements, it may be stated that prior to the outbreak of war in 1899 the normal provision for R.E. units in South Africa was :—

1 Fortress Company.

During 1899 the following additions to the R.E. were sent out, in addition to the authorized Army Corps units :—

2 Field Companies—1 Railway Company—the Headquarters and 1 section of the Telegraph Battalion—2 Mapping Sections, and a Balloon Section.

These units were augmented from time to time during 1899,

1900, and 1901 by a large number of other technical and Army units.

While these demands for South Africa were being met the formation of a large number of other units was approved and carried out for home and dominion services.

For his services in connection with this period he was awarded the K.C.B. in October, 1902.

It may also be mentioned that he was named and strongly recommended in 1898 for a still higher post and a further extension of service, from which the strict rules of seniority alone debarred him.

On retirement Sir William and Lady Salmond soon after settled down at Ditchingham Lodge, Norfolk, which was rented from Mr. Rider Haggard; here Sir William found most congenial neighbours, and enjoyed the shooting and country life. Lady Salmond's eyes had been causing her great trouble, and though she and Sir William constantly visited the famous oculist Pagensticker in Wiesbaden, she became almost completely blind. Thinking Norfolk with its East winds too rigorous for her, in 1911 they moved to Whaddon House, Bruton, Somerset.

Here Sir William interested himself in the schools and local affairs. The anxieties and terrible events of the European War were brightened to a great extent by the brilliant performances and repeated rapid promotions of his two sons (now Air Chief Marshal Sir Geoffrey, and Marshal of the R.A.F. Sir John).

He and Lady Salmond took over the management of the S.S.F.A. in their district until the end of the war.

Lady Salmond died in 1923, and Sir William who had attended her continuously and devotedly was very much pulled down and depressed. But he recovered wonderfully and though now 83 years old he took up again an old hobby of his—astronomy—played golf, and drove himself about in his motor-car. He was extremely active during his last years, and in his 90th year was at work lopping dead branches off trees at the top of a long ladder.

One of the proudest times of his life occurred in 1925, when he and his two distinguished sons attended a Levee held by the King. Then this well-known and distinguished father and his two sons, whose names are so prominently written in the record of the war, made a most interesting and exceptional appearance before His Majesty.

It has been difficult to find material for the memoir of Sir William who, dying in his 93rd year, had outlived most of his contemporaries—and there are many interesting occurrences and services that cannot now be recorded. But those junior to him, who served under him, and enjoyed his valued friendship, will always keep his memory alive by deep feelings of affection and regard.

It would be hard to find a better expression of this feeling than by quoting an extract from the school magazine at Bruton which was written soon after his death :—

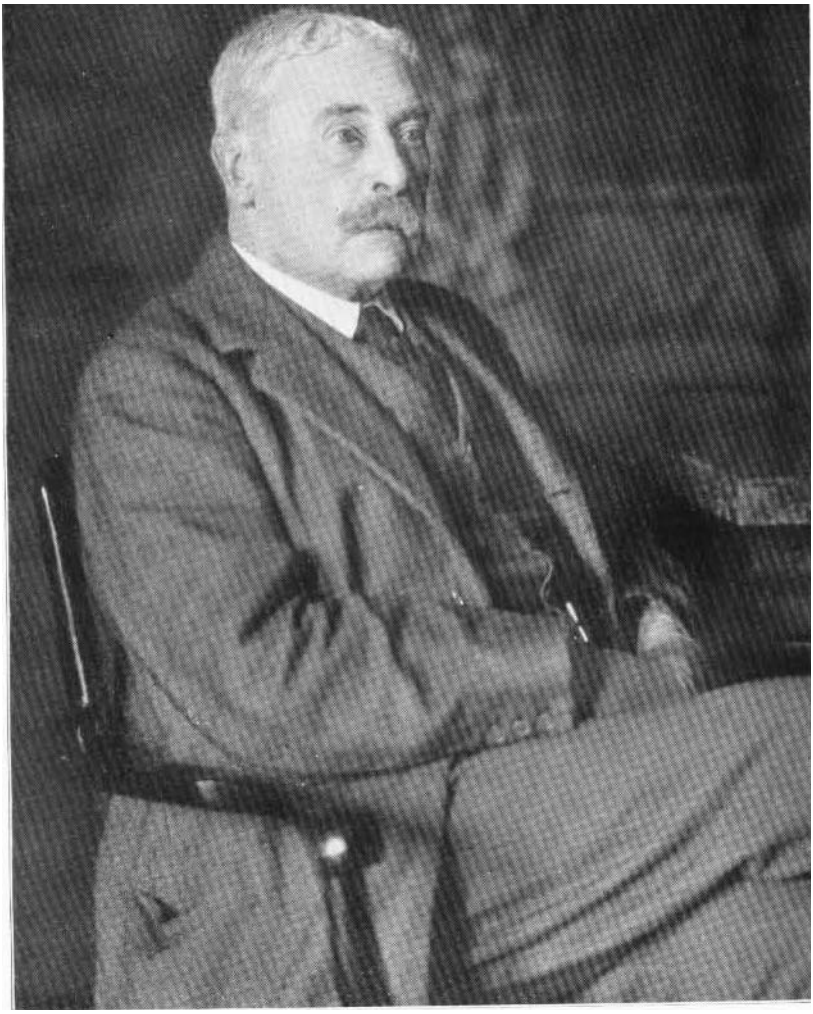
"By the death of Sir William Salmond this school has lost a "warm and dear friend. His very distinguished career has been "given in the newspapers. As a governor he took a keen interest "in all our affairs. . . . Whenever he spoke to the school his "address was simple, direct and friendly. If one may single "out a characteristic which endeared him to us, I would choose "his gift of eternal youth. To the last he could talk to the boys "as if he were one of themselves. Many a Bruton boy has carried "with him the pleasantest remembrance of a chat with Sir William "on the road outside the school ; it might be one of a few minutes "only as he was winding the handle of his car (a task in which "he would accept no help), but always, however brief the meeting, "one felt cheered and brightened by the few words. Here was "one of the most distinguished of living soldiers, and he a shining "example of the truth that men of real distinction are almost "always men of extreme simplicity. No one could know Sir "William and fail to see that here was an influence under which "all pretentiousness and swagger must wither away."

L.B.F.

COLONEL SIR HERBERT JEKYLL, K.C.M.G.

THE Jekyll family came early in the seventeenth century from Lincolnshire. It has produced some men very learned in the law, as well as divines and soldiers. The late Sir Herbert Jekyll once informed the writer of this memoir that its leading characteristics were a pronounced hesitancy of speech, small hands and obstinacy. He himself was the third son of Edward Joseph Hill Jekyll, formerly Captain in the Grenadier Guards, and of Julia, daughter of Charles Hammersley. He was born in London on November 22nd, 1846. Much of his childhood was passed at Bramley, in Surrey. In July, 1863, half through his seventeenth year, he passed into Woolwich where the course then lasted two and a half years. Though life at "the Shop" was not as rough as it had been some years earlier it was fairly strenuous. For Jekyll it ended by his passing out of the Academy second in December, 1865, and receiving the sword of honour "for his exemplary conduct at that institution." His first commission was dated the 17th April, 1866, and after two years on the establishment at Chatham he was posted to the 22nd Company there. In 1870, when the Government purchased the private telegraph systems of the country and placed them under the Post Office, construction and maintenance work in these systems had fallen behind and to make up leeway the assistance of the Royal Engineers was called in. The 22nd Company was placed under the command of Captain Webber for the purpose of undertaking the new duties. From May, 1870, this company had its headquarters in London, and with it Jekyll served as lieutenant until November, 1873. The object of having some of the Post Office telegraph construction work done by the Royal Engineers was not only relief to the then overworked civilian staff but also the creation of a body of thoroughly trained military telegraphists. The advantage of this was presently to be shown in the Ashanti War.

A long series of disputes with Koffee Kalkalli, King of the Ashantis, partly connected with the transfer to Great Britain of the Dutch Settlements on the Gold Coast, led to the invasion of the British Protectorate by the Ashantis early in 1873, and after lengthy fruitless negotiations, to the dispatch in September of that year of the nucleus of an expeditionary force under Sir Garnet Wolseley. The British troops, for which he asked shortly after his arrival, did not arrive till the end of the year. Among the first of these to be landed on the 12th December, 1874, were Lieutenants Jekyll and Skinner and 20 N.C. Officers and men of the Royal Engineers. The detachment was required in the first instance for the erection of a telegraph line into the interior. Seventy-two miles of wire had been



Colonel Sir Herbert Jekyll, KCMG

got in readiness for shipment from England. "Unfortunately, however, the wire and other telegraphic stores were shipped in the *Dromedary*, the slowest ship on record; and it was only by Lieutenant Jekyll, the officer appointed to take charge of the telegraph, having, with his usual good sense and energy, shipped the stores required for twenty miles of line, and two instruments, as part of his private baggage on board the *Himalaya*, that the line was laid to Dunquah before the *Dromedary* arrived" at Cape Coast on December 31st. First of all, want of stores and then lack of transport delayed erection of the line which, however, reached Prahsu on January 24th and ultimately, in spite of violent thunderstorms in February constantly breaking it down by splitting the insulators, was brought as far as Accropoomue, 23 miles north of the Prah. This was still nearly fifty miles south of Coomassie which had been occupied on February 4th. According to Sir Henry Brackenbury's narrative of the war prepared from official documents "great difficulties were encountered in laying the line. Lieutenant Jekyll was required to perform other duties besides those in connection with the telegraph; he was underhanded in labour; the labourers were unskilled; the tools hurriedly put on board the *Himalaya* were insufficient in quantity, and not always suited to his wants. . . . The progress of the telegraph therefore, though not equal to what had been hoped for, was the utmost that could in the circumstances have been made; and Lieutenant Jekyll deserves every credit for his strenuous exertions." Intense exertion, as so often happened in that climate, brought on malarial fever, and it was as a sick man that he was carried back from Headquarters to the coast and shipped to England. For many years afterwards he had a sharp attack of malaria every spring.

After a few months' leave in which to recover his health, Jekyll returned to the Post Office in London, where he remained in special employment under the Postmaster-General—then Lord John Manners—until the end of 1876. Then the Earl of Carnarvon, who since the time of the Ashanti war had been Secretary of State for the Colonies in Disraeli's second administration, asked for Jekyll's services as private secretary. He was lent by the War Office for the purpose and held the post until his chief resigned in January, 1878, owing to some difference with his colleagues in the matter of the position taken up by Great Britain with regard to the Russo-Turkish War. At that time when it was thought that this country might be involved in hostilities, much uneasiness was felt at the unprotected state of the enormous interests lying in British ports in all parts of the world. In 1879 a strong Royal Commission was appointed to consider and report upon the defence of British possessions and commerce abroad. Lord Carnarvon presided over this commission and Jekyll—a Captain since the end of the previous year—became its secretary. In the three following years three voluminous reports

were issued, in the last of which the fortresses and coaling stations of the Empire were authoritatively laid down and schemes of local defence examined and presented. The final report was dated 22nd July, 1882. At that time Sir Andrew Clark was Inspector-General of Fortifications, and had to consider the action he would recommend on the report ; to assist him he got together a small special staff at the War Office, which was in the first instance to prepare projects for the defence of the coaling stations. That staff, which worked at the Horse Guards in Whitehall, from the end of February, 1883, onwards, included Herbert Jekyll. Other members were George Sydenham Clark (the late Lord Sydenham), George Bartram, and the writer of this note. A little later on a gunner, Desmond O'Callaghan, and a naval officer, Captain T. S. Jackson (known in the office as " The Admiral "), were added to the party, which worked hard and in cheery good fellowship in the years that followed, in some cases visiting the places for which they were designing forts and batteries. Jekyll's first duty in this connection was the planning of works for the defence of Singapore. In 1881, he had married Agnes, youngest daughter of William Graham, and when in the latter part of 1883 he went out to the Straits Settlements for six months to survey for the works there, he was accompanied by his wife, who began the fifty years of assistance and support that she gave to him for the rest of his life by helping him to look after his chaining party of Malays. Jekyll became an expert in coast fortification as practised at that time and he was always an accurate and artistic draughtsman. On this work he spent the years till May, 1885, when the Penjdeh fight on the Afghan Frontier and the " Bosphore Egyptien " incident in Cairo occasioned another war scare and a realization in Great Britain of the unsatisfactory organization of our defences abroad. At the instance of the Colonial Office a small committee was set up to hasten inter-departmental discussion in these matters. Sir Andrew Clark presided and Jekyll was appointed secretary to this Colonial Defence Committee, which after 47 years is still doing useful work. But Jekyll's tenure of the secretaryship was only of short duration, for in June, 1885, he was wanted again as private secretary by Lord Carnarvon, who had become Lord Lieutenant of Ireland, in Lord Salisbury's brief administration. Charles Stewart Parnell was then leader of the Irish party which dominated English politics and when Lord Carnarvon, who favoured a moderate measure of home rule, conferred with this leader, Jekyll must have known much that was going on behind the scenes. The conference led to no results. After the general election at the end of 1885, the Liberals allied themselves with the Home Rule party, the Conservative Government, defeated in the House of Commons, resigned, and Lord Carnarvon left Ireland. Jekyll, promoted Major in April, 1886, returned to the War Office, first of all to act as *A.D.C.* to the Inspector-General of Fortifications,

Sir Robert Grant, and then to work in his office at the defences of Gibraltar, visiting the fortress in order to prepare his plans. These years of 1886 and 1887 and those that followed them were prosperous ones for British commerce and it was in the promotion of imperial trade and also of the arts as applied to trade that advantage was taken of Jekyll's organizing and artistic qualifications by his appointment in 1887 to the secretaryship of the Royal Commission on the Melbourne Centennial Exhibition, presided over by Lord Rosebery. After that, for five years Jekyll held the post of secretary to the Royal Artillery and Royal Engineers Works Committee, which had been another of the creations of Sir Andrew Clark, and secured the detailed design of defence works being in accordance with the considered opinion of artillery, engineer and naval technicians.

September, 1892, saw Jekyll—shortly to be promoted to Lieut.-Colonel—back in Dublin again as secretary to the Lord Lieutenant, but this time to one in a Liberal administration—Lord Houghton (now the Marquis of Crewe). It was the period of Gladstone's second failure to pass a Home Rule bill through the British Parliament. Lord Houghton's viceroyalty came to an end with Gladstone's last Government in July 1895, and Jekyll returned to England. After a couple of months at Aldershot he went back to Ireland as Commanding Royal Engineer at Cork, which post he held till April, 1897.

In the immediately following years Jekyll was employed as secretary to the Royal Commission to the Paris Exhibition of 1900. In this capacity he resided in Paris for over a year in charge of the British section; he was appointed Acting Secretary of Embassy, and he and his wife were popular in French society at a time when the popularity of England was at a low ebb in France and every stimulus to it was of value.

At the beginning of 1901 Jekyll became a Knight Commander of the Order of St. Michael and St. George, and at the end of July he retired from the army, passing nearly at once into the Civil Service as Assistant Secretary to the Railway Department of the Board of Trade. In this capacity he was a member of a committee of which the report in 1902 led to legislation ultimately consolidated in the Light Railways Act of 1912. In 1902 and 1905 he was chairman of committees dealing with electrical standardization and later on he was one of the principal witnesses before the Royal Commission on Canals, who issued their final report in 1909.

But his principal work at the Board of Trade was as first chief of its London Traffic Branch which was established in August, 1907, and was under his direction until his retirement four years later. During the period London vehicular traffic, from being almost entirely horse-drawn, became largely motor transport. This change was reflected in the invaluable information and statistics of the annual reports prepared under Jekyll's direction. In 1909 he

instituted a special enquiry into the sufficiency of the arterial roads leading into London and as a result of this he was able before he left office to recommend a comprehensive scheme of new roads and improvements to existing roads designed to meet the needs of actual traffic and probable future requirements. This scheme was favoured by the highway authorities concerned. The many conferences that its adoption involved delayed action on it until the Great War necessitated some years of postponement. Eleven arterial roads which have, however, been since wholly or partially completed represent the carrying into effect of suggestions originally put forward by Sir Herbert Jekyll.

On his retirement he became director of several companies and gave valuable services on the Board of the London General Omnibus Company. His war activities centred largely round those of the Order of the Hospital of St. John of Jerusalem, of which he had been Secretary-General for ten years from 1911 and was Chancellor between 1911 and 1918. He was a constant attendant at all committees during the war, when meetings were particularly frequent. He worked on the Joint Finance Committee of the Order of St. John and the British Red Cross, and he associated himself with the very active work of Lady Jekyll, who was head of the Hospital Stores Department at St. John's Gate.

So much for the bare facts of a full and useful life. But I have memories that go outside them—of the generous help given to me by a comparatively senior officer when 50 years ago I was ordered to West Africa and needed advice from someone who knew that country; of being taken by this brother officer to exhibitions of the Burlington Art Society and deriving inspiration from his cultured appreciation of them; of a long time afterwards visiting his home, set in a garden that he had made beautiful on a Surrey hillside; of a visit to the workshop where he produced beautiful carvings in the style of Grinling Gibbons; of the pleasure derived from chance meetings in that pleasant place, the coffee-room of the Athenæum; of a comparatively recent occasion when in answer to my request for a note on the Rev. George Jekyll, some time rector of the parish of West Coker, he sent me full genealogical and other information written out in his beautifully legible hand without correction or erasure; and lastly of seeing him a few months ago resting on a sofa in the library at Mells in Somerset on his return from a long drive and of my enjoyment of being again in his friendly company and once more hearing his attractive voice. He remains in my memory as a delightful companion and a strenuous and careful worker, with wide knowledge, cultured tastes, kindly humour and courteous manner—a verray parfit gentle knight.

M.N.

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

THE ROMANCE OF REGIMENTAL MARCHES.

By WALTER WOOD.

(William Clowes and Son, London. 6s.)

The regimental marches of the British Army have been chosen—as one might expect—in a charmingly haphazard fashion. In many cases old airs have been adopted, such as *John Peel, The Flowers of the Forest, St. Patrick's Day, Ap Shenkin,* and *The Rising of the Lark.* Sometimes a contemporary song has been appropriated, which accounts for *They all love Jack, The Light Barque,* and *We've lived and loved together.* The operas *Figaro, Scipio, Aida* and *Faust* have all furnished march tunes, and so has *The Daughter of the Regiment.* Many are of foreign origin, as for example *Braganza, Radetzky, La Mandolinata, Ça ira, Jägersleben,* and *Nachtlager in Granada.* A few have been specially composed, notably the R.A.F. march (it seems fair to call this a " regimental " march), by Sir Walford Davies, and there is a tradition that the celebrated slow march in *Scipio* was originally written by Handel for the use of the Grenadier Guards.

Pepys wrote in his diary on June 30th, 1667, with reference to his visit to Rochester : " Here in the streets I did hear *The Scots March* beat by the drums before the soldiers, which is very odd." A good question in an education examination would be to point out what it was that Pepys found so odd ; the tune itself, or the beating of the drums, or the fact that it was done in the streets, or before the soldiers, or that he himself heard it, especially in Rochester ! However, *Dumbarton's Drums,* to which he undoubtedly refers, is one of the very oldest of British marches, and the Royal Scots do it full justice.

The well-known R.A.S.C. march owes its adoption to the fact that when the then Army Service Corps was first required to march past the Commander-in-Chief there was some doubt as to what tune the cavalry bands should play. " Tell them to play *Wait for the Wagon,*" said the Duke. And it was so.

The general regrouping of battalions in 1881 resulted in certain changes in the regimental marches, not without some opposition, for the linked units naturally did not care to surrender their honoured and familiar tunes. There is now an official version of all the approved marches, so that various bands, when massed, can play them similarly—a very desirable state of affairs !

Having recently delved into back numbers of *The R.E. Journal* in order to trace the history of *Wings,* I can supplement the brief but accurate account given by Mr. Wood. *Wings* was adopted in about 1870 at the instigation of Lt.-Gen. Sir T. L. Gallwey, then Commandant S.M.E., who, finding that there was no recognized quick march, instructed the Band Committee to choose one. *Wings* was chosen, and found favour with both officers and men. Strictly, the name applies only to the second half of the Corps march, the first being a tune called *The Path across the Hills.* The two were fitted together by Bandmaster Newstead (Herr Sawerthal's predecessor) in what is practically their present form.

Some difficulty seems to have been experienced in marching past, because of what one correspondent calls " the padding between the first tune and the second."

Another complains of the "change in time between the tunes." He is not correct —unless he heard them very badly played—for what occurs is not a change of time but of rhythm. A strongly worded appeal was published in the *Journal* of August, 1889, setting forth the claims of the Corps to *The British Grenadiers*, and decrying "Claribel's vapid song" (*Wings !*).

The British Grenadiers became our recognized march for a few years, but a feeling in favour of a return to the more individual *Wings* continued to grow, and with Lord Kitchener's help it was reintroduced at the end of 1902.

Mr. Wood has remembered the most famous of all the 1914-18 tunes, although it was never a regimental march. He records that in February, 1924, an unmarried cripple named Henry James Williams died at Temple Balsall. On a marble stone in the little cemetery of Balsall is this inscription:

Author of
"It's a long, long way to Tipperary."

"Give me the making of the songs of a nation, and let who will make its laws."

I.S.O.P.

GORDON: AN INTIMATE PORTRAIT.

By H. E. WORTHAM.

(Harrap. 12s. 6d. net.)

This book has been written for the general reader in connection with the centenary of Gordon's birth, and as its sub-title claims, gives an intimate portrait of Gordon. The author has had access to all the letters written throughout his life by Gordon to his sister Augusta, the austere confidante to whom he poured out without restraint all his feelings; this material has never been fully made use of before.

The popular idea of Gordon has been that of the "soldier-saint"; here is seen the brilliant soldier and man of action at eternal war with himself in his endeavour to follow the ideal in the *Imitation of Christ*; he was always fighting the "Agag" within him, and the result was disharmony and an essentially unhappy life. Gordon was happy and free only in the society of youth of his own sex, and the oft-expressed longing for death as an end to his struggles seems to have been perfectly genuine, but in no way "morbid." The craving for action was insistent, and the opportunities for quiet and contemplation, when they came as in Palestine, quickly bored him.

His love of power, and sureness that he was always right in his views and plans, as he generally was, made him a difficult, though loyal, subordinate. As a soldier in his own line he was unequalled, both as strategist and tactician, as his exploits in China and the Sudan show. As a leader he was a hard man to serve, trusted and feared rather than loved. A strict disciplinarian and ruthless if his own side failed him, he was merciful to his enemies; he would shoot a mutineer or looter on the spot without pity, but the only example of similar action to a foe which met with his approval was the shooting of Suleiman, the son of Zobeir the slave-raider, by the Italian, Gessi. But during the last days at Khartoum he bitterly regretted that he had not tempered justice with mercy in the case of the two Pashas found guilty of treachery by a legal court; he felt he had been guilty of a judicial murder.

On the gigantic task he carried out in the Sudan during his three terms of service there the last word has been written by Dr. B. M. Allen (see *Gordon and the Sudan*, reviewed in this *Journal* in March, 1932), but Mr. Wortham brings out well the tragic game of cross-purposes that led to the fall of Khartoum. Gordon had always distrusted the statesman and diplomat, and in the bitterness of his last letters is seen the climax of this feeling. For himself he felt no pity, and, as always, he looked forward to death as a welcome release; the way down the river to safety was open to him, personally, almost to the end, had he chosen to desert his trust; it was his responsibility for those who had trusted him, and trusting him had withstood the Mahdi, that turned his hair grey, for unless rescued their fate would be slavery or

death. It made his blood boil that the force should be called the Gordon Relief Expedition. For ten long months Gordon, the soldier and engineer, single-handed kept Khartoum intact, whilst muddle and procrastination elsewhere bore their inevitable fruit.

On January 26th, 1885, this uneasy, restless life reached its end, and perhaps no better epitaph could be written than that spoken by Slatin when the Dervishes showed him Gordon's head, which is quoted by the author. " Is not this the head of your uncle the unbeliever? " they asked. The reply was, " What of it? A brave soldier who fell at his post. Happy is he to have fallen. His sufferings are over."

This book seems essential to a proper understanding of Gordon's character.

P.H.K.

THE ANATOMY OF MODERN SCIENCE.

An Introduction to the Scientific Philosophy of To-day.

By BERNHARD BAVINK.

Translated from the Fourth German Edition, with additional notes, and bibliography for English readers by H. STAFFORD HATFIELD.

(Bell & Sons, Ltd. Price 21s.)

The object of this book is to present a comprehensive and extended view of those problems of science which, in these days of specialization, students and others have no time to study unless they are put in a popular or semi-popular form. This want has been so keenly felt in Germany, where specialization is probably carried further than in any other country, that Dr. Bavink's book had already gone through four editions before it was translated into English.

The task, therefore, that the author has set himself is one of considerable magnitude, namely to present to the reader a rapid, accurate and up-to-date survey ranging over all the chief problems of science. It is a story of the achievements of chemistry, physics, astronomy and biology. This he does without the use of mathematics. It follows, especially in the case of the theory of relativity, the quantum theory and wave and quantum mechanics, which are extremely difficult to deal with, even when full use is made of mathematics, that " only the barest outline " can be given " and " the best part of them cannot be set out."

One has sorrowfully to admit that a large part of modern physics is a closed book to all except the higher mathematician. We have to accept without question what he tells us, not being in a position to analyse, much less dispute, what he says. In order to succeed as a modern scientist one must not only be a great experimenter, as Davy and Faraday were, but also must combine with this great mathematical ability.

To appreciate this book one should be thoroughly scientific-minded and have a real liking for science; if this is the case, then there is ample for the most fastidious.

In the course of a review such as this it is only possible to refer to a fraction of the subjects dealt with.

The chapter on " The Physical World-Picture of To-day " brings out some curious results. " Physics naturally strives to eliminate subjective elements in measurement " more and more, in order to arrive at objective facts, independent of all points of " observation," which is the true meaning of the relativity theory. But quantum mechanics leads to the following remarkable conclusion " within its order of mag- " nitude, no real independence between observer and observed can exist, since the " process taking place between the object on the one hand and the sense organs of " the observer on the other itself consists of such quanta action."

The consequence of this is that " if a precise description of atomic events in the " classical sense is impossible in itself the causal principle naturally loses its meaning " for physics."

According to this principle an exact knowledge of the present allows of an exact

prediction of the future, but this ceases to have any meaning if it is not possible to acquire an exact knowledge of the present. Accordingly causality does not apply to the inner working of things but only to coarser processes which we are accustomed to undertake.

Perhaps the following example may make this clearer.

The pressure of a gas is proportional to the energy with which its molecules bombard any object (say a flat surface) in contact with it, and the whole pressure is the sum of all the blows it receives from them on both sides of the object. It is assumed, if the body does not tend to move, the number of molecules being so enormous that on the average it receives as many blows on one side as the other. This is only a statistical rule of probability and not a law in the strict sense. If we make the surface under consideration sufficiently small, we soon find that a movement would take place under the same bombardment that produced no effect when the large surface was under consideration. Consequently Boyle's classical law concerning the pressure of gases is, strictly speaking, only true when we consider the larger application of it. Such laws only have the " character of average statistical " rules." Those of us who were brought up on classical physics must revise our ideas on many subjects in the light of modern discovery.

The well-known theory of the contraction of measuring rods introduced to account for the negative result of the Michelson & Morley experiment (which, by the way, the author attributes to H. A. Lorentz instead of to G. F. FitzGerald, who first suggested it) is commented on as follows: " This hypothesis is not in itself so fantastic when we " consider that all substances are supposed to consist of electric charges, which are " surrounded by an electric field, and therefore motion of these charges relative to " the field medium (the ether) might very well result in forces which would effect this " contraction." This is an interesting suggestion with regard to the theory. But it is unfortunately impossible to prove experimentally since all measuring rods would be equally affected.

Since the quantum theory is so often mentioned in works on physics, perhaps it would be useful to attempt to define its meaning. When light falls on a photographic plate it cannot only effect chemical changes, but it can eject an electron from an atom and cause it to jump out of its orbit. Now the speed or energy with which the electron is ejected depends not on the intensity of the light, but on its wave length only. The product of the energy of ejection and the wave length of the light causing the ejection is found to be a constant and is the same for every atom and every kind of matter. This constant is called the quantum. When an electron moves from one orbit to another farther from its nucleus, then a quantum of energy is absorbed. Conversely, when an electron moves to an orbit closer to its nucleus, a quantum of radiation is given out. The quantum is an absolute constant of the universe.

It enters fundamentally into all atomic physics. Energy and wave length are in some way connected so that their product is a constant, but this is only true where atoms are concerned. This fact evidently has a deep and far-reaching meaning, not at present fully understood, and it probably never will be until we understand the nature of waves of radiation and the medium by which they are transmitted across space or, in other words, understand space itself.

It is amazing the extent of the reading the author must have undertaken to produce a work of this kind, containing as it does so much concentrated knowledge.

As a work of reference in which can be looked up the progress that has been made in any particular science it is extremely useful, not only on account of its general contents, but on account of the extensive bibliography it contains together with a supplementary list of works in English which has been added by the translator. Further, almost every statement in the text is documented with notes at the end of the volume, no trouble seems to have been spared in this respect, or on the name and subject index.

H.L.C.

MILITARY ENGINEER SERVICES HANDBOOK

(First Edition, 1932).

VOLUME V—WATER PURIFICATION.

Compiled by COLONEL A. D. ST. G. BREMNER, M.C.

(Published by the Government of India Central Publication Branch, Calcutta. Price Rupees 5.)

The handbook contains a preface by Major-General A. G. Stevenson, Engineer-in-Chief, India, which explains in brief the object Colonel Bremner had in mind when compiling the book.

The table of contents is well arranged, and a very full index is included at the back of the book. Reference to either or both of these at once shows one where the information one is seeking can be found. The addition of a page on which the receipt of amendments can be noted is very useful, and might well be adopted when preparing other military books of reference.

In compiling this book Colonel Bremner has realized that in addition to the duties of the Royal Engineer officer as laid down in *Engineer Training*, Vol. II, 1926, Chapter VIII, Sec. 60 (3), and *Military Engineering*, Vol. VI, Sec. 1, para. 1, he, when in charge of steam and I.C. engines, is responsible for ensuring that all the impurities which are likely to damage his plant have been removed from the water used for conversion into steam or for cooling.

Bearing in mind all the duties of an R.E. officer in charge of water purification, the compiler has collected in one volume much valuable information which appears in no other single publication. The majority of existing textbooks deal with the subject from a medical or hygienic point of view, whereas the compiler explains the subject from an engineer point of view.

The book is divided into sections only; chapters, which are really unnecessary in a book of this kind, have been omitted.

Sections 1—4 give the various authorities governing the responsibility of the R.E. as regards the purification of drinking, cooking and ablution water, and show where further information on the subject of contamination and purification can be obtained if required.

A point, the importance of which is not always realized by those in charge of water purification, is the necessity for keeping records of the state of the water before, during and after purification in order to insure that the correct degree of purity is being obtained. This is stressed by the compiler in Section 2.

The list of points which should be brought out in the report on the reconnaissance of the source of supply in order to indicate to the expert what impurities to look for in his examination, is particularly useful. This is given in Section 3.

Sections 5—12 deal with water analysis. The reason for preliminary analysis is explained in Section 5, and references to sections dealing with the details of the analysis are given.

The physical characteristics of water are given in Section 6, and a note against each shows what its presence in a sample denotes.

Section 7 gives the number of p.p.m. of various impurities which can be allowed to remain in water for human consumption. This section also gives a guide to the interpretation of the results of a chemical analysis.

In Sections 10 and 11 it is shown how the electrical conductivity of water and p.H. values can be usefully employed, particularly for water used in machines.

Sections 13 and 14 explain the object of purification, give a list of the impurities to be removed with reference to the sections dealing with their removal in detail.

Sections 15—27 deal with purification methods. The various methods employed and appliances used in them are explained in detail.

Sections 28—42 deal in detail with inorganic impurities which are likely to be found in solution, and show how they would interfere with the working of both the human and mechanical machine if allowed to remain. The plant, appliances, and chemicals used in the removal of these impurities are also dealt with in these sections.

Section 43 draws attention to the use of activated carbon as an agent for the successful removal of practically every kind of organic taste and odour, and the elimination of free chlorine, for the removal of organic colouring matter, and for the separation of iron.

The use of activated carbon is a very recent development, and is being employed to an increasing extent in water purification, especially in Germany and the U.S.A.

Those R.E. officers who are employed on water-supply schemes are well advised to study its use.

Sections 44—53 deal with the removal of organic solids in suspension by sedimentation both with and without coagulants, by filtration both mechanically and gravitationally, and by sterilization.

A useful addition to Section 47 dealing with slow sand filters would be a description of a mechanical method of washing sand such as is used by the Metropolitan Water Board of London.

Sections 54—125 deal very fully with the sterilization of water with chlorine. Various methods of administering it are discussed and the mechanical appliances used for measuring and adding the dose are described.

Some very useful suggestions are made which, if adopted, ensure the proper control of the dose.

The question of eliminating the taste of chlorine is gone into very thoroughly, and various methods of carrying it out are described.

Tests which can be used by those responsible for determining whether the treatment is at all times adequate are described in Sections 97—101.

Sections 126—130 give examples of the problems which have been solved in various purification schemes.

Section 132 gives the *questionnaire* which should be kept in mind by officers preparing a purification scheme. This section is well worth study by all R.E. officers.

Sections 133—136 contain useful information about makers' tenders, firms supplying purification plant and materials, and data used in water supply calculations.

B.C.T.F.

A SHORT HISTORY OF THE 17TH AND 22ND FIELD COMPANIES, THIRD SAPPERS AND MINERS, IN MESOPOTAMIA, 1914-18.

A very graphic history of the oldest and youngest Field Companies of the Third Sappers and Miners (now the Royal Bombay Sappers and Miners) is given in this small book. These companies were the Field Companies of the 6th (Indian) Division, which was the original Mesopotamian Expeditionary Force. The Sapper companies were justly proud of the Division, and the Division of them. Of this Division, the following true story may be told: In 1920 during the Arab insurrection, a Staff Officer, who had never served in India, was asked why a newly-formed Division, composed of various units from different places, was called the 6th Indian Division. His reply was, "I understand that a division of this name created a great reputation here in the early days of the war. That reputation is still remembered by the Arabs, so we hope that the Arabs will think it is the old division back again, and that it will put the fear of God into them!"

The writer of this history describes well and clearly the difficulties under which the Sappers had to work in these early days, and also points out a lesson which is not even yet learnt by all who should know it, viz., the sin of using Sapper companies as infantry, except in extreme cases. Apart from the loss of British officers, who know and are known by their men, the replacement of trained Sappers is a matter of most serious consequence, since men with a knowledge of a trade, who can be enlisted in the Indian Sappers, are few and far between. The conditions under which the men worked were more often than not extremely trying, suffering as they did from heat, long hours of work, bad accommodation and short rations. In addition to this, they were without supplies of the necessary materials, stores, tools, etc., for their work, and this rendered their work harder to execute. Improvisation was the order of the day in these early times. In spite of all these factors, the spirit of the men never failed, and they came up smiling for any job set them, whether work or fighting. A tribute should be paid to the work done by the R.E. N.C.O's of these two companies; they were invaluable whether on work, the line of march, or during the siege of Kut-el-Amara. The history gives a very good account of the early days of the war in this, as it was then looked on, "side-show." It is supplied with a number of very clear maps, and in two appendices are accounts of their experiences written by two of the Indian ranks, who were prisoners of war, one a Mohammedan and the other a Hindu. The difference in the way the men of these two religions were treated is plainly shown in their narratives. A pathetic note is sounded by the Hindu at the end of his story, where he regrets the passing of his old British officer. He says, "This will be a great pity." Times have changed, but the disappearance of the British officer who spent his service in a Sapper and Miner Corps and got to know the men really well and was known and trusted by them, cannot but be a matter of regret, and by none will it be more regretted than by those sterling men, the Indians of these Corps.

E.J.L.

MILITARY HISTORY FOR THE STAFF COLLEGE ENTRANCE EXAMINATION.

By Captain E. W. Sheppard, o.b.e., m.c., *p.s.c.*, with a Foreword by General Sir Charles Harrington, g.b.e., k.c.b., d.s.o.

(Published by Gale & Polden. Price 6s. 6d.)

This little textbook will be welcomed by those officers who are starting to read for the Staff College Examination. The author sets out to provide a method on which the student can base his study of military history, particularly of those campaigns included in the syllabus for the examination. In tabloid but readable form he summarizes each campaign. He then gives notes on the principal points of interest, and follows them up by a few questions set in the style of those asked in the examination. Answers are given, too close to the questions for human nature to resist looking on.

The author is careful to point out that these notes and answers are only his views, and should be used by the student as a stimulus to further study on which to base his own opinions. To this end some very sound advice is given on the choice of books for further reading.

The idea of this work is admirable. It undoubtedly helps an officer to start the difficult process of "reading a little military history, and thinking a lot." The author has, however, made the mistake of unduly compressing his summaries of campaigns. By squeezing each campaign into two or three pages he has kept the book within 120 pages. Had he allowed himself twice that number the book would still have been reasonably short, and the stories of the campaigns would have been much more informative. There is a danger that the brevity of the present arrangement will tempt students to learn by heart the facts stated in the summaries, and not to bother

about further reading. Larger and better sketch maps would be a great improvement, but would possibly entail too great an increase in expense.

These criticisms are of minor importance when compared with the undoubted benefit which the book will confer on future generations of Staff College candidates. I commend it to them.

C.P.W.

THE BATTLE OF TANNENBERG.

By COLONEL BIRCHER.

(Published by Hans Huber, Berne. Price, 6 Swiss francs.)

In order to distinguish between this book and others, such as those by Elze, von Schäfer and Ironside, which deal with the same subject, it is useful to start by giving it its full title, *The Battle of Tannenberg as an Applied War-game Exercise in Switzerland.*

The author, who commands the Swiss 12th Infantry Brigade, claims for his production that it is " an experiment and a didactic novelty." The accounts of real battles as a basis for the war-game were used by a great Staff College teacher, Colonel Lonsdale Hale, R.E., for the battles of Colombey and Vionville, and have doubtless been used thus many times before and since. The novelty claimed appears to lie principally in the transfer of a whole theatre of war, including strategy, from one country to another, and in this Colonel Bircher has shown great ingenuity. His book is, in effect, neither history, nor an historico-critical study, but a book for purely instructional purposes, the narrative of which, though disguised by the transfer of theatre and of troops (for the Germans are replaced by Swiss actual formations) is based upon facts. As an instructional work it falls into the category of " studies " like *Custozza* or *Spicheren*, in which the narrative is frequently interrupted for the setting of exercises, followed by the author's solutions, but here again there is a great distinction, since Colonel Bircher, although he similarly sets upwards of one hundred exercises in the course of the book—appreciations, dispositions, instructions, orders, etc.—gives no solutions. The book is, therefore, not for self-instruction, but for study with a teacher, and it completely lacks, in consequence, the personal touch which is so typical and so pleasing in the studies of von Verdy du Vernois and of G. F. R. Henderson.

The author sets out its origin and purpose as follows: While the idea of time is fixed for all of us in our daily life, it is extraordinarily difficult for us to represent to ourselves the idea of space, even in two dimensions, and this difficulty has increased greatly with the wide strategic moves of modern warfare. The ability of representing space to ourselves accurately is, however, one of the first psychological requirements of the military leader. The best means of education to this end is the study of the history of war; but it is precisely in this study that the fundamental ideas of space need to be most firmly fixed. In order to familiarize the latter a battle has been chosen, the strategic situations of which have already been the basis of many war-games, and which have also furnished many exercises in applied tactics for carrying out on the ground. Further, to assist comprehension the battle of Tannenberg has been transferred out of E. Prussia, together with its most important centres, to Swiss soil.

After many attempts a framework of eight points was found, in which the distances between the different places in Switzerland differed at most by only two to three km. from the distances between the corresponding places in E. Prussia. When this framework was fixed it was quite feasible to apply not only the strategic operations of Tannenberg, but also tactical events.

Colonel Bircher counters the first objection, which will rise in the reader's mind, by pointing out that it would be a mistake to call E. Prussia a flat country and simple for military operations. The military obstacles of Switzerland in the shape of

heights and water courses may be taken as corresponding to the lakes, swamps, heavily-wooded country and bad country roads of E. Prussia.

The book is a monument of industry. It is pathetic to record that that industry broke down in so simple a matter as indexing. The important index, in which the Swiss place-names are followed each by its E. Prussian counterpart, is arranged alphabetically only as far as concerns the first letter of the word. This would be a blemish in any case, but since many Swiss names in the text are taken direct from the Swiss maps (which are not furnished), and have no E. Prussian counterpart, the looking-up of a place-name reminds one all too often of the proverbial search in a dark room for an absent black cat.

F.A.I.

WHAT IS THE TERRITORIAL ARMY?

COLONEL G. R. CODRINGTON, C.B., D.S.O., O.B.E., T.D.

(Sifton Praed & Co. Price 4s. 6d. net.)

Of recent years training policy has led to a great advance in the intercourse between the regular and territorial armies. There is, then, every reason for all regular officers thoroughly to understand the difficulties and particular circumstances, as well as the excellencies, of the citizen forces.

Colonel Codrington has given us a very valuable account of the Territorial Army. For those taking up appointments with the T.A., or working for examination, the value of the book is enhanced by its frequent references to *Regs. for T.A.* But to all who wish to learn anything of fundamental value it is the matter which is subject to no regulation that is so vital. The T.A. is a delicate machine and to generalize regarding it is not merely foolish; it is to court disaster. Its problems are wide and varied. A number of them are touched on, and these serve as an introduction to many larger ones which will occur to the reader but are outside the scope of the book.

The significance of the reconstitution of the T.F. as the T.A. in 1921 is not perhaps generally realized. It is definitely the machine for expansion and as such is the national army. In considering its relationship with the regular army, that should be borne in mind. It is national in another sense in that it stands or falls entirely on the voluntary support of the younger men of the country, backed by the selfless labours of a few individuals.

To many, men's reasons for joining the T.A. are somewhat of a riddle. The author suggests some answers, which his experience well fits him to do. The fact that the body is alive proves that fundamentally the attraction is a lofty one, a spirit of giving rather than receiving. If we understand the motive for joining, we shall have gone a long way towards understanding the problems and capabilities of the T.A.

The subject of training is always open to controversy, and the factors in the T.A. are so complex that ideas vary widely. Many may disagree with the remarks on "progressive training." Lack of thoroughness in handling small units can never be made up and will reflect on leaders of all ranks. On the other hand, given competent and suitable instruction, there is no reason for training—not the mere execution without comprehension of faults—of this nature to be uninteresting. This admittedly demands a high standard of instruction, not necessarily of a type suitable for regular units. If all officers and N.C.O's understand the duties of the section leader (or equivalent) thoroughly and intelligently, then units can expand with expectation of success. Otherwise, there will always be a fatally weak link.

But it is the spirit which counts in the Territorial Army. Colonel Codrington goes some way to describing it. The Territorial expects and deserves the sympathy of the Regular, but the attitude "I take off my hat to the T.A." does not satisfy him. He has no use for the Regular who does not criticize him as a soldier.

Every regular officer should read this book, which is given additional force by a foreword by General Sir Charles Harrington.

C. de L.G.

ORDNANCE SURVEY.

PROFESSIONAL PAPERS.—NEW SERIES, NO. 14.

(Paper read at the British Association Meeting of 1932 on the Subsidence of London.)
(Price 2s. 6d. net.)

It is all too seldom that the chance of carrying out a piece of geodetic survey comes the way of an R.E. officer. Work of this kind which appears to return no immediate practical benefit is always the first to be stopped when a cut in expenditure is being made.

The second geodetic levelling of England and Wales, which was completed in 1921, has, however, recently furnished a striking example of the value of such work. In 1929 there were serious floods on the Thames, causing much loss of life and damage to property in London. An outcry was raised that Ordnance Survey bench marks were inaccurate. As the paper under consideration shows, this outcry was found to be justified. The fault, however, lay not with the original surveyors, but in a subsidence of the ground.

Owing to the existence of two comprehensive levelling frameworks measured at an interval of 60 years and to some secondary work carried out at shorter intervals, it was possible to plot out the movement of the bench marks. With the assistance of archaeologists and geologists, it was possible to arrive at a theory of the nature of the movement. A practical result of the highest importance arising out of this work, is the possibility of predicting with confidence that certain bench marks will remain stable in future.

The conclusion reached is that the whole of South-East England is sinking at a rate of something more than one foot per century, and that, in addition, a definite subsidence is taking place in Central London. A possible cause of the latter is the removal of the subsoil water due to the fact that the whole area is covered with a "mackintosh" in which only a few holes exist. This point is illustrated by a number of interesting maps.

The paper contains a number of graphs of great interest, and an appendix describing a new precise method of transferring levels across water.

G.C.

GEODETIC TRIANGULATION.

BY CAPTAIN G. BOMFORD, R.E., Survey of India.

Published under the direction of Brigadier R. H. Thomas, D.S.O., Surveyor-General of India. Price 4s. 6d.

This is a new edition of the *Handbook of Professional Instruction* dealing with triangulation of precision, or geodetic triangulation, the horizontal framework on which the survey of a country is ultimately based. This class of triangulation has been undertaken in India for over one hundred years—it was begun by Lambton in the early years of the last century. There have, of course, been many changes since then and perhaps the most remarkable is in the design of the theodolite.

Lambton used an instrument the graduated arc of which was 36 ins. in diameter, then came the 24-in. followed by the 14-in. and 12-in. theodolites. Now we have, in this handbook, a full working description of the new Wild theodolite with a graduated horizontal arc of only about 5½ ins. in diameter, yet it is anticipated that this small instrument will give an accuracy at least equal to any of the larger theodolites. Should this prove to be the case the advantages of the small instrument are enormous, both from a transport point of view and for speed of working.

The construction of the Wild theodolite is a complete departure in design from previous instruments. The graduated circles are of glass and it is possible, with only a slight movement of the head from the observing position, to read both the horizontal and vertical arcs as well as the level. This is accomplished through an optical arrangement of a series of reflecting prisms which collect and bring the various

readings to a convenient position beside the eye-piece of the telescope. It will be readily understood that all these advantages cannot be achieved without considerable complication in the design, which means there are many parts that might get out of order, the derangement of any one of which would put the theodolite out of action. Unfortunately most of these, if not all, are " makers' adjustments " and cannot be carried out in the field. With that care, however, which should always be bestowed by the surveyor on his instruments, the chances of mishap ought to be reduced to a minimum.

Another innovation is the employment of portable trestle observing towers, reaching a height of 60 feet and weighing less than one ton, which can be erected in eight hours. Used in conjunction with these are signals carried on portable masts extending to 100 feet, or even 150 feet, in height. Both these devices have been designed by Dr. de Graaff Hunter, Director of the Geodetic Branch, Survey of India.

With regard to the effect on accuracy of these special measures for carrying triangulation across flat and wooded country it is remarked, " The triangular errors of triangles involving this trestle have never averaged less than one second and it seems unlikely that angles will ever be measured in India from high trestles with the best primary accuracy. Nevertheless, the triangulation can be accurately carried forward provided closer base and azimuth control is provided, and in flat country this will generally be easy."

Everything that the geodetic triangulator requires is found in this handbook, including the adjustment of instruments; the routine to be followed when observing and the special precautions which should be taken; the computation and the adjustment of errors, including the reduction of the quadrilateral by the method of least squares; and a great deal of every sort of information necessary to secure the greatest possible accuracy. Worked out examples of the forms employed in computation are also given.

This handbook should commend itself to every geodetic surveyor as it has behind it the cumulative experience of a great survey department.

H.L.C.

SURVEY OF INDIA, MAP PUBLICATION AND OFFICE WORK, 1930–1931.

Published under the orders of BRIGADIER R. H. THOMAS, D.S.O., Surveyor-General of India.

This report, so far as the general public is concerned, is important for it contains the index maps showing the progress of the publication of the modern series of maps, on various scales, which are the chief work of the Survey of India. The different series are as follows: the Southern Asia series, 1/2 million; India and adjacent countries 1/1 million; the *Carte Internationale du Monde*, also on a scale of 1/1 million, but the sheets embrace a different area and are prepared according to an agreed uniform international specification; ¼-inch series, or degree sheets covering one degree of latitude and one of longitude; finally, the ½-inch and 1-inch series which will eventually cover India in modern style. The exact state of publication of these maps to the date of the report is shown by index charts.

Over 900,000 maps were printed at Calcutta during the year, and taking all the publication offices into account over 1,174,000 were printed.

As regards the 1-inch sheets, in modern style—the standard maps of India—3,050 have been published out of a total of 6,218, or rather less than one-half.

Though the new series was begun after the report by the Survey Committee appointed by Lord Curzon in 1905, some 25 years have elapsed and only one-half of the programme then recommended has been accomplished.

It is evident that the maps published at the beginning of this era must now be considerably out of date, unless revision has been provided for.

H.L.C.

WELL-BORING FOR WATER, BRINE AND OIL.

By C. ISLER.

(Third Edition. Spon, London. Price 16s.)

The author is the head of a well-known firm who specialize in well-boring, both in England and in the Colonies. The book was recommended as being the best practical guide to well-boring, but it is unfortunately 11 years old, and many of the details are now out of date. It gives a detailed account of various systems of boring, and contains in addition two excellent chapters, one on "Geological Considerations" (the substance of which is now taught to R.E. officers at Cambridge) and the other on "Raising Water."

A brief chapter deals with dug wells. The author purposely dismisses this subject in a few pages; but although the dug well is admittedly a thing of the past in Europe, America and Australia, it has still to be reckoned with in India. There, in some cases, the lack of permanent and deep supplies of water may necessitate the use of perennial underground streams at depths between fifty and one hundred feet. In such cases, a dug well may sometimes be the most satisfactory solution to the problem. The employment of local labour on work which is thoroughly familiar to them has certain advantages over the use of British or American machinery, as the latter involves considerable expense in transport and freight and requires moderately skilled labour for its operation.

After dealing at some length with driven tube wells (*e.g.*, the Norton tube well), the author gives a detailed description of the following systems of percussive drilling:

(1) *The Kind Chaudron System.*
By this method large wells up to 14 feet in diameter can be bored by percussive. Average progress two feet per day.

(2) *Dru Deep-Boring System.*
A variation of the above suitable for bores between one foot and four feet in diameter.

(3) *Mather and Platt Deep-Boring System.*
Suitable for bores from six inches to 24 inches in diameter. This is a slow system which has been largely superseded by more modern methods.

(4) *American Rope-Boring System.*
This system is described in considerable detail. For military purposes, however, it is not so suitable as the keystone drill which, unaccountably, is not described in this book.

An excellent chapter is devoted to rotary methods of drilling. The diamond drill is described in great detail, and brief mention is made of the Calyx drill and also of a combination machine for both percussion and rotary drilling.

Some interesting figures are given in connection with various deep tube wells bored by Messrs. Isler & Co. The figures show the yields from various sizes of bores at various depths, and in some cases the improvement effected by blasting at the bottom of the bore.

Finally a description is given of the most modern method of rotary drilling, namely, the Calyx system, using hard chilled steel shot. This system is capable of drilling through the hardest rock, and by using a Davis cutter it may be adapted for drilling through soft strata as well. Bores of over 2,000 feet in depth have been successfully put down with this system. Its chief advantage over the percussive system is that the possibility of failure through accidental jamming or breakage of the tools in the bore is very much reduced. Through the softer rocks progress is, however, much slower.

The final chapter entitled "Raising Water" contains descriptions of the air-lift and of deep-bore pumps. Useful practical details of the air-lift system are illustrated

from an actual plant installed in London which was capable of raising 7,600 gallons of water per hour to a height of 120 feet, at a cost of 1½d. per thousand gallons.

For military purposes the air-lift has many advantages where it is required to raise water from bores of 80 feet or more in depth. The air-lift pipes can be easily improvised and rapidly connected to a portable compressor. All working parts are above ground, and one compressor can be used for working a number of air-lifts in turn. The whole plant can be easily and rapidly dismantled and set up at another site.

The book as a whole serves its purpose as a practical guide to the various systems of boring. Success in well-boring is largely a matter of experience, and the value of a book of this sort would be greatly increased were it to contain practical details of a number of bores carried out with each type of machine. The information which is normally required from such a book is the likely yield from bores of various sizes, the effect of increasing the depth, the probable rate of progress, the most suitable type of air-lift or pump, and the design of tube wells to meet variations in strata. It may be said that these problems are particular to each individual bore; but the number of successful tube wells now in existence is such that it should be possible to deduce from them general principles to guide the practical engineer.

The book is well illustrated with photographs and drawings, and clearly printed on good paper.

C.L.R.

HIGH-SPEED DIESEL ENGINES.

By A. W. Judge.

(Chapman & Hall. Price 10s. 6d.)

The high-speed diesel engine, after passing through a troublesome period of development, has at last proved itself a commercial success; it is already entering the field of road and rail traction as a formidable rival to the petrol engine. Besides the very light types which are being developed for purposes of aviation, there are also moderately heavy designs which may displace the large slow-speed machines at present used in small power stations and motor-ships.

Up to the present very little authoritative literature on the subject of these engines has been available, except in the form of papers read before various societies, and it is with pleasure that we welcome a textbook by Mr. Arthur W. Judge, whose works on the petrol engine are already familiar to many of us.

He starts by giving us a brief historical account of the development of the c.i. (compression ignition) engine, as it is now called; after this comes a chapter on the thermodynamic principles of the engine, which is followed by an explanation of the manner in which these principles affect the design and efficiency of the actual machine. So much for theory.

Now comes the matter which is of more general interest: a comparison of the c.i. engine with the petrol engine. Here it is brought home to us that the chief advantage of the c.i. engine over its rival is on the score of economy, and that, apart from using a much cheaper fuel, it consumes less of it for a given power output; these two effects combined result in a saving of about 80% on fuel costs. We are furthermore told that it has advantages of safety from fire risk, immunity from ignition troubles, and greater flexibility under conditions of varying speed.

Against this must be set the drawback of the increased weight, due to the higher pressures and stresses which call for heavier scantlings, and the consequent higher cost. To mitigate these difficulties it was essential to increase the speed as much as possible, and the chief obstacles to be surmounted were the production of a fuel pump that would inject the oil accurately and quickly into the cylinder at these high speeds, and the design of a combustion head that would give easy starting from cold and a clear exhaust on load, without producing the rough running known as "diesel knock."

The next chapter deals with the principles underlying the combustion process, a knowledge of which has been made available by the tireless researches of the Ricardo laboratories and the perfection of the Farnboro' high-speed indicator. The injection problem having been more or less solved for them by the advent on the market of the Bosch high-pressure fuel pump, a large number of makers, both English and Continental, began to produce high-speed c.i. engines, each designer trying to achieve the desired results by more or less empirical methods. This has resulted in the production of a bewildering chaos of widely different designs into which the author brings order by giving an account of about twenty selected types, systematically classifying them into groups and discussing their respective features in detail. This is perhaps the most useful section of the book, as it enables a potential purchaser to decide between the merits of the different types offered to him.

The chapter on pumps and sprayers which follows reassuringly informs us that, although many English firms still find it necessary to use the Bosch pump on their engines, there are now a number of successful British-made fuel pumps. The latest development in design, initiated by Ricardo, is the use of lower injection pressures, while ensuring admixture of spray and air by producing a high degree of turbulence or "swirl" in the compression spaces. The adoption of this plan will allow manufacturers of engines to make their own pumps, as the low-pressure types do not require such extreme precision in manufacture as those of the high-pressure variety.

After the two-stroke engine has been given a chapter to itself, the remainder of the book consists for the most part of descriptions of various engines now on the market. These are given under the separate chapter headings of "Automobile," "Aircraft," and "Stationary and Railway Type" engines, the last-named being of peculiar interest to the Sapper officer who has in his mind the construction of underground power stations for coast defence.

A short chapter on care and maintenance of high-speed c.i. engines deals largely with the maintenance of fuel pumps and sprayers, the Bosch pump, as the most common, being taken as an example. This points to the injection system as being the only likely source of trouble.

An account is given of fuel filters and fuels, and there are two appendices which deal with the experience so far obtained of the wearing qualities of these engines, and the experience of the L.G.O.C. in particular. It is interesting but disappointing to note that no great success has been met with in using fuels derived from coal, for which it would seem that special engines must be designed.

This is a very useful and interesting book and we can only hope that the author and publishers will see to it that it is periodically revised and brought up to date in later editions. Progress in the field of the compression ignition engine is so rapid just at present that the most up-to-date engine of to-day may be a back number in a few years' time.

W.M.B.

THE FUTURE OF INFANTRY.

By CAPTAIN B. H. LIDDELL HART.

(Faber and Faber, Limited. 2s. 6d. net.)

This little book is No. 1 of a series entitled *The Art of War*, which, the publishers state, forms a new experiment in military literature. The purpose of the experiment is to provide for the British soldier in convenient form the essence of the literature of his profession. It is intended that cheapness and portability should answer a general complaint that bulky tomes and high prices deter the wandering officer of modest means from purchasing present-day military books. Quality, however, will not be sacrificed to brevity, and the series is designed to provide information in a form that can be grasped as quickly as possible.

The book, or rather booklet, under review runs to 83 pages, is certainly compact, and will take up little room on the shelf or in the overcoat pocket. Future publications will deal with subjects that bear on preparation for future war, outline accounts of campaigns, short lives of famous commanders and abbreviated and condensed versions of the military classics.

In this first volume of the series Captain Liddell Hart gives expression to views on the future of infantry which he has already made public in lectures and publications. His theme is that, under modern conditions of war, the mass employment of infantry as an offensive arm is impracticable. He devotes the first part of his booklet to following up the lessons of history regarding the uses and misuses of infantry, and to proving that a light and mobile foot soldier has ever been essential for manœuvre tactics.

The illustrations provided by the success of Epaminondas, with his "oblique attack" tactics over the "drill sergeant" trained Spartans, is the first of several digs which the author has against the "archaic influence of parade drill." Has history revealed any policy superior to that of the Theban, developed by Philip of Macedon and Alexander the Great, with the phalanx as a stable yet mobile pivot, light infantry as the joint, and cavalry as the mobile arm? English archer against armoured knight, American revolutionist against British regular? The fire effect of Wellington's light infantry as compared to Napoleon's fire tactics with massed artillery, are these not instances which prove the necessity for mobility in infantry tactics?

The past has shown that the common foot soldier has tended to become a bulk soldier, and that under the influence of certain great commanders a class of picked foot soldiers has sprung out of these armed masses to play a vital part in war. That class is held to represent the real infantry tradition and embody the spirit which we should seek to revive. The Great War showed us how "bulk" infantry was incapable of making its own way forward in face of developed defensive fire, and that infantry movement was revived only by making men bullet-proof, the British way, or by stalking methods, the German way. The latter method, leading to the development of infiltration tactics, required picked men, light infantry.

When the author proceeds to offer his suggestions as to how to bring our infantry up to date to fulfil its future fundamental role, he straightway makes a distinction between heavy, or common, and light infantry. Heavy, or common, infantry is considered to be fit for defence only and will have its value in protective duties. The statement that "we know that we can train ordinary infantry in less than six months," and the implication that much of our present drill system and technical and tactical instruction go beyond the needs of the ordinary infantryman, are likely to raise protests from those who would wish to be assured that any type of modern foot soldier is deserving of the title "common" or "ordinary."

The author proceeds then to regain the goodwill of the infantry business by the further argument that in peace time the Regular Army should not include any regiments of mere garrison infantry. As every infantryman knows, his share in the administration of a military community is not one of the least of his functions. The common infantry is to be formed in and trained for conditions of emergency.

The problem of the light (Regular!) infantry is examined by Captain Liddell Hart under the categories of arms, equipment, mobility organization, tactics and training, and his arguments and conclusions are fully worthy of close study and consideration. He sets out to show that the infantry soldier of the future must embody the attributes of the stalker, the athlete and the marksman, and must be in every sense a field-craftsman. He may not be convincing to all readers, but he is certainly interesting. The problem which the proposed organization of an infantry battalion puts to the engineer-tactician is one which perhaps this new series will solve in the next booklet.

H.J.D.C.

MAGAZINES.

REVUE DU GENIE MILITAIRE.

(*September*, 1932.)—1. *L'emploi d'un groupe de sapeurs de chemins de fer.* General de Lastours continues his series of articles under this head, and gives a number of instances of railway works carried out by sappers during the war.

2. *Note sur les projecteurs de campagne.* This is the first of two articles by Captain de Solère on field searchlights: the result of his personal experience during the war. The French army carried two kinds of searchlight: a smaller model with oxy-acetylene light, and larger models with electric arc light. Some of the latter were horse-drawn and some mounted on motor-cars.

The best way to work the projector is by having, alternately, flashes of light and periods of darkness; the ray should never be allowed to continue longer than is necessary to show up a particular object. Changes of direction or height of ray should be made in the periods of darkness. With a good observer, a period of light of six to ten seconds should suffice. Constant changes of observing stations are very necessary, and it is a good thing to have projectors working in pairs, some distance apart, but under control of the same observer.

3. *Etude pratique concernant la protection de la population civile contre les gaz toxiques.* Dr. Parisot and Captain Beautemps here conclude their article on this subject.

4. *La ventilation et le rafraichissement des locaux habités dans les pays chauds.* This is an extract from a civil engineering magazine by M. Beaurienne and deals mainly with the theory of cooling buildings in hot climates.

(*October*, 1932.)—1. *L'emploi d'un groupe de compagnies de sapeurs de chemins de fer.* In this article General de Lastours deals with repairs to breaches in railways. He compares the methods adopted, respectively, by the Germans, the French, and the British.

The Germans used light, portable material; they carried out repairs more quickly than the French, but their work was rougher and the factor of safety much smaller.

The French work was more thorough, stronger, and more permanent than that of the Germans.

The British had no military railway material at the beginning of the war, but, after noting the work done by the French sappers, they organized special railway units with machinery on a colossal scale. Their huge pile-drivers had a much larger radius of action than the French ones and could drive much longer piles. This led to the use of very long piles, which resulted in instability and excessive oscillation.

The writer is clearly in favour of the system adopted in his own country.

2. *The Royal Corps of Signals.* Colonel Coussillan gives an account of the formation, organization and work of the Royal Corps of Signals. He gracefully acknowledges the courtesy with which he was received in England, where he was given opportunities of seeing what is being done at Catterick and elsewhere.

3. *Note sur les projecteurs de campagne.* Captain de Solère concludes his article on field searchlights.

(*November*, 1932.)—1. *Les travaux d'irrigation du Niger.* Colonel Doizelet gives us the first of a series of articles on the irrigation works on the Niger River. After some remarks on the climate and rainfall, he goes on to describe the valley of the middle Niger, where the French have carried out extensive irrigation works. One

of the first schemes to find favour was the Sotuba canal, an experimental canal, taking off at a point in the Niger that formed a kind of natural rocky barrage. The canal is 21 km. long from the head-works down to the first distributary. The discharge is ten cubic metres per second, and the water is deep enough for navigation. Details are given of its construction, maintenance and cost.

2. *Tarification de l'énergie électrique*, by Captain Leygue.

3. *La tuyauterie souple d'aérage dans les travaux de mine*, by M. A. Lami, mining engineer.

The extensive use of mining during the war has shown the importance of ventilating tunnels satisfactorily. The usual method adopted has been the use of metal sheet tubing, through which air is forced at high pressure by means of a fan. Ventilation can be carried out either by blowing or exhausting. For work under war conditions the writer is distinctly in favour of the blowing system.

M. Lami strongly advocates the use of pliable tubes known as "Ventube." They are made of cotton tissue specially treated to give additional strength and resistance to heat, damp, mould, acid or alkaline water, and gases. The tubing is manufactured in varying lengths and diameters. The jointing is extremely simple. The tubing weighs from a twentieth to a thirtieth of metal tubing of the same diameter.

A.S.H.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(*October*, 1932.)—1. *La bataille de l'Yser*, by Colonel Duvivier. An account of the operations in Flanders commencing on the 9th October and terminating on the 30th October, 1914.

2. *La campagne des dix-jours.* Lieut.-Colonel Baron Verhaegen contributes another chapter to his series of articles on the ten-day campaign of 1831 between the Dutch and the Belgians. In this chapter he deals with the secondary operations.

3. *La préparation d'artillerie dans l'attaque.* Major Sottiaux discusses the official regulations on artillery preparation.

4. *Fonctionnement et fractionnement des C.T.*, by Colonel Robyns.

(*November*, 1932.)—1. *Pages d'histoire de l'armée belge au cours de la guerre* 1914–18. Major Gerard and Lieut-Colonel Keymeulen give accounts of the operations of the cyclist detachments of the 3rd and 5th divisions respectively.

2. *Vers l'armée de demain.* This article is a review by Lieut.-Colonel Van Overstraeten of Captain Liddell Hart's book, *The British Way in Warfare.* The writer holds a very high opinion of Captain Hart's views, and he advises all to read his book.

The war has proved the futility of the policy of extermination, the powerlessness of the infantry soldier in the face of machine-gun fire, the vulnerability of masses of troops by aircraft, and the general paralysis engendered by heavy artillery fire. And yet modern states still continue to maintain large armies, loaded like beasts of burden and encumbered with masses of horse-drawn transport.

In the present state of affairs aviation is the only branch in keeping with modern ideas.

Great Britain and France are well ahead of other countries in bringing their armies up to date. The main difference between French and British tanks is that the former are heavily armoured, while the latter have less protection and greater mobility.

The writer asks what will become of the infantry in the mechanized army. It will still have its place, but in reduced numbers, and will do its work in country unsuited to tanks. It will, however, be lightly equipped, and will be carried in armoured lorries. The field gun, in its present form, has had its day: the field gun of the future will be mounted on a tank.

The principle of the nation in arms has brought the world to bankruptcy. Now

the tank will abolish the meaning of numbers, and wars of masses will be at an end. A mechanized army will reduce the horrors of war: there will be a clear distinction between civil population and the fighting element. That will prove a better obstacle to aerial bombardment than any convention. Gas warfare, too, will be useless against such mobile weapons.

The writer concludes with a few remarks as to the effect a mechanized army will have on Belgian strategy.

3. *De l'organisation des marches*, by Lieut. Thonnard. An article on the graphic method of organizing marches.

4. *La géologie appliquée à l'art militaire.* Major Stevens, Professor of Geology at the Ecole Militaire, deals with the importance of the study of geology in warfare.

5. *Le régiment léger de C.A. dans la marche vers l'ennemi.*

(*December*, 1932.)—1. *A propos du combat retardateur.* Lieut.-Colonel Bouha has written an article on "retarding combat," in which he compares the German regulations on *hinhaltendes Gefecht* with the Belgian treatises on similar subjects. There is no exact French equivalent to the German expression, which means fighting that keeps at a distance.

The main object of this form of fighting is to make the enemy waste his time, without compromising the small force at one's own disposal. The general principle to be followed consists of an alternation of stubborn resistances and quick retirements. The duties of the various arms are given briefly. As regards retirement, if it has been possible to hold out until nightfall, the actual retirement should hold out no difficulties, the action being that of a rearguard.

Occasion may sometimes arise for offensive action, but it must be suitably timed.

In a further article under this head Captain Wanty works out a concrete scheme, in which the general idea is that a force, consisting of two infantry divisions and one cavalry division, is required to delay an invading army from the east for at least four days.

2. *La campagne des dix-jours.* A final article by Lieut.-Colonel Baron Verhaegen on the 1831 campaign. Here he deals with the action of the fleet, and draws his conclusions regarding the execution of the campaign.

3. *L'observation terrestre à l'A.fC.A.*, by Lieut.-Colonel Nonnon.

4. *Manœuvres de défense passive contre l'agression aérienne du Pas-de-Calais*, by Captain Calberg.

5. *La sûreté en marche.*

A.S.H.

REVUE MILITAIRE SUISSE.

(*September*, 1932.)—1. *Réorganisation des troupes du génie.* Colonel Lecomte works out, on the lines selected by Major Montmollin for the Artillery, a scheme of reorganization for the Engineers, based on Colonel Petitpierre's project.

2. *Le service de renseignements dans les corps de troupes d'infanterie*, by Lieut.-Colonel Dubois. This is the fifth and concluding article of a series on the subject of intelligence.

3. *Emploi de l'aviation en temps de guerre*, by Major Ackermann. In this concluding article on the employment of the Swiss air force in war-time, the writer deals with the probable position of Switzerland. Should the country ever be involved in war, the probability is that it will be a war in which several of the powers are implicated, and the air force should be organized on those principles.

(*October*, 1932.)—1. *Les batailles de Caporetto et du Dubropolie.* Colonel Verrey here begins a series of articles on the battle of Caporetto. The battle of Dubropolis, in which Bulgaria was finally defeated, is described later on.

The position occupied in September, 1917, by the second Italian army, which was subjected to the main Austrian assault, is given in detail. This army, commanded by General Capello, was holding a line along the Isonzo from Mt. Rombon on the north

to the Vipacco River on the south. On its right, on the Carso, and extending to the sea, was the 3rd Army under the Duke of Aosta. On its left were the troops of the Carnic zone, and beyond them the 4th Army. The distribution of the corps of the 2nd Army, and the four lines they occupied, are described in detail, with the help of two sketch maps.

At the end of the summer of 1917, after the eleventh battle of the Isonzo and the capture of the Bainsizza plateau, Austria's morale had sunk to a low ebb. The higher command felt that if Italy achieved a further success, all would be up with the Austrian country and people. An appeal was therefore made to Germany for assistance to help to gain a victory that would relieve the Italian pressure and restore Austrian prestige.

The upper Isonzo formed a hinge in the Italian line, from which one branch ran approximately from east to west, and the other from north to south. The Central Powers realized that if they could pierce through at this point, and secure Udine and the Tagliamento, they would not only cut off the retreat of the Bainsizza and Carso armies, but would also threaten the troops in the Carnic Alps, who would be taken in front and rear. The further they could advance beyond the Tagliamento the more decisive would the victory be, and, if they reached the Adige, Italy would be decisively crushed.

The Austro-German army entrusted with the penetration of the Italian army was the 14th, under von Below. Its distribution early in September is described. In six weeks it had to move to its new positions opposite the 2nd Italian army, ready for the great break-through on the 24th October. All movements were carried out by night, and guns and personnel were kept concealed as far as possible by day. Various subterfuges were adopted to deceive the Italians as to the intended point of attack.

The first chapter ends with the tasks assigned to the various units in the attack.

2. *Le réarmement de notre artillerie*, by Lieut.-Colonel Anderegg.

3. *L'armée de mitrailleuses et la suppression de l'artillerie*, by Colonel Gertsch.

4. *L'aviation. Arme unique*, by General Rouquerol.

(*November*, 1932.)—1. *Le service des étapes de l'armée suisse*, by Colonel Eberle.

2. *Les batailles de Caporetto et du Dubropolie*. Colonel Verrey continues his study of the battle of Caporetto.

General Cadorna's staff gradually learned, through deserters and others, of the impending Austrian attack. But the Austrian preparations were so well concealed that the Italians could discern no signs of preparation for an attack. Cadorna counted on the 2nd Italian army, with 2,430 guns of all calibres, 1,134 trench mortars, and 353 battalions, being able to hold out for three days. This would enable him to ascertain where the enemy intended to strike the main blow, as the attack on the Plezzo–Tolmein front might only be a feint. The Italian commanders were full of confidence and optimistic as to the result.

On the 24th October the blow fell. It was raining, and the mountains were covered with mist. At 2 a.m. a gas attack was launched along the whole front. One after the other the Italian batteries were obliged to cease fire. At 6.30 a.m. the Austrians opened fire with ordinary projectiles. This bombardment had little effect on the mountain positions, but the results in the plains were terrific. The Italians were new to gas warfare, their gas-masks were inefficient, and consequently the troops were seized with panic.

The writer goes on to describe the progress made by the four Austrian groups.

The Krauss group—to the north—captured the first and second Italian lines, but was then held up by fresh Italian troops and by a fall of snow. They captured a large number of guns.

The Stein group directed its attack on Caporetto and the mountains north and south of it. The projected Italian barrage never materialized, and the mist favoured the attack. The front line was easily captured, but the second line offered a stout resistance.

The Berrer group had, similarly, no difficulty in capturing the front line. There was heavy fighting on the second line, but the Austrians were eventually able to turn it.

The Scotti group, on the left, gained a large area of ground, secured an enormous booty of prisoners and material and cut off the retreat of the troops on the left bank of the Isonzo, while suffering very few casualties. It inflicted a moral disaster that affected the whole Italian army.

The 25th October was spent by the Austrians in consolidating their gains.

On the 26th the avalanche began rolling. Cividale was reached on the 27th, and Udine on the 28th. The Austrian advance was delayed by swollen streams, but the Italians suffered still more severely from floods as the bridges over the Tagliamento, which they were about to cross, had been washed away.

Between the 24th and 31st October the Italian losses are said to have been 10,000 killed, 30,000 wounded, 300,000 prisoners, 400,000 fugitives. In material they lost 3,152 guns, 1,732 mine-throwers and 3,000 machine-guns.

The Italians finally made their stand on the Piave, and this position transformed the mentality of the army and the nation, as Hannibal's arrival before the gates of Rome had done many centuries before.

3. *Le réarmement de notre artillerie.* Lieut.-Colonel Anderegg recommends the adoption of a 75-mm. gun and a 12-cm. howitzer for divisional artillery, of a 105-mm. gun for long-range fire, and of a 75-mm. gun for anti-aircraft work.

(*December*, 1932.)—1. *Quelques réflexions sur nos méthodes d'instruction*, by Col.-Commdt. Sarasin.

2. *Les leçons de Caporetto.* Colonel Verrey who, in the November number, gave an account of the battle of Caporetto, here deduces the lessons to be learnt from the battle. He gives them in the following order:—(1) political causes, (2) pre-war military causes, (3) psychological causes, (4) mistakes in orders, (5) mischances, (6) mistakes of higher commanders, (7) mistakes in the supreme command.

(1) The morale of the Italian army had been sapped by pacifists, by revolutionary anti-militarists and by enemy propaganda.

(2) Prior to 1860–70 many of the provinces of Italy were under foreign control, and some had foreign armies. There was no military tradition, such as Signor Mussolini is now trying to create.

(3) General Cadorna and others tried, from a high sense of duty, to enforce severe discipline in too short a time.

(4) The Austro-German army showed itself superior to the Italian in many ways. The small number of killed and wounded in Below's army is remarkable. The collaboration between artillery and infantry was excellent, the attackers made good use of the ground, their fire was accurate, they showed skill in manœuvre, their patrols did first-rate work. With the Italians it was different, although some of their counter-attacks were made with energy.

(5) The Italian army was certainly unlucky. The wet and misty weather hampered their observation when the attack was launched, and the spate that came down the Tagliamento could not have occurred at a more inopportune moment. But perhaps the greatest misfortune was the illness of General Capello, the 2nd Army commander.

(6) In consequence of General Capello's illness, his three corps commanders did not organize a system of defence on the lines intended by General Cadorna.

(7) As regards the supreme command, General Cadorna was a great leader: an excellent organizer; energetic, clear, cool and decided. In defeat he showed himself splendid. But he has been blamed for not realizing the danger sooner, for not seeing that his orders were being carried out (knowing, as he did, that General Capello was ill), and for throwing his reserves into the fight without artillery or machine-gun support.

3. *Le réarmement de notre artillerie.* Lieut.-Colonel Anderegg here continues his series of articles on artillery reorganization and details the conclusions to which he has come.

A.S.H.

RIVISTA DI ARTIGLERIA E GENIO.

(*September–October*, 1932.)—1. *L'evoluzione dell' impiego dell' artigleria durante e dopo la guerra mondiale*, by S.R. The writer quotes from an article by Major Meyer in the American review, *The Field Artillery Journal*.

From the outset of the Great War the Germans made use of heavy guns and masses of field artillery to dominate guns of small calibre and carry their fire right up to the adversary's reserves. The French 75's, although capable of firing up to 10,000 metres, were mounted and sighted to a maximum range of 6,500 metres. Under pressure from the enemy, the French found themselves obliged to revise their ideas.

Under modern conditions the object for divisional artillery to attain is a range of 12 to 14 km., and it should be capable of firing at both ground and air targets, as well as moving targets, such as tanks. The importance of counter-battery work was brought home to the French in 1914, and from that time it has been considered as indispensable.

We get an interesting aspect of the duties of artillery in the lengthy preparations for an attack made in the earlier part of the war, *e.g.*, six days in the Artois offensive of May, 1915. The time was gradually shortened until, in the British offensive at Cambrai, in November, 1917, and in the Franco-American offensive at Soissons, in July, 1918, there was no artillery preparation at all. During the offensives of 1918 success depended very largely upon the realization of surprise.

The writer dwells upon the importance of co-operation between artillery and infantry. With mechanization the mobility of artillery has greatly increased, and future wars are likely to see the massing of artillery carried out to the utmost limits of time, space and ammunition supply. It is consequently necessary to provide a very large general reserve of artillery.

2. *Gli effetti di penetrazione e di scoppio dei projettili e delle bombe lanciate dagli aerei*. By G. Stellingwerff. This is a plea for an elaborate series of experiments to test the penetration of aerial bombs. Whereas formerly only the coast or the land frontier required to be prepared for defence, every portion of a country is, nowadays, open to aerial attack.

There have been considerable improvements made in recent years, both in explosives and in the strength of concrete, and our knowledge of the capacity of concrete to resist penetration is, more or less, theoretical. The writer takes the formulæ ordinarily in use for the penetration of artillery projectiles, and shows how difficult it is to deduce the penetration of aerial bombs. In order to obtain a striking velocity of 300 metres per second, it is necessary to drop a bomb from a height exceeding 4,000 metres. The difficulty of hitting a small target from such a height is obvious.

3. *A proposito del tiro d'artigleria in prossimità di truppe amiche*. By Lieut. Pico. A technical article on gunnery.

4. *Le grandi esercitazioni militari del* 1932. A brief article on the manœuvres carried out in Italy (in Umbria), in the east of France, in Germany (on the Oder), and in England.

In all countries trials have been made, under conditions resembling those of actual warfare, of new mechanical devices and new formations.

A campaign on the land frontiers of Italy necessarily means mountain warfare. With this object in view, the Italians have specialized in a small armoured car capable of turning sharp bends, with four-wheel drive and an overall width of 1·30 metres. The mule is still considered essential for mountain artillery, and no suitable substitute is likely to be found. The *dovunque* car, which corresponds to the French *tous terrains*, though extremely efficient, is not likely to oust the Bersaglieri cycle regiments.

In the French mountain manœuvres difficulty was found in maintaining proper liaison over broken ground between artillery and infantry.

From the French manœuvres in the plains the writer comes to the conclusion that (1) the mechanized division, especially the cavalry division, has not taken its final shape, (2) a normal infantry division, if equipped with modern armament, still retains its offensive-defensive capacity, even when opposed to large mechanized formations, (3) it is absolutely essential for columns on the march or troops in action to conceal themselves from aerial observation, (4) the consumption of ammunition under modern conditions is enormous, and its supply to the firing line has become a very serious problem.

The Germans are handicapped by their treaty obligations, but a line of development that they are following is the provision of motor-cycles with side-cars, carrying three men. They are also providing motor-cycles with small guns for employment against armoured cars.

5. *Striscia longitudinale e pendenza del terreno.* By Captains Cavicchioli and Morricone.

6. *Il vento contro gli edifici.* By Brig.-General Cianetti.

(*November*, 1932.)—1. *Criteri d'impiego dell' artigleria con la divisione celere.* By Brig.-General Trezzani.

2. *Il calcolo del vento balistico.* By Lieut. Prato.

3. *La XXI riunione degli scienzati italiani a Roma.* This is an account of some of the papers read before the Italian Scientific Society in October, that are of military interest.

General Pricolo read a paper on the " Defence of a Large Urban Centre against Aerial Attack."

The greatest danger for a large city is not the explosive effect of bombs, so much as the conflagrations that may be started by incendiary bombs. A very much larger weight of bombs can be dropped from aeroplanes than was possible during the Great War. The Austrians dropped a total of 270 tons of bombs on Italian towns: this amount could now be dropped on a single town in one night. Apart from anti-aircraft defence, the writer considers that preparations should be made against aerial attack in a number of different ways.

General Tellera made certain observations on General Pricolo's paper. He said that, in spite of international prohibition, the possibility must always be taken into account of an aerial attack on an undefended city. But he thought that a prolonged bombardment of such an intensity as to cause a moral effect throughout a whole country, would require an expenditure of material beyond the capacity of the wealthiest nation. The counter to the bombing plane is the " fighter," and the modern fighting plane is so fast and well armed that it can deal not only with the day bomber, but with the night bomber as well. A " fighter " costs about the third of the price of a " bomber," and it is, therefore, the weapon best suited to a country poor in material wealth but rich in intrepid airmen. Even a rich country could not afford to concentrate on bombers at the expense of other costly weapons.

As regards anti-aircraft defence, the efficacy of anti-aircraft guns during the war was anything but negligible. Since the war these guns have been brought to such a state of perfection that the bombardment of a defended locality is almost impossible by day and dangerous to the attackers at night.

4. *Attività della specialità pontieri.* Colonel Scarsella, of the Engineers, begins this article with a brief history of the specialized art of military bridging, and goes on to deal with the materials used at various times in bridges. He divides floating bridges into two types, a light type that may have to be constructed rapidly under fire, and a heavy type that can be put together at a safe distance from the enemy. The Italian pontooning equipment is now in a state of transition, and a type of bridge is being designed capable of carrying 20-ton loads.

The various methods of putting a floating bridge together are dealt with. In warfare it is important to have as few men as possible on the bridge at a time. One

method of reducing the strength of working squads is by the use of a rubber-tyred hand-cart, handled by five men, and capable of carrying loads of bridging material up to one ton in weight.

For rapid work the writer considers the method of construction by rafts as the best. He mentions an instance that occurred in August, 1917, when a bridge was begun from a dead angle on the enemy bank, and the remaining gap on the near shore was completed as a surprise manœuvre.

Constructing a bridge by swinging is almost impossible with the short spans of modern heavy bridges, but may have to be carried out in an emergency. The length of the bridge and the velocity of the current are the deciding factors, a velocity of two metres per second being the limit, beyond which swinging is impossible.

For dismantling a bridge, an operation that may have to be carried out hurriedly under pressure from the enemy, the " swinging " method is the best, and has the advantage of exposing a minimum number of men.

In future wars practically all bridging will have to be done by night. German authorities maintain that if a bridge is built by day, its position will have to be changed at night, under penalty of destruction.

The writer deals with flying bridges—which may be worked in pairs in the case of wide rivers—and rafts, and with various bridging expedients and extemporised bridges. He advocates the use of detachable motors in boats for speeding up work and saving labour. The article ends with a description of some bridging work carried out in peace and in war.

(*December*, 1932.)—1. *Il servizio aereo d'artigleria.* A prize essay by Major Liuzzi.

2. *Baricentri e pesi degli affusti moderni.* By General Mattei.

3. *Lo stato attuale della tecnica delle onde ultracorte e loro possibilità d'impiego nelle radiocommunicazioni militari.* By Major Gatta.

4. *Aggiustamento in alzo in base al senso delle deviazioni esaminato col calcolo delle probabilità.* By Captain Cavicchioli.

5. *L'esplosione delle mine a distanza senza l'impiego di fili.* By Major Poli. In this article the writer draws attention to the drawbacks inherent in the usual system of firing mines, whether by ordinary fuze and detonator or by electricity. With ordinary fuze, the length is limited to a hundred yards or so, and the fuze is liable to perish or be damaged. Misfires are fairly common. Electrical detonation depends upon the reliable working of an exploder and other conditions and is limited to a range of about a kilometre

Major Poli gives an outline of a method of firing mines by a wireless system. He utilizes a portable field transmitting set at the firing point A. At a point B, at a distance of several miles from A, but as close to the mine as it can be placed with safety, is a receiving set, taking up the waves transmitted by A, and controlling a relay by means of an amplifier. This relay is made to close an electric circuit furnished by a dry battery. The closing of the circuit fires the mine.

This is the general idea. In actual practice it is rather more complicated. To prevent the accidental firing of the mine by a transmitting set of the same wavelength as A, the first relay works a thermal relay which has a delay action of 20 seconds. The mine cannot be fired unless the transmitter furnishes a continuous impulse lasting 20 seconds.

The standard field transmission set in use in the Italian Army, with an output of 10 watts, can ensure the firing of a mine at a distance of 10 km.

The writer concludes with a list of the drawbacks of his proposed system and goes on to suggest how they can be minimized.

6. *Sull' impiego dell' artigleria nell' avanguardia.*

A.S.H.

REVUE MILITAIRE FRANÇAISE.

(*October*, 1932.)—In the second instalment of *Le but des opérations de guerre*, Général Brossé discusses the German higher command from 1915 onwards. His view is that throughout this period the German strategy never stretched out enough. As a result enormous areas were conquered, in Russia, Serbia, Rumania and Italy, but in none of these was the German offensive continued once the country came under the German power. As a result, although fresh territory was available from which food was available or petrol could be found, Russia was not finally " knocked out " of the war till 1917. Général Brossé then considers first Verdun and finally the tremendous onslaught of 1918. Verdun was undoubtedly a mistake from the start, the Germans wore themselves out just as much as the French; the whole operation had tactical rather than strategical objectives. In 1918, however, one cannot help feeling that Général Brossé is rather too hard on the German higher command. It is true that they failed to maintain the objective of separating the British and French and driving the British into the sea, but the reason may be that there were not enough German troops available rather than that the German higher command failed to realize the success which so nearly crowned their efforts. The article is, however, very interesting in the method in which Général Brossé regards the situation during this period.

Colonel Bailly begins *Giberne de Sapeur* in this number. The work of the sapper is divided into four categories: communications, destruction, mechanization and fortification. The greater part of this instalment deals with communications, chiefly railways, and their destruction at different stages of the war. Colonel Bailly explains in an interesting way how often bridges were left intact for the enemy, how destructions were not carried out really effectively, especially by the French and Belgians in 1914, and eventually how lack of communications would have brought the Allies to a halt in 1918 if the Germans had not thrown up the sponge. All soldiers probably realize how difficult it is to detail the right man to destroy a bridge on a railway and how frequently this was not done. It was, of course, easier for the Germans to destroy a hostile country on retirement than for the Allies to do the same to a friendly one. The writer concludes the section on communications and their destruction by pointing out that they will in future be more important than ever.

The fifth instalment of Chef d'escadron Dupuy's *La lutte pour l'Hartmannswillerkopf* deals entirely with the French artillery, the types of guns, their position and the rounds fired. The description is far too detailed to be of interest unless the reader is studying the special artillery problem in this sector. One is apt to feel that a tremendous amount of work was put into an attack on this part of the front, which was really secondary compared with the country further west.

Lieut.-Colonel Guigues deals with the surrender at Metz and the preliminary negotiations with the Germans in the seventh instalment of *Le gouvernement de la défense nationale*. Although the article as a whole deals with the government rather than the action of the various soldiers, the writer shows how Marshal Bazaine failed utterly in his surrender. When the troops at Metz had no more food, their commander might have made an effort to cut his way out; instead he meekly surrendered. This disaster had a great effect on France generally and it induced M. Jules Favre and M. Thiers to attempt to arrive at an armistice with the Germans. The difficulty was the lack of a really representative government in France. The instalment closes with efforts to induce the other powers of Europe to look at France with a friendly eye and finally describes the armistice signed after Thiers had interviewed Bismarck at Versailles.

Général de Fonclare continues *Le Maréchal de Monluc* in this number. His description of the Marshal, who was appointed by Louis XIV as Governor of Sienna, is really amusing. Although de Monluc was ill, he arrived at Sienna very soon after he was appointed there and held it for a considerable time against the Imperial

troops. When eventually he was forced to surrender owing to no more food being available, his own account of the deference paid to him is entertaining. On returning to Paris the King received him (again according to himself) like a long-lost brother. There is no space here to give any details of this "defensive action," as the instalment is headed, but it is well worth reading.

(*November*, 1932.)—Général Brossé finishes *Le but des opérations de la guerre* in this number. After pointing out how Foch never lost sight of his strategic objective, to seize the important communications in Flanders and Luxembourg, throughout the allied offensive of 1918, the writer then casts his eye finally over the German actions during the war. Although General Brossé's principle, that the Germans failed by their highest strategy being always insufficiently grand, is probably correct, one cannot help feeling that the complete fall of Russia is a little hard to justify. He does, however, say that he thinks that Russia would have lasted a still shorter time if the German attack had been pushed "*à bout*," and this is possible though no one can be certain. General Brossé then points out that the capture of territory, especially where there are mines, petrol, wheat, etc., is of great importance, so long as it is kept subordinate to the military necessities of the situation. He closes by stating that the French strategical view was borne out by the successful events of the end of the war.

La manœuvre d'aile, by Colonel Loizeau, begins with a description of Cannes and Leuthen, two of the greatest successes from the flank by two of the greatest commanders. The descriptions of these two battles are interesting and devoid of too much detail. Both Hannibal and Frederick had far fewer troops than their opponents, and both achieved great successes. This particularly applies to Hannibal, where he crushed both wings of the Romans. Colonel Loizeau makes it quite clear that the commander must have great energy to bring off a success by the wing, rather than by the centre, and this energy was a feature of both the above commanders.

In completing *Giberne de Sapeur*, Colonel Bailly has a long and very interesting article on the work that will be required from the sapper in future. After considering how the sapper will be employed in fortification, he then goes on to what he will have to do, both destruction and construction, as a result of mechanization. A few sappers, with a ton of explosives, sent over by aeroplane, will be able to destroy many of the enemy's bridges, etc., unless they are better guarded than in the last war. Then the movement of troops with motor instead of horse transport will be harder than ever and more work will be required from the sapper. In fact, the command and staff will have to consider communications and their destruction and construction more than ever. This whole article is of great interest to anyone who wishes to consider what will happen in the next war.

Le Gouvernement de la Défense Nationale, by Lieut.-Colonel Guigues, is completed in this number. To a foreigner this instalment is the most interesting of all as it deals with Alsace and Lorraine being handed over to the Germans and the discussions which took place between Bismarck and Thiers beforehand. To us it is impossible to conceive what it means to have another country's troops billeted on us and to have part of our own country torn away. There is, therefore, bound to be far greater animosity liable to blaze up between France and Germany than between ourselves and any other nation. For this reason it is good for us to read an article like this which really exposes what the French feel under conditions of this kind.

Chef d'escadron Dupuy finishes *La lutte pour l'Hartmannswillerkopf* with a description of the terrible casualties caused on both sides by the fighting for this hill in the Vosges. Attacks had gone backwards and forwards right through the war and at the end the Germans had turned their side into a real fortress. The German historian, in fact, says that their casualties were 60,000; although this seems exaggerated it gives an idea of the type of fighting. The whole article, however, is given in too great detail to interest anyone who does not know the country.

The final instalment of *Le Maréchal de Monluc*, by Général de Fonclare, gives the Marshal's opinions on every kind of war chiefly in his own words. There is no space here to reproduce them but they are both amusing and interesting. The Marshal had a very good idea of how the King of the seventeenth century regarded his commanders if they failed him, and he also realized what the soldier thought of his officers if they were given up to " wine, women and song," rather than to soldiering.

(*December*, 1932.)—Général Loizeau continues *La manœuvre d'aile* by describing how Napoleon and the elder Moltke used this manœuvre. Most of Napoleon's battles were designed for this type of operation, and it is quite clear from the writer's description that both a vigorous chief and an army that can manœuvre are required. What he does not point out is that a number of the armies, to whom Napoleon was opposed, had no idea of any operation of this kind and it therefore made it all the easier for him to out-flank them. There was no sign of an out-flanking movement at Waterloo. In the Franco-German War the efforts of Moltke are regarded as far below those of Napoleon, but one must remember that here the forces were far greater, information was correspondingly more vague, and a successful out-flanking movement was correspondingly more difficult. General Loizeau finishes the instalment by describing the battle of Sadowa, in 1866, where the German armies came together on the field of battle and crushed the Austrians.

Général Lugand has an article called *Organisation du territoire en vue de la mobilisation nationale*. This really deals with France and Germany, although Great Britain, Belgium, Italy and Russia are also mentioned. The writer gives very clear maps showing communications and divisions of the country, from which the rivers, railways and also industrial areas can be seen to run in quite a different way in Germany from those of France. One of France's drawbacks has always been the industrial area of the north-east, quite apart from Paris lying comparatively close to the frontier. If there is another war between these countries, however, the air will form a fresh form of attack and no one really knows at present how successful it will be. Here again the French lie more open than do the Germans, unless they have a considerably greater air force at the outset of the war. One can only hope that only preparation and not the war itself will occur, anyway in our lifetime.

Général Camon begins *Le système de bataille du Prince du Condé* in this number. When studying the campaigns of Napoleon the writer gradually came to the conclusion that some of Napoleon's battles were founded on those of Condé, and so he then studied him as well. Condé commanded the French armies at the end of the reign of Louis XIII and during the reign of Louis XIV, and his chief battles were Rocroi, Fribourg, Nordlingen and Lens. Condé's system was to break the enemy's line with his cavalry and then attack them from the flank or rear with his infantry and it can be seen that Napoleon used this principle in many of his great battles. In this number General Camon describes the battle of Rocroi, where, in spite of a considerable check on the left during the battle, Condé achieved a most brilliant success, and the beginning of the battle of Fribourg.

Commandant Delbe begins *Les bibliothèques d'officiers* in this number. It was not till after 1870 that the French began to realize properly that it is not enough for officers to carry out their ordinary work, they must read history as well. Although this idea was started in 1770 and a certain amount more was done during the Revolution, it was not till after the Franco-German War that M. Thiers spoke of how the French nation depended on the French army and how more must be spent to allow the officers to carry on with " self-education " apart from their normal training. As a result libraries were started in the various military centres and by 1914 the French officer knew a great deal, not a smattering, about the military history both of France and of other nations.

In *La guerre sainte des Senoussya*, Général Meynier begins a part of French military history important but little known to foreigners. The first instalment deals with the earlier portion showing how France found it necessary to reach further and further

forward across the Sahara during the latter half of the last and the beginning of the present century. It was after the Turks had their navy destroyed at Navarino that their influence decreased and that of the Western European nations developed. On the whole, the French found that their policy met with favour among the many tribes in Northern Africa, but the Touareg and Senussi were always hostile and gave continual trouble. The article gives considerable detail and mentions names familiar during the Great War, and is of considerable interest to anyone wishing to read about this part of the world.

H.A.J.P.

WEHR UND WAFFEN.

(*October*, 1932.)—*The Differentio-Integraph.* Dr. von Harbou has invented a mechanical differentiator and integrator, of which he published a full description in the *Journal of Applied Mathematics and Mechanics*, 1930, pp. 526–532. Attention is called to the instrument here, since in ballistics velocity and acceleration of the projectile's motion in the bore are arrived at with the aid of the recoil measurer as a function of the time in such a way that the time-path curve has to be differentiated twice.

The article shows two diagrams, one of the first, and one of the second differential quotients of a recoil measurer curve as obtained by use of the instrument. Results obtained by calculation are shown for comparison, and show very good agreement.

The respective times taken are 10 minutes, with no particular amount of practice, for mechanical, and 1½ hours for numerical working.

Another advantage of the Differentio-Integraph is that it affords a simple and immediate check of differentiation results by immediate integration.

The Long 155-mm. Schneider Gun, 1930 Model. This new creation of French gun construction claims special attention because it revives in modern form the old carriage of the garrison and siege artillery. Though thus definitely intended for land warfare, the 6-in. remains still a coast-defence gun, and its minimum ballistic performances derive from its effect upon the protected 10,000-ton (Washington) cruisers, since its half-armoured shell, weighing 1 cwt., pierces the 7 to 8-mm. thick side-armour of these ships up to a range of 8 kilometres, or their armoured decks of the same thickness up to 20 kilometres. In both cases the shell bursts behind the armour after penetrating. The following figures are taken from a table showing comparison with similar modern guns :—

Range: Schneider, 26,000 m., against U.S.A. 1920 model, 23,775; Krupp's, 22,000; Bofors, 22,000; Skoda, 20,000.

Weight of projectile: Schneider, 50 kilos, against Skoda, 56; Krupp's, 52·8; Bofors, 46; U.S.A., 43.

Muzzle velocity: Schneider, 900 m.s.; U.S.A., 853; Bofors, 770; Krupp's, 750.

Total weight: Schneider, 16·4 tons; U.S.A., 10·9; Bofors, 10·2; Krupp's, 10·1.

From which it appears that increase of range has been purchased by a considerable increase in weight.

What Equipment is Necessary for Opposed River-crossings? By Lieut.-Colonel Wabnitz. The advent of the tank has increased the difficulties of bridging and hence the value of water obstacles. With increasing weights heavier bridging equipment will be required more and more, and the bringing of it into use will take up more and more time. In other words, the forcing of rivers will be necessary more frequently than heretofore, and will gain in importance; while the engineer bridging equipment, which furnished formerly by far the greater part of the material used in the first stages of opposed crossings, viz., ferrying, and which was still suitable for that purpose, can no longer be considered for ferrying, being too heavy.

The author then paints a picture of the difficulties encountered at the second crossing of the Marne: pontoons being manhandled by night between three and four kilometres, and carried down a steep bank overgrown with bushes for launching in pitch-darkness by men wearing gas-masks. Bad as this was, it will be worse in future, for motorized pontoon trains will have to stop even farther away from the enemy, *i.e.*, from the bridge site, while the pontoons will have to be heavier. Even if the circumstances were more favourable than those depicted the use of modern heavy pontoons for ferrying purposes would not be recommended, since modern conditions, such as well-screened machine-guns, long-range artillery with air observation, aeroplane-bombing, are likely to cause heavy losses in pontoons, the main *raison d'être* of which is to be built into bridges.

On the Marne the loss of pontoons before and during ferrying rose to 38%. Further heavy pontoons, except under the simplest conditions of wind and stream, really require outboard motors, as proved by the failure of the 121st Regt. to cross the Tagliamento at Codroipo, on the night of the 30th October, 1917, when they were using heavy captured Italian pontoons. The necessary use of outboard motors on heavy pontoons forms, however, one more argument against the use of the latter for early and rapid crossings. Hence we are able to make two deductions: modern pontoon equipment must be left out of consideration altogether for the first forcing of a river in the face of the enemy, and secondly, the first transhipping and the subsequent bridge building can nowadays no longer be two operations passing one into the other, or even two operations separated by a short interval of time. These are the teachings of the Piave and the Marne, and they agree with the deductions made by Colonel Baills from the experience of the French in forcing the Aisne in August, 1918 (*v. R.E. Journal*, September, 1932, p. 578).

Bridge construction cannot be started as long as the bridge site can be kept under effective fire. If a powerful and persistent smoke-screen and efficient A.A. defence can protect against hostile bombers for short periods, there still remains, as an obstacle to bridging, observed concentrated fire of artillery, the only way to get rid of which is to drive the enemy back; and this may well take days. In this time the building of heavy pontoon or even of ordinary military bridges is more or less useless, and leads only to the heaviest losses in men and material. For neglect of this rule the Germans lost 83% of their pontoons at the Marne.

Lieut.-Colonel Wabnitz doubts whether, if the Germans had stopped any longer on the south bank, they would have had as much as one complete bridge per division to retire across.

When, six weeks later, the French were driving the Germans back they did not make at Soissons the same mistake as the Germans had made at their second crossing of the Marne, viz., that of using only their war bridging material; but for that they made a new mistake. Having started correctly with light material, boats, rafts, Habert sacks, and footbridges, they commenced their heavy bridging too soon, viz., on the evening of the first day. They thus suffered, not 83% loss of pontoons like the Germans, but only 50%; and Lieut.-Colonel Wabnitz thinks that if they had only postponed the heavy bridging until the second night they would probably have reduced their pontoon losses to zero. He appears to consider that the right moment for the heavy bridging to start is in that blessed interval of calm which follows a successful advance, and which lasts until the enemy's artillery has got back into its new positions.

The whole point is that the preparatory phases of the crossing and the final bridging for all loads must nowadays lie far apart, and that they demand imperatively the use of entirely different materials. These two kinds of materials, light and heavy, must be carried separately, and to emphasize the difference between them the columns of the former should not be called "bridging columns," but "transhipping columns."

The author then examines certain instances of opposed river-crossings in order to discover what light material the transhipping column should carry.—(*To be continued.*

The Supply of Weapons and Equipment to Russia, 1914–17. Of all the nations that took the field against the Central Powers, none suffered so much as Russia for lack of the necessary weapons and equipment for war. The supremacy in the Baltic of the German Baltic Fleet and the closing of the Dardanelles by the Turks cut Russia off from any direct and short road of supply from its better-equipped Allies, and only the way through Siberia remained open for supplies from Japan and the United States; and later the Murman railway. Russia's own armament works were unable to fulfil requirements, so it had often to live from hand to mouth. At no time did it possess the equipment requisite for war on so large a scale. These are the facts which stand out after a study of the Soviet Government Statistical Department's recently published book, *Russia in the World War in Figures*: and for a correct understanding of the events of the Great War it is precisely as necessary to be acquainted with the Q side as with the G side, with the questions of logistics as with the strategic situation. In every department, infantry, artillery, engineers and signals, the book tells the same tale of huge consumption, and in nearly every case, of inadequate supplies. Although the publication claims to deal with the years 1914 to 1917, the figures extracted cover eighteen months only, viz., from 1st January, 1916, to 1st July, 1917. Examples of consumption are: guns (field and horse artillery only) per month, 300; trench-mortars per month, 529; infantry rifles per month, 200,000. As regards requirements being fulfilled and source of issue, 7 million tons of barbed wire were required in the eighteen months mentioned, 2 million tons were imported and only ·6 million tons produced in Russia; of 900 searchlights required, Russia produced 600 and imported 250; a greater shortage occurred with aeroplanes, 1,500 being produced and 400 imported against a requirement of 5,200; telephones 298,000 required and wireless sets 1,232 required are among the few items in which imports, 60,000 and 342 respectively, could with home production satisfy the demands of the army.

Tactics and the Technics of Supply in the Great War, by Captain Zirzow. The text of this article is that all military operations in the Great War had as their underlying idea the destruction of the enemy, and if this idea could never be completely carried into execution, the final reason for failure lay almost invariably in the extraordinary difficulties of supply. These difficulties slowed down the speed of the operations of the field army, for though strategic objects in the first place determine the movements of large armies, they are themselves bound to the supply question, which makes them possible or impossible of attainment.

In modern warfare where nation fights nation with all its resources, the theatre of war is in a sense extended beyond the zone of the armies to embrace both lines of communication and the home country, since these three are indissolubly connected. The most favourable utilization of all existing routes, the most appropriate use of all available means of transport, and a frictionless carrying out of all movements create for the fighting army the ground conditions of its success. Even the all-important morale of the troops is greatly affected by the arrival or non-arrival of adequate supplies. Germany, whose troops were second to none, was beaten in the end by the blockade, while its enemies had the whole world to draw upon.

Of all means of transport for armies, railways with their 600-ton loads per train of 60 trucks come easily first. Canals, with their slow transport but of great capacity, are a valuable adjunct to railways, and suit quiet fronts. Motor-lorries (2 to 3 tons each) and horsed transport (wagons carrying 1 ton each) come last, but are both indispensable, owing to the necessary distance from the enemy of railheads. The Germans were in no doubt as to the signification of railways for war, for in 1914 there led to the Western Front thirteen separate double-track, broad-gauge lines. This fact, it should be remembered, the late Sir Henry Wilson discovered for himself by dint of a remarkable number of journeys up and down the frontier on foot and by bicycle, covering a period of some years before the war. Its publication as evidence of Germany's intentions led, by his own account, to his general opprobrium, in which,

according to whether his veracity was impugned or his wisdom, there was indeed an alternative of classification, but none of epithet. These thirteen double-track railways, which would enable Germany to flood her western frontier with armies, were supplemented by four more double-track railways as laterals. These "Rokade" lines, named after castling in chess, were capable of transporting from one wing of the army to the other four army corps in three days.

On the Eastern Front Germany had been less liberal in provision of railways, and when, in 1915, the Russian front was broken and war became mobile, the lack of railways and good roads checked the speed of the German advance to such an extent that the Russians were able to save themselves.

An even more striking example of the dependence of operations on supplies is furnished by the attacks on the Suez Canal. The first of these, attempted as a surprise in January, 1915, failed. In the summer of 1916 a larger force of eight German machine-gun companies, in addition to Turkish troops, was assembled and started off upon a similar enterprise. This expedition broke down and was called off on the supply question, the single line of the Hedjaz railway, its only source of supply, proving unequal to requirements. In its inception, as in its end, operations and supply were intimately connected, since its underlying idea was to interrupt one of the most important enemy lines of supply. Captain Zirzow thinks that these attacks had a tremendous repercussion, for by calling England's attention to the weak spot of the Suez Canal, they contributed greatly to the decision for the British offensive against and through Palestine. Further, that the lessons to be learnt from the Turkish failures were put to good account by the British in their praiseworthy preparations for that campaign.—(*To be concluded.*)

Elimination of Gun Report. A sound and smoke eliminator is said to have been invented by two Italian ex-artillery officers, and to have been thoroughly tried out at Pozzuoli, near Naples, in the presence of officers and representatives of armament firms. The results are said to have been extraordinarily good. No details of construction are published, but it is presumable that the arrangement does not do away with the muzzle flash, which betrays the gun at night, and it also appears that it does not reduce recoil to any great extent, as muzzle-brakes do. The newspaper *Mattina* says that the invention can also be applied to heavy guns with success, which might imply that heavy guns were not used in this trial. Whether by means of silencers, muzzle-brakes, the addition of suitable chemicals to the charge, etc., nearly all countries have been trying for years to eliminate smoke, report and flash, but with only partial success. Notwithstanding this a satisfactory solution may still be arrived at.

German Exhibition of Sporting Aeroplanes. At this Show much interest was taken by visitors in exhibits of models intended, according to the designers of aircraft, to characterize the tendency of the future development of sporting aeroplanes, *i.e.*, those only for pleasure purposes. A picture is shown of one of these possibilities, a combined motor-car and aeroplane, actually a tri-car and an autogiro, the sails, arms or wings of the latter folding together and being laid back from the pedestal to the rear of the car for road work. The appearance is strange, but not too unpleasing. It would be perhaps too much to expect that the next effort would satisfy æsthetically, since it endeavours to cope with three elements. It is called the "Week-end Amphibian," and is a combined motor-boat, cross-country vehicle with caterpillar tracks, and monoplane.

(*November*, 1932.)—*The Wheeled 75-mm. Vickers-Armstrong A.A. Defence Gun.* A notable addition to the different guns used for A.A. defence is a 75-mm. field-gun by Vickers-Armstrong, which fires from the usual cross-arm mounting, but travels on its own carriage and wheels with a limber for horse draft, or dragon. Photographs show the gun in column of route, anti-aircraft loading and firing positions, and in use against tanks. Figures are quoted from Vickers-Armstrong's pamphlet which are instructive. According to these, it took British A.A. guns, in 1918, to bring down

one German aeroplane 4,450 rounds, and the French over 4,000. During the last few months of the war improved methods and improved aids to shooting brought the average of 4,450 per aeroplane down to 1,500. Since then, although the improvements have continued, greater aeroplane heights and speeds tell against the gun.

What Equipment is Necessary for Opposed River-crossings? Having decided that the first crossing is not to be made by the ordinary bridging column, but by a light bridging column carrying entirely different equipment for rafts, assault bridges, etc., and that this light column should preferably not be called a bridging column, so as to emphasize the difference between it and the bridging column proper, Lieut.-Colonel Wabnitz now sets out to discover what particular equipment the light column should carry. For this purpose he chooses the method of examining successful river-crossings in war, such as the crossing of the Piave by the Austrians, 15th to 23rd June, 1918, and the passage of the Aisne between Mouron and Termes by the French on the 14th October, 1918. As regards the former some of the conditions were exceptional, *e.g.*, the extreme breadth of the river, 320 metres, and the current strength, rising in flood to 4·2 m. per sec. A chart showing the state of bridges discloses several facts of importance :—(1) during the 192 hours that the battle lasted, the Austrians during 84 hours had no bridge at all ; (2) those 84 hours in which there was no bridge included the two days when the battle was at its greatest height ; (3) except once for two hours there was never more than one single bridge through on a corps front of three divisions in line ; (4) finding it impossible to keep a pontoon bridge through, one division managed to keep the bridge going by means of repairs with trestles for 21½ hours, until that also was abandoned. That under these circumstances the Austrians were able to cross at all and to maintain themselves on the further bank for eight days was due to a special issue for the operation of 384 light boats, in addition to the necessary pontoons.

The second example mentioned shows that by October, 1918, the French also had learnt what can be done with small boats and light material before the time for heavy bridging arrives.

The author examines two more crossings, one French and one Russian, taken from manœuvres, before answering his own question as to what transhipping (light bridging) columns should carry. He then details as follows :—(1) not too heavy wooden boats of simple construction with a carrying capacity to about 2·5 tons. The boats must be such that for replacements or increase of number they can be made by the engineers themselves ; (2) light trestles for depths up to about 11 feet ; (3) superstructure for rafts and bridges up to about 4 tons capacity ; (4) kapok floats, with planks for assault bridges. Of chesses it is not easy to take too many, since even without floating supports quite serviceable rapid bridges can be made of them. It does not matter if such footbridges are carried by the stream a little below the surface : it is even an advantage because of concealment. The author condemns all floats like Habert sacks and Poljanski floats, which depend upon airtightness, as far too easily damaged for war. As a result of German experience crossing the Aillette in May, 1918, he considers cork or kapok alone possible for floats, agreeing in this with Colonel Baillis, who calculates that one 3-ton lorry can carry enough for 300 running metres of bridge.

The article concludes by considering shortly whether and to what extent the new weapons, gas, smoke, aeroplanes and tanks, affect river-crossings, and decides that they cannot be made greatly to serve the attacker, while the defence by their aid receives an accession of strength which makes an opposed river-crossing one of the most difficult of tasks, necessitating the most suitable material, and sappers, numerous, perfectly trained and fearless.

Tactics and the Technics of Supply in the Great War. In tracing the connection between the conduct of war and the supply question, the author adduces three examples, the first two of which go to show how transport can govern strategy,

while the third shows how a nation can be defeated in war owing to lack of supplies, although her armies have not surrendered.

The first example also shows to what extent the technics and organization of supplies had increased in importance and developed during the course of the war. It is the story of Caporetto, following Germany's decision in the autumn of 1917 to strike a blow in aid of its Austrian ally, who was finding the Italian pressure too great. A German army of six divisions with numerous artillery was sent to assist the Austrians to drive the Italians back 40 miles from the Isonzo to the Tagliamento. The Germans found the position as regards supply and transport none of the best, the railway network inadequate, railheads too far, 40 to 45 miles, from the front, hence always congested, with only two mountain roads, each 40 miles long, leading to the front. The first thing the Germans had to do was to supply extra locomotives and railway staffs. By working the mountain roads on the railway block system, ammunition was sent up for the offensive, and during five weeks stores were accumulated close up to the front. When the attack came the well-organized supply arrangements for following on a successful offensive broke down under the enormous and surprising success obtained. Although the captured railways were put in order as quickly as possible, they could not save the situation, and for want of supplies one of the world's greatest victories remained unexploited, and as far as the result of the war was concerned, without effect.

Captain Zirzow's other two examples are the German offensive in March, 1918, which, he says, fought itself to a standstill, not on any fighting superiority of its opponents, but on their superiority as regards supply and transport, and finally Germany itself, compelled to surrender by blockade.

The Best Shape and Size of the Gas-mask Filter. This article consists entirely of a comparison between the German form of filter, which screws into the mask, and the box-container used by other nations. The writer shows that all advantages lie with the former, except that the box-container can absorb from 2 to 2½ times as much phosgene, nitrochloroform or hydrocyanogen. He then attempts by working out concentrations of gas clouds to show that the smaller filter is sufficient.

The Part Played by Nickel in National Defence. The significance of nickel for modern armaments is such that without it the defence of a great power would be partially crippled. It is used for gun-making, armour, tanks, cars, cupolas, turbines, etc., and in aviation for engine parts, wire, axles, etc. In most of these cases no other metal can take its place, and hence its consumption during the war on both sides was considerable. Germany, in 1914, found itself in possession of a nickel coinage in circulation, and of large stocks obtained from a Norwegian refinery. By 1916 its supply of nickel had fallen so low that the German authorities decided to let a submarine run the gauntlet, so as to fetch a cargo of nickel from the United States, at that time neutral. This was done with perfect success, the *Deutschland* passing through the blockade twice.

Since the war nickel has become even more necessary for national defence than before, and is indispensable in a wide industrial field, for engine shafts, tools, moulds, furnace parts, and apparatus for chemical processes at high temperatures and pressures.

The author then recounts the nickel sources of the world, of which the two chief are a French possession in the Pacific, New Caledonia, where the amount of ore is almost inexhaustible, and the vast Canadian nickel-copper-ore beds at Sudbury in the province of Ontario.—(*To be concluded.*)

French Railway Guns. A list gives particulars of nine French A.L.V.F. (*Artillerie Lourde sur Voie Ferrée*) guns and howitzers, from 9·6 in. to 20·8 in., *i.e.*, from the St. Chamond and Schneider 240-mm. gun to the Schneider-Creuzot 520-mm. howitzer, which is carried on 16 axles in 4 bogies. The list includes, apparently somewhat prematurely, a railway-gun designed by the great artillerist, Général Herr, calibre 18 to 20 in., weight 80 to 100 tons, firing to about 25 km. a shell weighing about

16 cwt. and having a bursting charge of 6 cwt. The article compares French railway guns unfavourably with German railway guns as regards simplicity and uniformity of construction.

(*December*, 1932.)—*The Influence of Atmospheric Disturbances upon the Trajectory, and the Determination of their Ballistic Values by the Method of Layers.* An attempt by Dr. Wehage to arrive at the ballistic values of weather disturbances, side wind, head or following wind, temperature, barometer, etc., as if they were constant over the whole trajectory, and so to replace the more complicated methods in use, viz., of Schwarzschild in Germany, and of Garnier, Haag and Marcus (G.H.M. method) in France, which deal with successive small arcs.

Field-guns in Anti-tank Defence. In spite of all efforts to create special weapons for anti-tank defence, field artillery must continue to take part in anti-tank defence, as a subsidiary task, in addition to its principal duties. It can do so in two ways: (1) by being sent far forward into position so as to command a field of fire several hundred metres broad in front of the foremost infantry, (2) by leaving anti-tank defence in the infantry zone to special A.T. weapons, and confining itself to engaging tanks which have broken through the infantry zone. These tanks will be put out of action in the artillery zone, where the artillery is distributed in depth.

In either case only direct fire is reckoned with, so that a gun is not likely to open fire at a tank at over 1,200 metres. A tank travelling 1,200 metres in open country at 15 km. per hour would give a field-gun time to fire 30 rounds at it. From the tank's point of view, the field-gun is therefore to be taken very seriously. But owing to the use of cover and of a zig-zag course, the condition of keeping the tank under fire for five minutes is unlikely to occur. Further, the recent increase in weight of the field-gun and increased speed of the tank are both in favour of the latter. Perhaps the best treatment would be for the artillery to arrange to take under fire all those spots in which tanks will collect to re-form.

Thoughts About Angular Measurement in the Artillery, by Lieut.-General Marx. The division of the compass into 360° was a most unfortunate one for military practice and much too complicated for use in action. Hence in almost every country the artillery abandoned the right-angle of 90°. This way came confusion. There are now in use in various armies five different systems of angular measurement, sometimes two in the same army, even two in the same branch. The author considers that the latest French system of 100° to the right angle, and the new degree sub-divided into tenths and hundredths, has no chance of being adopted in any country within measurable time. "England has not yet adopted the metric system, or the Centigrade thermometer." The best artillery division of the circle is and remains that into 6,400 parts, or preferably each 180° into 3,200.

The Part Played by Nickel in National Defence. Besides the greatest sources of nickel in the world, which are controlled by France and by the British Empire, there are many minor sources, *e.g.*, Christiansund, where a Norwegian company both mines its own ore and refines ore from Falconbridge in Canada; Burma, whence the Burma Corporation supplies refineries in Hamburg and in Saxony; the Monte Rosa for Italy, and the Ural for Russia. Most countries will have no trouble in making sure of the necessary nickel supplies in war. Germany will have to rely on Norway; Italy has 2,400 tons of pure nickel in its coinage; England's supply from Canada may surely be looked upon as safe; France's supply has to come a six weeks' sea journey from Noumea. There is accordingly an agitation in France to provide a war reserve of 4,000 tons of nickel, which could be done by the saving on making 160 million five-franc pieces of that metal in place of 68% silver, 32% copper.

The Fifth General Meeting of the German Photogrammetry Society. This meeting took place at Charlottenburg on 28th and 29th October, 1932. In addition to the usual business, and to lectures by the experts, reporting work done, improvements and proposals, a special note was struck by combining the meeting with the exhibition of the results of the voyage of the airship *Graf Zeppelin* to the Arctic Ocean in 1931,

as obtained by the Aeroarktik, or Society for the Exploration of the Arctic by Aircraft. Corrections and discoveries extend from the W. coast of Franz Josef Land to White Island and the Taimur Peninsula, the latter affording a new mountain range 120 miles long. In all 5,000 square kilometres were fixed photogrammetrically by 1,000 exposures.

Future arrangements fixed are: the next annual meeting, autumn, 1933, at Essen; the fourth International Photogrammetric Society meeting, 1934, in Paris; to be followed in the autumn by the sixth general meeting of the German Society in Berlin.

Signals in Various Countries. A comparative list of the signal formations of forty-one countries, not "from China to Peru," as both these countries are missing from the list, but from Japan to Chile. The compiler of this table has added to it two pages of notes to elucidate the figures and to assist comparison. He emphasizes the importance of signals for intelligence work, which in the German army was the origin of that service, and from which it still preserves its name.

F.A.I.

MILITAERWISSENSCHAFTLICHE MITTEILUNGEN.

(*September-October*, 1932, *continued.*)—*Literature of the Great War.* This second instalment of Professor von Frauenholz's article deals with biographies and memoirs, which it places under three heads: (*a*) Austro-Hungary, (*b*) Allies, and (*c*) Entente. Under the first head a good case is made out for according pride of place to two books about the Emperor Francis Joseph. There had arisen before the war an Austro-Hungarian problem which had no counterpart in Germany or in France. One may, perhaps, in those days of prosperity have underestimated the economic necessities of the separate members of the Empire, but many people saw in the venerable person of the Emperor Francis Joseph the last and only bond holding together the nations of the Danubian Monarchy in their struggle to get apart. The two books mentioned are Redlich's *The Emperor Francis Joseph of Austria* and Tschuppik's *Francis Joseph I: The Downfall of an Empire*, both published in Germany. The two authors differ widely in their estimate of the Emperor, agreeing only that his death meant the end of the Habsburg Empire.

Of books written by soldiers, chief interest is claimed for Field-Marshal Conrad's *During my Service*, 1906–1918, which unfortunately was never completed. Five volumes of this work have been published by Rikola's of Vienna, covering up to the end of 1914. Specially interesting are Conrad's views as to the necessity for war, his opinions about Italy and Rumania, and about the extent of the assistance received from Germany in 1914. Next in importance comes *A Contribution to the History of the Great War*, in a single volume, also published by Rikola, and written by Baron Arz, who was Conrad's successor as Chief of the General Staff.

Amongst books written by army commanders and by the attachés at Allied G.H.Q.—General Count Stürgkh with the Germans and General von Freytag-Loringhoven with the Austrians—the most interesting appears to be General Krauss' *The Causes of our Defeat*, published by Lehmann's of Munich, since it is essentially critical and throws a light on political questions, treating less of military events.

Besides the soldiers a number of statesmen, Burian, Czernin, Andrassy, Karolyi, have written war books, which consist mainly of justifications for their own actions.

Under the second heading the first sub-head is, of course, Germany. The central figure in Germany, the Emperor William II., has found no worthy biographer, since the accounts of Emil Ludwig and of Count Zedlitz are considered too partial. The ex-Kaiser's own books about himself, although giving interesting lights, are incomplete as autobiographies, and for lack of access to the Berlin archives they contain errors which could easily be utilized against him by his enemies.

The Crown Prince's publications are of the greatest interest in the second volume, written by himself, in which he deals with the arrangements for and execution of the attack on Verdun.

A unique position must be accorded to the Crown Prince Rupert of Bavaria's *My War Diary* since, unlike other memoirs, it was not compiled afterwards, but written at the time and indeed written up almost daily. It contains his views as to nearly all the important political and economic questions of the war, and is militarily of the greatest interest, since the 6th Army, which he first commanded, and later his Army Group took part in some of the most important operations on the Western Front.

All four leaders of German military operations have given us printed records—Moltke (a book brought out by his widow), Falkenhayn, Hindenburg and Ludendorff (three books); while Liman von Sanders and von Lettow-Vorbeck have dealt with their own respective theatres, Turkey and East Africa.

In Germany, as in Austria, the statesmen have also had their say. Prince Bülow's four volumes are regarded by the writer as a source to be read critically and with caution. His attitude towards himself alienates the sympathy of his readers, while his attitude towards the Kaiser has also given offence. Two war chancellors, Bethmann-Hollweg (for ever famous for his remark about "a scrap of paper") and Michaelis, his successor, have also entered the field. The former incidentally lightens the charge against the military Supreme Command of having exceeded their province by their excursions into politics, since he shows that they were forced to do so by his own feeble attitude.

As regards Bulgaria no recommendations are made.

Turkish works to be considered are the Grand Vizier Ahmed Izzat's *Commentaries*, and the Ghazi Mustafa Kemal's *The New Turkey*, which latter appears, however, to be mostly post-war. *The Collapse of the Ottoman Empire* (Amalthea, Vienna), by the Austrian military attaché in Constantinople, Lieut. Field-Marshal Pomiankowski, is highly recommended.

Turning now to the Entente Powers the author has a few words only to bestow on Foch's *War Memories*, and even less upon Poincaré's *In France's Service* and Clémenceau's *The Greatness and the Tragedy of a Victory*. He dismisses French war literature with a little wail, that it all goes to show how difficult it is to bridge the gap between German and French modes of thought. About England he is more interesting. Sir John French and Lord Haig are mentioned as having produced "more or less dry reports," but Sir Henry Wilson's diaries call for comment, while Sir William Robertson's *Soldiers and Statesmen* is praised. As with British soldiers so also with British statesmen the author gains the impression from their writings that German feeling and German thought are far closer to English than to French ideas. At the same time he does not lose sight of the fact that political opinions in England are more clearly defined and less capable of compromise than in Germany.

The war books of British statesmen mentioned are those of Lloyd George, Sir Edward Grey, Lord Asquith, Lord Haldane and Winston Churchill. They are dismissed in one sentence: "Through all these memoirs is woven like a red strand the thought that England must preserve its supremacy at sea. It was the new building programme of the German fleet which caused England to join the Entente."

Among Russian publications are mentioned three books by General Daniloff, *Russia in the World War*, *Towards the Collapse*, and *The Grand Duke Nicholas*, in which strategical considerations are specially worthy of notice; also General Brussilow's *Mémoires* (Hachette, Paris); and Sasonow's "extraordinarily untruthful" *Six Difficult Years*, which, like Prince Bülow's *Commentaries*, mentioned above, quickly called forth a rejoinder, in this case a collection of articles and documents made by General Steinitz.

Isvolski, former Russian Minister for Foreign Affairs and later Ambassador in Paris, whom the student can hardly fail to recognize as the least disinclined for war of all European statesmen, has published nothing himself, but his letters and reports together with official correspondence have been collected and published in German by von Wegerer (Verlag für Politik und Geschichte, Berlin).

Two foreign ambassadors, M. Paléologue and Sir George Buchanan, have written

about Russia during the war; and the Dictator Kerenski about the subsequent revolution.

The most important Italian publications appear to be Cadorna's *The War on the Italian Front*, of which there is a French edition; and, on the civil side, three outspoken books by the former prime minister, Nitti.

Finally have to be included from the American side General Pershing's reminiscences, three volumes by Baker dealing with President Wilson and the Versailles Treaty, and Seymour's *The Confidential Documents of Colonel House*.

(*To be continued.*)

The Close of the War Year 1915. Under this title Major-General Kerchnawe welcomes the appearance of the last double number of the third volume of the Austrian *Official History of the War*, which he finds equal to its predecessors in style and clearness and in the adequacy of its maps, and superior to them in that it includes two panoramas, viz., of the Karst Plateau and of the Isonzo front. He praises the preference, of which there is growing evidence, for statistics in the place of verbal descriptions, since the former permit the drawing of more correct conclusions. Thus, a quite false picture may be conjured up of the troops who in consequence of "enormous losses" are "forced" to break off their attack, when one does not know that these same losses did not exceed 10%, or a daily average of even 1%. Similarly, of the "deadly precision" of fire, when one does not know that the weight of iron, steel and lead expended have exceeded the weight of all the men thereby put out of action, let alone of those killed. But a very good picture may be made of what the defender has had to put up with when we learn that there was fired at him every twenty-four hours one round of artillery ammunition to every metre of his front. By the latter method is made possible a military study of real utility.

Although General Kerchnawe's own opinion has always been that insufficient equipment for war was the principal reason why the all-important early decisions turned out so unfavourably for the Central Powers, he feels himself constrained after reading this book to admit that chances did occur later, if not of recovering what had been lost, at least of equalizing matters. These opportunities were missed through dissension between German headquarters and Austrian headquarters, *i.e.*, for want of a unity of command, not arranged for beforehand and impossible of achievement during the war, so that "the splendid evening-red of the Victory-year 1915 turned into the morning-red of Defeat."

The Marne—Germany's Fate? Lieut.-General Marx in this book fights in general what he calls the "dramatic" tendency of historians which leads them to trace back very great results to small causes, and to regard the act of commission or omission of a single individual in a leading position as determining the fate of a great nation. The particular case in his mind, and to which the greater part of the book is devoted, is the case of Colonel Moltke at the battle of the Marne. A vast number of people in Germany and in Austria, adopting the view of German military literature generally, attribute the loss of the war quite simply to Colonel Moltke's famous—or infamous—decision. The same judgment in the German Official History must cause, the author says, "wailing and gnashing of teeth at home, scorn and derision abroad."

In putting forward his thesis and arguing the particular case, General Marx is ploughing a lonely furrow, and his Austrian reviewer, while mildly praising him for opposing the doctrinaires, still thinks he has gone too far. What General Marx has done was, however, something which some bold spirit in Germany was bound to do sooner or later, and the next step will obviously be: "Is it, or can it be, just barely possible that Colonel Moltke was right, and not wrong, in ordering the retirement?" *Quae spes!*

(*November–December*, 1932.)—*Editorial.* General Ratzenhofer, an engineer and well known to *The R.E. Journal* by his admirable articles on railways, having succeeded Major-General Schubert as editor, makes his introductory bow to the public in an editorial of retrospect and prospect, a glance at Austria's great past, and for

the future the warning that " History knows no right to live apart from military strength."

Field-Marshal Conrad. The Director of the National Archive, Dr. Glaise-Horstenau, writes on the occasion of what would have been Field-Marshal Conrad's 80th birthday, a glowing eulogy of " one of the best " the centuries have produced, and the last great soldier of an Empire which he exerted all his strength to save.

Lützen, 16th November, 1632. Major-General Kerchnawe asks whether any value is to be derived from the study of a battle which took place 300 years ago, and which was so much smaller than our modern battles, both in the space fought over and in the numbers engaged, albeit greater than they in the relatively far greater losses. His answer is that the soldier can learn from every passage of arms, if he will but study it seriously, first thinking himself into the historical period. He then describes with the aid of a clear map the fighting that took place.

Apart from Lützen's historical interest as a turning-point in by far the longest, bloodiest and most destructive of all wars—for the population of Germany fell 20 millions between 1618 and 1648—apart from the fact that the two greatest generals of the day, Gustavus Adolphus and Wallenstein, fought each other with forces nearly equal in strength for eight hours, that the one lost his life there, and the other his reputation of invincibility, Lützen has special interest in military history.

For Lützen was also a turning-point in tactics. The success of the Swedes, based upon the linear tactics of the Netherlands, and seeking salvation in infantry fire power, increased by that of numerous light artillery, was gained over a system established and acknowledged everywhere as a model. The Imperial troops, like most other Continental armies, employed the Spanish mass tactics, which sought a decision by the impact of masses of pikemen, supported by the fire of musketeers. Lützen decided once and for all the superiority of linear tactics, and the line, with its greater manœuvring power, set its seal upon the battle tactics of the centuries that followed—in the British army, with only slight alterations, right up to the Boer War.

The American Army in the Great War. A final short instalment carries the story on from the capture of the St. Mihiel salient, 12th September, 1918. The smallness of the bag of prisoners, only 16,000, goes to confirm the other indications that the Germans had already started to abandon the salient before the attack started. Contingent upon the success of this operation a general advance had been decided upon at a G.H.Q. Conference on September 2nd, the British in the direction of Cambrai, the Americans on Mezières and Sédan, and the French, in the middle, to advance W. of Rheims across the Aisne. Final victory was not yet reckoned with; but the operation of a general advance, originally intended for 1919, had been made possible of anticipation owing to the great French and British successes in July and August.

The Meuse and Argonne sector which now lay in front of the Americans to the north was of vital importance to the Germans. Its natural strength had been enormously increased during four years of occupation. Its strategic importance lay in the network of railways behind it, the cutting of which would have been the ruin of the German army in France and Belgium. The Germans expected the Americans to continue their attack due east on Metz, and were encouraged in this belief. The blow fell on September 26th, when the American army made its second great attack. In two days they had penetrated 11 km., capturing Montfaucon and Dannevoux. On the 29th the Germans threw in six new divisions, which had been hurriedly brought up for the counter-stroke. In spite of the counter-attacks the Americans were able by means of three fresh divisions to start a second advance on the 4th October, which by the end of the month had got forward to a maximum depth of 17 km., kept 31 German divisions occupied, taken 18,600 more prisoners and another 400 guns. The third phase of the Meuse–Argonne battle started on November 1st, when three American corps attacked with Busancy and the heights of Barricourt as objectives. From the first this attack was a great success, and ground was won

daily in ten days' fighting up to the date of the Armistice. The Americans were then east of Beaumont and only 20 km. short of Sédan, their strategic goal. During the forty-six days the battle lasted, 22 American and 4 French divisions had encountered and worsted 47 German divisions, or one-quarter of all the German divisions on the Western Front.

The article closes with very brief summaries dealing with the activity of American troops on other fronts, the occupation of the bridgehead, the withdrawal from Europe, measures against submarines, and four pages of statistics.

If, as is sometimes said in derogation, one can prove anything by statistics, it is nevertheless a fact that some things can be proved only by statistics, and of many things the best picture is obtained by their aid. An idea is given of America's vast effort, and of its value to the Entente. Figures, where money is concerned, become of proportions almost astronomical, thus :—the war cost the U.S.A. 22 milliards of dollars, or 1 million dollars an hour for over two years. The rate of expenditure rose from 2 million dollars a day during the first three months to 44 million dollars a day during the last ten months.

The Backbone of the Eastern Front, June, 1915, to May, 1916. General Ratzenhofer, the new editor, deals with the problems of railway construction which arose behind the Austro-Hungarian eastern front consequent upon the success of breaking through the Russians at Tarnow-Gorlice on May 2nd, 1915, and the subsequent advance of 250 km. For this purpose he has first to glance at the permanent networks on either side of the frontier, in Austria and in Russia, then to show what the Russians had done after invading Poland and Galicia to improve the railways in those provinces so as to meet their own requirements. He then traces the progress of the offensive, shows what the requirements of the Austro-Hungarian and German armies became in their new positions, and how the same were met. Besides new construction of lines and yards, much strengthening and general improvement, 2,500 km. of broad-gauge had to be reduced to normal, and 3,800 km. of track and 500 stations had to be restored to working order.

The story is broken off on the 5th June, 1915, when the Russian " steam-roller," or Brussilow, offensive commenced.

Should Salonica have been Attacked in 1915? The last time this question was asked in the *M. Mitteilungen* (*v. R.E. Journal*, June, 1928, p. 376), Captain Wisshaupt made a thorough examination of certain arguments which had been advanced against such an enterprise, and decided nevertheless that Salonica should have been captured, since in the end it proved to be the starting-place of the Allies' breakdown.

The question is now reopened by Lieut-Colonel Mühlhofer, who has been gathering opinions on the subject from war literature. He quotes in turn Generals Cramon, Ludendorff, Gallwitz and Krauss, all of whom, if for slightly different reasons, approve that no sideshow was started in an attempt on Salonica. Against these authorities he can only place General Hoffman who, in his *The War of Lost Opportunities*, contests Falkenhayn's reasons for breaking off after the conquest of Serbia and Macedonia, and cannot understand why the 1915 campaign did not lead to the capture of Salonica, which Conrad had guaranteed.

Lieut.-Colonel Mühlhofer ranges himself on the side of the first four authorities whom he quotes, and against General Hoffman. Finally, as regards the argument that Salonica should have been captured because it was from there that the besieged ring of the Central Powers first began to crumble, he considers this latter fact as proving no more than that the break-up, when it came, was bound to start at the operatively most unfavourable point.

The Turkish Narrows as a New Object of Strife. After a short retrospect of the many solutions which history has provided to the question of the ownership of the Narrows, *i.e.*, of the Bosporus at the Black Sea end, and the Dardanelles at the Ægean end of the Sea of Marmora, the author gives a clear and concise survey of present international politics relating thereto.

Such an article, apparently written by a diplomat, does not lend itself easily to

condensation, and its logical construction almost precludes quotation, or the picking of sentences away from their context. The argument hangs upon a teaching of history, that the possessorship of the Narrows has never been purely a sea question, or purely a land question, but always both. The present solution, "the Freedom of the Narrows," imposed in 1918 by two great maritime powers, Great Britain and France, neither of which holds either the littorals or the Ægean Islands, cannot therefore be looked upon as a condition of permanence. A change of ownership to be considered is that the Narrows should once more be controlled by Turkey, a condition made possible by the Turkish alliance with Russia (Shades of Plevna!), and Turkey's general development in all directions; but lacking the sea power necessary for permanence.

A solution perhaps even more likely is that the Narrows should pass under another great sea power, Italy, in alliance with the land power, Greece, holding the Ægean Islands. Italy's needs point in this direction, and so do her efforts to woo two other land powers, who are intimately concerned, Bulgaria and Rumania—the former an adherent of the rival party, Turkey and Russia; the latter a protégé of France.

The Fight in Darkness, by Colonel Barger, consists of three examples, taken from the experiences of Count Khevenhüller's 7th Carinthian Infantry Regt. in the Great War, and showing the skilful utilization of darkness for the approach to the enemy, for the preparation for the assault, and for the carrying out of a counter-attack. All the instances described took place on the Isonzo. They depict two wonderful achievements. First, how a battalion was moved literally step by step for two km. through occupied trenches until four hours later it found itself lined up ready for the assault and within only a few yards of the sand-bag parapet which the Italians had hastily thrown up to defend the trench they had captured. The movement was carried out under artillery fire and in spite of the Italian searchlights. There was no possibility of artillery co-operation owing to the trenches being too close. Surprise and success were complete.

The second instance is that of one month's night work by the engineers in providing the necessary approaches, wire-rope guides, collecting-places for companies and sections, etc., before the capture of a hill rising 440 metres above the attackers, and carrying four lines of trenches. The work done each night had to be carefully camouflaged before daylight; and the preparations were never discovered. As this operation, the capture of Potounik on the Isonzo, took place as late in the war as November, 1917, it would be instructive to know how many air photographs of the spot were taken by hostile airmen during the month of preparation.

Colonel Barger's third example is the capture of Mt. Pertica, after a 4½-km. movement by night which would have been quite impossible by day. All three examples show the necessity of thorough reconnaissance, simplicity of plan, secrecy and minute preparation, as inculcated by our own *F.S.Regs.*, and of two more requisites for night operations, which Regulations may, but which commanders cannot afford to, take for granted, a high state of discipline among the troops and resolute and powerful leadership.

Literature of the Great War. Having completed his account of histories of the war, and of memoirs and biographies connected with the war, Professor von Frauenholz deals in this number with individual accounts of military events and questions, of which he has compiled a bibliography 18 pages long and containing over 400 titles, comprising books, but chiefly magazine articles. Regimental histories will be dealt with separately. Of these individual accounts generally, the author does no more than point to the fact that some phases and events have been copiously written about, *e.g.*, Schlieffen's Plan, the battle of the Marne, Tannenberg, the 1917 offensive in Italy, the Gorlice break-through, and the German 1918 offensive, while other important events, such as Conrad's offensive from S. Tyrol in May, 1916, which got forward 30 km. on a front of 30 km., took 46,000 prisoners, and came within one mountain ridge of eliminating Italy from the war, have received but scant treatment.

The classification of the bibliography is first "general" and then by theatres. Name and date of publication are given in brackets for the following extracts :—

Cyprian Bridge : The Anglo-Belgian Military Convention (*Berliner Monatshefte*, 1930).

F. W. Nagel : The British Expeditionary Force in France, 1914 (*Wehr und Waffen*, 1924).

Anonymous : The British in France, 1914 (*Deutscher Offiziersbund*, 1926).

Major Heigl : The First Tank Battle, Cambrai (*M. Mitteilungen*, 1926).

F. Abtrichter : The Great Battle in France, 21st March—4th April, 1918 (*Wehr und Waffen*, 1924).

W. Foerster : The Strategic Idea of the Michael Offensive, 1918 (*Deutscher Offiziersbund*, 1928).

Major Kerrich : The Crossing of the Piave by the British, 1918 (*M. Mitteilungen*, 1929).

A. E. Rolleston : The British Artillery in Italy (*M. Mitteilungen*, 1923).

The author promises to publish yearly additions to the bibliography.

Moscow Dictates. Major-General Schubert reviews a book with this title, giving the experiences and impressions of a long journey through Russia in 1931, of F. Krotsch, who had formerly spent three years in the country as a prisoner of war. The author emphasizes "the will to reconstruction of the Russian people, and their consequent enormous achievements," which are already beginning to make themselves felt "on our very bodies." "The Russian economic administration by Plans, will, unless we find a means of defending ourselves, destroy within measurable time the last miserable remains of our national administration." The author by no means sings a hymn of praise to Bolshevism, but he points out "the inward strength of the system, which could not indeed maintain itself in any other country, but in Russia is on so firm a foundation that its progressive political and economic growth of strength most severely threatens a Europe already pressed to the edge of the precipice." In face of the enormous change in Russia, Europe has every reason for ending as quickly as possible the fight of all against all, and for creating for itself those fundamental principles which will give it a better chance in the unavoidable competition with the Russian national economy. "Left to its own resources each one of the European nations would be unequal to this struggle, and would in measurable time be driven into such a condition of distress as to prepare the way for the Bolshevik experiment, better than by all Soviet propaganda."

F.A.I.

THE MILITARY ENGINEER.

No. 137. General articles :—*The Franco-German Problem*, by Major B. T. Reynolds (late R.A.), a well-known writer on German matters. *History of the Holland* is a spirited account of the life of the privately-owned submersible boat of that name built in 1898. As is so often the case with epoch-making inventions the authorities regarded the "monster war-fish" with considerable scepticism.

Articles on civil engineering include :—*The Ariel Hydro-electric Project*, with full particulars and good photographs ; *Railroads and Flood Control :* and *The New Jersey Canal*, which is to connect Borden town on the Delaware River with Morgan on Raritan Bay, thus linking New York Harbour with the ports on the Delaware and Chesapeake Bays.

Survey articles include :—*Triangulation in Interior Alaska*, where fog and cold are serious considerations ; and *Mean Sea Level and Half-tide Level*, in which the difference between these terms—not immediately apparent to everyone—is explained. *Methods of Geophysical Prospecting* describes the search for mineral deposits by gravitational, magnetic, electric and seismic methods. This article will be of interest to diviners, although the "wigglestick" is regarded as being comparatively unimportant.

A Few Notes on Light Railways in France is the modest title of a careful description of the light railway system in the area of the British Third Army in 1917, and is interesting in view of the increasing amount of recognition that is being expressed of the tremendous services rendered by the light railways. *Armoured Trains and Their Field of Use* covers very completely this romantic but little known subject. *With the 308th Engineers in France* is an account of the adventures of this unit in the Meuse–Argonne sector in the autumn of 1918.

The article on *Portable Steel Military Bridges* in the July–August number, which was commented upon in *The R.E. Journal* of September, 1932, has brought some correspondents into the field. One of these draws attention to the advantages of rolled steel I-beams for spans up to 80 or 90 feet. He states that I-beams in depths up to 36 inches are " now being rolled by both of our largest American steel manufacturers in mills widely separated at strategic points in the United States, and are finding increasing favour among our highway bridge engineers. In general, it may be stated that a good highway bridge makes a good military bridge. The loading requirements are substantially the same."

No. 138. *The Great Bridge Lock*, in the intracoastal waterway near Norfolk, Virginia, may well be claimed to be unique, for it is described as a " million-dollar structure built for half-a-million dollars." Full details are given and progress is illustrated by photographs. *Rock Island Hydro-electric Development* is an account of the project now approaching completion on the Columbia River, near Wenatchee, Washington. *The Lincoln Highway at Turtle Creek* deals with the realignment of some three miles of this main road, 42 feet in width, to take four lanes of traffic.

Duluth's Aerial Lift Bridge describes the construction of a new bridge to replace the out-of-date aerial ferry which was based on the suspended car-transfer bridge at Rouen. The new span was built on the site of the old and is operated electrically. The weight of the span and counterweights is 450 tons. *Navigation Installations at Louisville* contains a description of the Boulé system of shutter supports for a weir. It consists of a series of steel trestles fastened to anchorages in the concrete sill by hinge-pins. When the dam is down the trestles lie flat on the sill, like cards ready for " cutting." When the dam is up the trestles are vertical and the shuttering is held up against them by the pressure of the water.

Survey articles include *The Triangulation of Pittsburgh*, with particulars of the extensions and base-to-base discrepancies. *The 1929 Adjustment of the Level Ne* describes the means adopted to get rid of the small discrepancies that have occurred from time to time where the increasing number of lines of first order levelling have formed closures. *Rectangular Co-ordinates in Surveying* draws attention to the need for users of this system to base their work on the Federal control system.

A Dog that Cannot Bite is the title of an editorial view of the present League of Nations, which " is not, and in its very nature cannot be, equipped to handle the difficult situations which must continue to arise. Even those statesmen who were instrumental in creating it are now expressing doubt as to its further usefulness."

Purification of Water in the Field is a thorough survey of water purification methods in various armies. Under the heading of recent experimental work the chloramine process of Majors Harold and McKibbin, R.A.M.C., and Major Elliott's mobile purifying plant receive recognition.

In *Modified Military Footbridges* it is shown that the Lampert equipment can be duplicated so as to give a roadway on which carts and limbers can be manhandled. The result is very much like the " pack " bridge made with our kapok equipment. The Lampert floats are wooden boxes covered with paulins, and are therefore very vulnerable under fire. It is said that kapok may replace them. At present kapok is used in a different way; the " pillows " are laid longways, and not across the line of the footway. The result is that unless traffic is carefully confined to the centre line the bridge is unstable. An experiment is described in which outriggers of chesses were used to increase stability. I.S.O.P.

CORRESPONDENCE.

HISTORY OF THE R.E. YACHT CLUB.

To the Editor, *R.E. Journal.*

DEAR SIR,—Writing under an (I hope) impenetrable alias, I venture to submit a mild protest against the cavalier way in which Captain Fryer, in his fascinating article on the R.E. Yacht Club, dismisses the R.E. eight of 1909 as a "heavy sea-going craft." The eight of 1909 was the first R.E. eight to appear at Henley since 1870.

A fortnight before the race its crew sustained a casualty, and a subaltern on leave from India who had not rowed for four years had to be hastily caught and dragged to Chatham. (Sankey's idea of restarting the rowing career of this unfortunate was a $7\frac{1}{2}$-minute "course" on the Medway at its roughest.) The boat, however, after a couple of days' coaching, most kindly given by that great Gunner oar, Gibbon, succeeded, in spite of its sea-going appearance, in defeating the Thames Club by half a length, and was beaten the same afternoon, after a close race, by a very strong B.N.C. crew, who had not rowed before that day and who drew the best station, a thing which meant much more on the old course than it does on the present one.

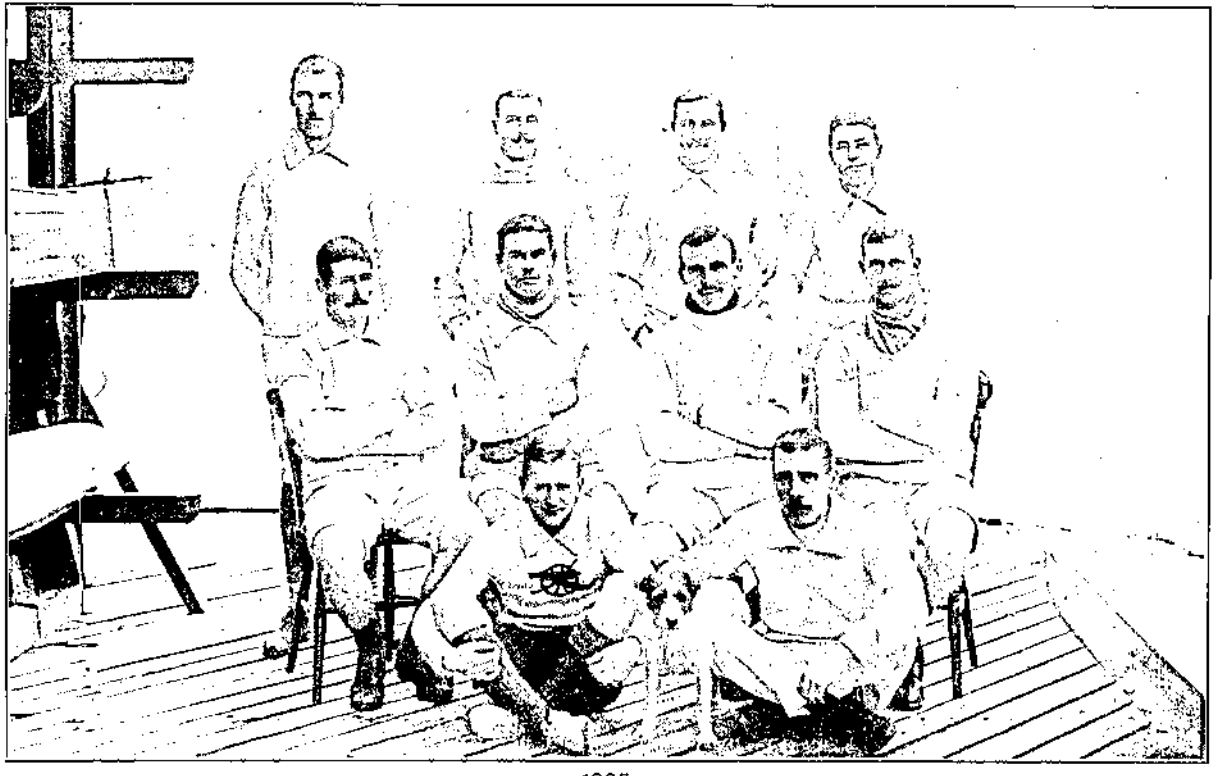
I have also a note or two on the 1905 four which may be of interest. Here again just before the race the crew sustained a severe blow, its main inspiration—Guy Pears—developing diphtheria. A distinguished officer of superhuman strength but literally no rowing experience was empanelled and, though the style of the four never quite recovered its previous orthodoxy, it inflicted the heaviest defeat ever given to a Gunner four. The umpire—Mr. Wylie, the famous artist—was in a small boat with J. O'Hara Moore, and he wished to give the result as eight lengths, but J.O'H. represented that this would mar the harmony of the succeeding Guest Night, and the official result remains on record at six lengths.

Those who had the good fortune to know J.O'H. (he was killed in France) would understand the reluctance of a comparative stranger to disagree with him at any time, especially when alone with him in a small boat. He was twice runner-up in the Army Heavyweights. The four owed an immense amount to its coach, Major Bailey.

Of the crew, Ginger Chase, the stroke, was killed in France when commanding an Infantry Battalion, and "bow," Dolly Gray, in Palestine while in command of the 1st Company, 1st K.G.O. Sappers and Miners—two among the heaviest of the many heavy losses sustained by the Corps.

Yours faithfully,

"EMERITUS."



1905.

Back Row (left to right).—R. R. Curling, R.A., H. K. Sadler, R.A., E. P. Le Breton, R.E., J. F. Gray, R.E.
Second Row.—A. A. Chase, R.E., R. Benson, R.A., R. F. A. Hobbs, R.E., R. H. D. Thompson, R.A.
Front Row.—W. Cowan, R.A., L. F. N. I. King, R.E.

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By LIEUT.-COLONEL E. W. C. SANDES, D.S.O., M.C.
(Author of "In Kut and Captivity," etc.)

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HISTORY OF THE 7th FIELD COMPANY, R.E., DURING THE WAR, 1914-1918.

A LIMITED number of copies of the above History, by Captain H. A. Baker, M.C., R.E., reprinted from the 1932 *R.E. Journals*, is available from the office of the Secretary, Institution of Royal Engineers, Chatham, price 1s. 6d. each post free.