VOL. LXVII. No. 2 JUNE, 1953

THE ROYAL ENGINEERS JOURNAL

CONTENTS

PUBL... EERS
CHA... 2669
AGE... HAM

THE ROYAL ENGINEERS JOURNAL—JUNE, 1953
VOL. LXVII. No. 2

THE ROYAL ENGINEERS JOURNAL

Authors alone are responsible for the statements made and the opinions expressed in their papers.

VOL. LXVII — CONTENTS — JUNE, 1953

CONTENTS

THE COUNCIL OF THE INSTITUTION OF ROYAL ENGINEERS

(Incorporated by Royal Charter, 27th February, 1923)

Patron—HER MAJESTY THE QUEEN

President

Major-General Sir Horace E. Roome, K.C.I.E., C.B., C.B.E., M.C., D.L. ... 1951

Vice-Presidents

Major-General J. C. F. Holland, C.B., D.F.C. 1951
Major-General G. N. Tuck, C.B., O.B.E. 1952

Elected

Brigadier C. G. Martin, V.C., C.B.E., D.S.O. 1950
Lieut.-Colonel F. A. Rayfield 1950
Colonel R. M. A. Welchman 1950
Captain J. L. Stevens 1950
Brigadier R. Gardiner, C.B.E 1950
Lieut.-Colonel W. H. Bond 1951
Major-General C. de L. Gaussen, C.B., M.C. 1951
Colonel A. R. Mais, O.B.E., T.D. 1951
Major-General I. S. O. Playfair, C.B., D.S.O., M.C. 1951
Colonel G. F. Hutchinson, D.S.O. 1951
Major W. W. Chapman, T.D. 1952
Lieut.-Colonel J. F. D. Savage, D.S.O. 1952
Lieut.-Colonel F. W. Simpson, D.S.O. 1952
Major-General J. F. D. Steedman, C.B.E., M.C. 1952

Ex-Officio

Brigadier F. C. W. Fosbery ... ... D/E.-in-C., W.O.
Colonel I. G. Loch, O.B.E. ... ... A.A.G., R.E.
Brigadier C. E. A. Browning, C.B.E., M.C. ... ... Comd., S.M.E.
Brigadier C. E. M. Herbert, C.B.E. ... ... D.Tn.
Major-General D. C. T. Swan, C.B.E. ... ... D.F.W.
Brigadier J. C. T. Willis, O.B.E. ... ... Dir. of Mil. Survey
Colonel E. S. de Brett ... ... D/Comd., S.M.E.
Brigadier R. P. G. Anderson ... ... Comd., Trg. Bde., R.E.

Corresponding Members

Lieut.-Colonel A. R. Currie, D.S.O., *New Zealand Military Forces* 1st January, 1949
Colonel J. R. B. Jones, D.S.O., O.B.E., *Canadian Army* ... ... 1st May, 1951
Colonel K. T. Gilson, D.S.O. *Union Defence Force, South Africa* ... 1st January, 1952
Brigadier R. R. McNicoll, *Australian Military Forces* ... 1st September, 1952

Secretary and Editor R.E. Journal

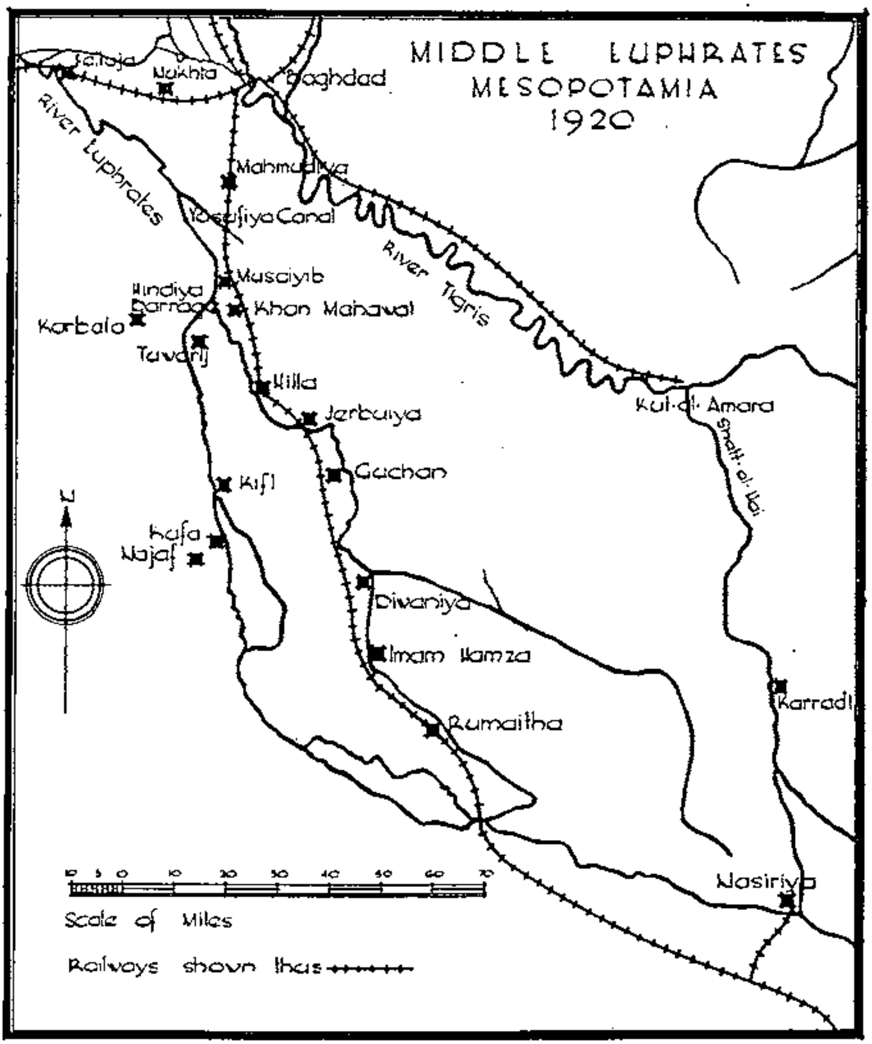
Brigadier C. C. Phipps, C.B.E., M.C. ... ... 13th January, 1945

Bankers

Lloyds Bank, Ltd., Cox's and King's Branch, 6 Pall Mall, S.W.I.

3,850. 1.6.53.

MESOPOTAMIA, 1920



WITH 61 FIELD COMPANY QUEEN VICTORIA'S OWN SAPPERS AND MINERS DURING THE ARAB INSURRECTION IN MESOPOTAMIA 1920

By " A.B.D.E."

THE Arab insurrection in Mesopotamia in 1920, though it gained little publicity, was by no means the least of our small wars. In fact, at one time, the safety of the British Garrison as a whole, with all the prestige throughout the East that this implied, trembled in the balance.

General Haldane, who was General Officer Commanding in Chief at the time, writes in his book as follows : " These twelve days in Baghdad in 1920, days that seemed like years, surpassed all earlier ones in the strain which they imposed. Not only at this period, but for several weeks, the situation of affairs was critical and the visions of the siege and the fall of Khartoum sometimes flitted through my mind."

For the cause of the insurrection we must go back to the Anglo-French declaration of 1918. This declaration stated that the intention was to give the Arabs in Syria and Mesopotamia independent National Government. About the same time a secret society was formed in Syria, its aim being to free the Arabs from any foreign control. The natural outcome of all this was the formation of a Nationalist Party in Baghdad.

However, in spite of the 1918 declaration, little was done to institute an independent Government and the army of occupation remained. In the two years that followed the declaration, the Arabs, led by the extreme Nationalists, became more and more hostile. In May, 1920, we accepted the Mandate for the country, but this did not give the independence for which the Nationalists were craving. Furthermore the priests of the holy cities of Karbala and Najaf had become frankly hostile to any form of organized government by a Western Power. They saw that the consequent bettering of the superstitious masses would seriously undermine their influence and their revenues would suffer thereby. They therefore allied themselves to the Nationalist movement, and sought and found ample opportunity of appealing to the religious fanaticism of the people.

The situation was not improved by the very wide dispersion of the army of occupation. Making allowances for the sick, etc., the number of British and Indian combatants was about 34,000. In addition to garrison duties through the country, guards were required for 15,000 Turkish prisoners. Also the safety of 1,000 British women and children in the Persian hills and of Assyrian and Armenian refugees had to be considered. Last, but not least, the L. of C., the maintenance of which was essential for military purposes, was 2,000 miles long. The mixed brigade, normally the only reserve in Baghdad, was in the Upper Euphrates area.

Hence in June, 1920, only 3,500 British and Indian troops were available as mobile troops, and of these only one battalion could reach the Middle Euphrates in twenty-four hours. To add to the difficulties rolling stock was scarce, the single-line railway was very vulnerable, and it was the hottest season of one of the hottest countries in the world.

At the end of May, a rising led by Turkish officers took place 200 miles north of Baghdad near Mosul, which was a hotbed of Turkish intrigue, and an Arab Levy officer and his two British assistants were killed. Two punitive armoured cars sent out were ambushed and their crews also killed. The set-back, although small, was serious and by the end of June the political situation in Baghdad and elsewhere had become alarming.

The incident which started the insurrection finally was trivial in itself. The Assistant Political Officer at Rumaitha reported that an outstanding agricultural loan of 800 rupees, about £60, was owed by a Sheikh in this area. The Sheikh was arrested as ordered and was detained at Diwaniya. However, his retainers killed the Arab guard and he escaped. This tribe then proceeded to tear up the railway line north and south of Rumaitha. As a result of this, the garrison there carried out a rash expedition to collect grain and burn a village as a punitive measure, sustaining sixty casualties, of which forty were missing. All the townsmen and tribesmen in the neighbourhood now became openly hostile and the siege of Rumaitha began.

On the 7th July a small column consisting of one squadron of Cavalry, one section Pack Artillery, and a battalion of Indian Infantry, endeavoured to force its way into Rumaitha with a small train carrying food, ammunition and water. About 5,000 tribesmen appeared, however, in a strong defensive position and the small relief force had to retire with the loss of some 220, including fifty killed. A dust storm which arose at the critical moment, probably saved the column which reached Imam Hamza, 18 miles north of Rumaitha, on the following day. A trainload of reinforcements, including 61 Field Company, Q.V.O. Sappers and Miners now arrived at Imam Hamza, and the Arabs lessened their pressure on the relief column. The company was the first Sappers and Miners unit to take part in this campaign.

From the 9th until 19th July there was a pause while a larger column, under Brigadier-General Coningham, with Major F. V. B. Witts, R. E., as Brigade Major, was being assembled for a second attempt to relieve Rumaitha. During this interval the company was employed on strengthening the post at Imam Hamza. Actually the village of that name was on the opposite side of the Euphrates from the post. Being on the bank of the river, the post, which was to be garrisoned during the relief column's absence, formed a good half-way house for the column on its retirement to Diwaniya.

Some grain was found in the village of Iman Hamza, so an aerial ropeway was erected to transport it across the river. Another task which fell to the company was the construction of double platoon posts towards Diwaniya. This was in connexion with a scheme whereby posts were made and garrisoned about every four miles along the seventy miles of railway from Hilla to Imam Hamza. As the force was tied to the railway it was fortunate that this was accomplished before the insurrection became too widespread.

However, a section of the company with a platoon of infantry found itself deposited one hot afternoon beside the railway line where a post had to be constructed. A site was selected, and a water tank and cookhouse installed by the infantry, whilst the Sappers erected a perimeter wire entanglement and constructed four Lewis gun emplacements. These were excavated in the sand and revetted with old " gunny " bags. Having finished, the garrison rested, but at 2 a.m. was rudely awakened by sniping, followed by a charge of Arab horsemen. The garrison, however, proved sufficiently determined and the attackers were soon dispersed, the casualties to the Garrison being one killed and two wounded.

On the 12th, the food shortage in Rumaitha was very serious. However, a well-organized sortie by the garrison, with the able cooperation of bombing 'planes from Baghdad, resulted in a supply of food for twelve days being obtained practically without loss. Also three boxes of small arms ammunition were dropped by 'plane. One killed a member of the garrison and the other two were only recovered from outside the perimeter at very considerable risk. The Garrison was now able to carry on until the 23rd. Actually it was relieved two days before this.

On 19th July the second relief column consisting of a Cavalry Squadron, one Pack and one Field Section Royal Artillery, 61 Company and five Infantry Battalions was ready.

After careful consideration it was decided to take a railway train with the column. The hampering effect of such an encumbrance was considered to be outweighed by the advantages it gave as regards supply, evacuation of casualties and the provision of a mobile hospital for cases of exhaustion and heatstroke. As circumstances might arise which would make it impossible to move the train forward with the column, two days reserve rations were loaded on army carts at Diwaniya and each man carried two days' food and an emergency ration.

The column moved off at 4.30 a.m. on the 19th July in the diamond formation generally adopted during this campaign. The train, guns, Sappers and Miners (less one section), the battalion in reserve and the transport were in the centre and the protecting troops forward, on both flanks and in the rear, the outer fringe being 1,500 to 2,500 yards distant. One section of Sappers and Miners was with the advance guard.

There was only sniping at first but at about 10 a.m. the column was confronted by a strongly held Arab position which definitely showed signs of the leadership and advice of Turkish ex-officers. It was based on three large embankments, remains of ancient canals, running parallel to one another from the Euphrates across the path of the column and into the desert on the west. In addition a number of enemy posts had been made on the farther (east) bank of the river. These posts were admirably sited to bring enfilade fire on troops attacking the main Arab position. They also denied the attackers access to the river for water. Access to the water farther to the rear was not practicable as the river diverged from the railway.

The battalion in the advance guard attacked with determination supported by the artillery and eventually by all the available infantry, without any appreciable success. The position of the column fighting for many hours in the intense heat and cut off from water was far from happy, but at 5 p.m. a battalion of Gurkhas arrived. They had come down that day by train and marched at once " to the sound of the guns." The column commander directed the battalion to the east flank and by nightfall it had established itself in posts on the river bank. The troops on or near that bank were thus able to get water but most of the widely scattered column had to go thirsty or drink from the stagnant pools in the bed of a dried up channel. The unsuspecting Company Commander was immediately and violently sick as a result of drinking such water laced with whisky, which his bearer, with the best intentions in the world, produced for his refreshment. Actually some of the Indian transport drivers spent the night collecting water in saucers or any shallow receptacle until there was enough in a bucket for a mule to drink.

Early next morning the Gurkhas waded across the river with the water up to their arm-pits and established themselves on the far bank. It was now found that the Arabs had evacuated the main position and serious opposition ceased. The cavalry reached Rumaitha the same afternoon, and the garrison was escorted out the next day by a column made up of representatives of all units in the relief column, including a section of 61 Company.

On 22nd, the day after the relief, the withdrawal towards Diwaniya began. The column was pressed closely by the Arabs, with whom a rearguard action had to be fought most of the day. At about 7.30 a.m. under cover of a dust-storm a large party of tribesmen fell on the rearguard battalion. There was some disorganization and for a short time the situation appeared to be critical until restored by the British battalion which was in reserve. The pressure by the Arabs was not sustained beyond their tribal boundaries. One of the company drivers distinguished himself during the rearguard action. His mule having been wounded and unable to proceed, he remained behind until discovered by a party sent back with an engine and some trucks to pick up stragglers. The officer in charge of the party shot the mule and placed the driver on the train with the saddlery, which the driver was in the process of removing from the animal when found. He was decorated with the Indian Distinguished Service Medal four months later. Prior to this he was wounded in action south of Hilla. The column reached Diwaniya on 25th July having picked up on the way the garrisons left at Imam Hamza and other posts.

For one day's march during this withdrawal the company performed the duty of advance guard to the column, two sections being in the vanguard and the remainder of the company in the main guard. Thus ended the first major operation.

* * * * *

The company was soon to be on the move again, as on the day prior to the column arriving at Diwaniya, a serious disaster had occurred to a column near Hilla. Through the persuasion of the Political Officer at Hilla, this column was sent to demonstrate towards Kifl in order to impress the wavering tribes in this area. On the second evening out, about fifteen miles from Hilla, the column had almost prepared its night camp when it was surrounded by Arabs. Although the men were greatly exhausted by their exertions in the intense heat, it was decided to withdraw towards Hilla by night, and only half an hour was given to organize. The Arabs caused a stampede of the transport animals during the withdrawal, direction was lost, and the column became disorganized. The result was the loss of 200 killed, 150 prisoners and one 18-pounder gun. In consequence the rebellion became more widespread and the Kufa Garrison, 33 miles south of Hilla, was besieged.

The direct result was that a withdrawal to Hilla was an urgent matter as practically the only troops immediately available were at Diwaniya. As a preliminary, a section of the company was sent out on a railway construction train with an infantry escort and Indian Labour Corps. The object was to proceed as far as possible towards Hilla and open up the railway. The party had not proceeded very far before a break in the permanent way was found. As there were Arabs in the vicinity the Infantry and Sappers and Miners formed a screen some 500 yards from the train to protect the Labour Corps who commenced to repair the break. Ammunition ran short. The Sappers and Miners bugler was ordered to proceed by a covered route to the train and bring up more ammunition. However, on his own initiative, he took the shortest way there and back over the open desert under considerable rifle fire and undoubtedly saved the situation. Eventually the party with the train were able to retire to Diwaniya, having accomplished little.

The withdrawal from Diwaniya to Hilla was a peculiar operation in that a train half a mile long was an essential part of the column. The available road transport was quite inadequate to carry the available six days' rations for the whole force, while ammunition sufficient to fill 300 army transport carts and 23,000 gallons of water had to be taken. Also rolling stock was so scarce that to leave it behind was out of the question. Furthermore a few trucks with an engine were converted into a protective train carrying two armoured cars and two machine-guns and these did excellent work with the rearguard.

The Arabs had by now made a " dead set " at the railway line, carrying away sleepers to their villages, bending rails and damaging bridges across nullahs. It was, therefore, often necessary to take the entire track up from behind, a hundred yards or so at a time, carry it along the whole length of the train and relay it in front. The train moved on and the process was repeated. This laborious work had to go on for twelve hours a day exposed to the full glare of the sun. The working party consisted of 61 Company, a battalion of Sikh Pioneers and 2,000 Labour Corps, and working all out the average progress was 5½ miles per day.

The Arabs who viewed the destroyed line, often quite bare of rails and sleepers after the column had passed, were disposed to credit the commander with supernatural powers in moving the train along.

For the company this was not the only work, for a road had to be made alongside the railway for guns and transport. This entailed for the most part continuous filling in of depressions and the crossing of nullahs.

The withdrawing column was roughly the strength of the one which relieved Rumaitha with some additional artillery, and as it advanced it collected the garrisons of the posts which had been put out earlier to protect the railway at certain points. The withdrawal began on 30th July, the diamond formation again being adopted. As the column proceeded, the damage to the railway became greater and the progress consequently slower. The time was utilized in burning villages near the line of march and shelling the more distant ones. The Arabs contented themselves by sniping during the day and when the column was halted in camp at night. The camp at night was formed around the train, the advance, flank and rear-guards having closed in from their day positions and occupied defensive positions surrounding the camp.

On the 1st August the repair to the railway was progressing in two directions, as an isolated train at Guchan, from which area the Arabs had cleared, was working towards the column. This train had originally attempted to get through to Diwaniya, but was forced to remain at Guchan under the protection of its escort. The trains met on the following day and the whole proceeded to Guchan where water tanks were filled. The combined train was now about one mile long, including as it did some 183 trucks.

The next stage in the withdrawal operation was the preparation for the crossing of the Euphrates at the Jerbuiyah railway bridge. As a preliminary, on 3rd August a battalion of Sikhs escorted a construction train out of Guchan with orders to repair the railway line towards the bridge as far as possible. A good deal of repair work having been accomplished the force returned before dark. The repaired line was protected during the hours of darkness by intermittent fire from artillery, and machine-guns.

The next day saw the column on the move again, but beyond the portion repaired the previous day, the line was very extensively damaged. Also to add to the difficulties the heaviest of the locomotives, the type which has " eight of everything," and some wagons left the track. The excessive heat and the necessary rapidity of repair had caused the track to buckle. This delayed the column for 5½ hours, during which time the Arabs did more damage ahead. It was not until early on the following morning that a position was reached from which the operation of crossing the river could begin.

The advance began at 8.45 a.m. on the 5th August and by 12.30 p.m. all objectives were taken. The Gurkhas were once more to the fore, as at Rumaitha, and waded across the river and occupied a small village on the other side. The Arabs now retired, but not before they had suffered very heavily. In spite of what might have proved to be a " sticky " operation, the casualties were only fourteen Indians wounded in the whole force. Everything now closed up as near to the Jerbuiya bridge as possible.

* * * * *

The company's next task, assisted by a section of 9 Field Company, Q.V.O. Sappers and Miners, which was part of the Jerbuiya bridge garrison, was to make the single railway track across the bridge suitable for wheeled traffic. This was done by laying extra sleepers throughout. In addition the approaches had to be improved. There was little suitable screening material immediately available, and the time factor was vital. In consequence the passage of each vehicle over this forty yards of narrow bridge provided a thrill, more especially was this so in the case of the guns drawn by six-horse teams. However, only one army transport cart containing shells, and an officers' mess cart, with the Gunner " wine cellar," suffered immersion. By 7 p.m. the whole force and train had completed the crossing and were assembled at Jerbuiya station.

By the afternoon of the 8th, with the aid of a further construction train from Hilla, the line to that place was restored. The combined trains now consisted of six locomotives and 250 trucks, about half the total rolling stock in the whole country. This train proceeded to Hilla the same night. The column followed on the following day without incident, having taken eleven days since leaving Diwaniya with only six days' supplies. The Commander's early decision to restrict the issue of rations had proved a very vital one.

This completed the second major operation in which the company was concerned.

* * * * *

The small post left at Jerbuiya was withdrawn later in the month of August and then the Arabs burnt the bridge.

The situation was too serious for any rest to be allowed and the day after its arrival at Hilla the company was again in a column. The object of this operation was to reoccupy the Hindiya barrage, which had been built to control the supply of water to the Hindiya and Hilla channels into which the Euphrates divides.

Its early recovery was necessary for four reasons :—

(*a*) The stations on the railway to Baghdad depended on the canals leading from the river for their water supply.

(*b*) Hilla, which acted as the base in this area, could be cut off from water, if the Hilla channel regulators were closed by the Arabs.

(*c*) If Kufa was to be relieved the route to be followed was watered by canals from the Hilla branch.

(*d*) We could deprive, or threaten to deprive, many of the insurgent tribes of water. At this time of the year the lack of water meant the complete destruction of their crops.

The column marched out of Hilla on 10th August and proceeded along the railway to Khan Mahawal and eventually to Musaiyib and the Hindiya barrage. By the 14th the barrage had been recovered and infantry posts made, two 18-pounder guns being left to assist the defence. A small garrison was also left at Musaiyib where a boat bridge across the river existed.

As for the Sappers the work consisted of improving the rough track from Khan Mahawal to Musaiyib by filling in the innumerable small depressions that existed. In addition the company with other units constructed wired sandbag blockhouses along the railway to Khan Mahawal and then along the road to Musaiyib. These were built and garrisoned about every half a mile and ensured a protected L. of C. to the garrisons at the barrage and Musaiyib.

By this column a certain amount of punitive action was carried out, some thirty mud villages being destroyed. Also, except where we required water for our own uses, all canals commanded by the blockhouse system were dammed. Especially was the country to the east of the railway affected by the consequent lack of water.

Whilst at Musaiyib, Company Sergeant Major Mainwaring, one of the three British non-commissioned officers in the company, became ill and died. He was buried there, the firing party being provided from the British troops available and the service being conducted by the Company Commander.

This third operation was concluded when the column returned to Hilla on 24th August.

* * * * *

The fourth operation was the relief of Kufa which had been besieged for a month, but still had sufficient supplies and ammunition to hold out for some time.

At Hilla the situation was now secure as the Public Works Department had constructed a perimeter consisting of thirty-two brick blockhouses surrounded and connected by wire entanglements. As a result one battalion was sufficient for its defence. By now, too, the railway from Hilla to Baghdad was again open and blockhouses established throughout its length, a party of Sappers and Miners having been working from the Baghdad end. These blockhouses were of sandbags, were about twenty feet in diameter, contained a 400-gallon tank for water, and were provided with a 160 lb. tent cover as a roof.

A minor operation was necessary as a preliminary to the actual relief of Kufa. In order to ensure that convoys of supplies reached troops operating towards Kufa, it was decided that the L. of C. from Hilla to Kifl, which was on the way to and only twelve miles from Kufa, should be along the road south of Hilla, and the Nahr Shah and Rustumiya canals. By this route water was available all the way.

The Nahr Shah Canal takes off from the right bank of the Hilla branch of the Euphrates, 2½ miles below Hilla. On this stretch the banks were covered with a dense belt of date palms and the road to be used was close to the right bank of the river, which was only about fifty yards wide. The Arabs had been in the habit of occupying these palm groves in considerable strength. It was certain that, if they were not driven out, they would seriously interfere with the passage of boats from Hilla to the mouth of the Nahr Shah Canal and also with the use of the road to the same point.

On the 6th September the troops moved out from Hilla on both banks with the object of constructing a sandbag blockhouse line, protected by a continuous wire entanglement, on both sides of the river and a mile below the mouth of the Nahr Shah Canal. At first there was little opposition except sniping, but on the following day the resistance became much more stubborn. As the infantry slowly moved forward, 61 Company and a battalion of Sikh Pioneers constructed the blockhouses and wire entanglements on the right bank, whilst another party carried out a similar task on the left bank. By the 8th this minor operation was successfully concluded, the total casualties being twenty killed and seventy wounded.

* * * * *

It was now decided that the force for the relief of Kufa should advance in two columns. One along the bank of the Nahr Shah Canal which was to be the eventual line of supply to the whole force, and the other along the Hilla–Kifl road. Both columns were to keep abreast of each other. Another independent force operated farther to the right and eventually captured Tuwarij on the Hindiya branch of the Euphrates.

The advance commenced on 12th September and as the left column progressed the company was employed with the Sikh Pioneers on more wired sandbag blockhouses along the Nahr Shah Canal. Garrisons were left as the column proceeded and these assisted the small party of sappers at each. The sappers rejoined the Company the same day on conclusion of their task. The provision of the necessary stores was greatly facilitated by the fact that the canal was navigable by country boats for a considerable way.

The columns carried out punitive expeditions during the advance and stopped the flow of water in every canal where it was of no use to the force. These were in particular those canals running eastward from the Nahr Shah Canal and to the west of the Hilla–Kifl road. Many tribes were thus deprived of water.

There was considerable opposition at the Rustumiya Canal, but this was overcome. On the 14th the two columns met where the Rustumiya Canal meets the Hilla–Kifl road and reached Kifl on the same day. Blockhouses had now been constructed throughout the route from Hilla to Kifl via the Nahr Shah and Rustumiya canals.

In order to relieve Kufa it was necessary to cross the Euphrates at Kifl. The 1st K.G.V's.O. Sappers and Miners pontoon bridging train was dispatched from Hilla on 15th and arrived at Kifl at 2.30 p.m. the same day, after an 18-mile march. The 100-yd. gap was bridged by the train in 2½ hours. The company remained at Kifl, but a large column, ably assisted by low-flying aircraft, was able to relieve Kufa on the morning of the 17th. This column remained in this area for some time carrying out punitive expeditions, eventually occupying the holy city of Najaf.

The company in the meantime, with the assistance of Pioneers, was employed in demolishing the Arab portion of Kifl, the Jewish part in the centre being left intact. Kifl was quite a large town and the houses or huts were mostly of mud. The flimsy roofs were first burned and the mud walls flattened. The walls were often 3 ft. thick at the bottom, decreasing to 1 ft. at the top and were built in several layers.

The better-class houses were built generally with brick pillars at intervals, with panels filled in between them. By tackling the pillars with guncotton or dynamite, which was more plentiful, for a small amount of explosive the demolition was spectacular and complete. In other cases the houses were built with cellars. After blocking the entrance the firing of a gunpowder charge placed in the cellar proved effective.

The only opportunity the company had of destroying a tower in the approved manner was frustrated by a Political Officer. He forestalled everyone at a prominent insurgent's domain a few miles outside Kifl and burnt the floors and roof of the tower. By the time the company demolition party had arrived the floors and roof had fallen in. The actual house, however, being built on pillars presented an easy demolition problem.

Towards the end of the company's time at Kifl a small column was sent out to collect grain from and burn a village on the river south of Kifl. The only troops available were those left behind at Kifl and in consequence the company had another experience of infantry duties, as left flank guard to this punitive column.

It must be realized that at this time, columns were also operating north of Baghdad, and around Samawa. The 6th Division had been sent out from India as reinforcements. Samawa, which had been besieged, was relieved on 14th October, and this ended the major operations.

As a result of the efforts of a squadron of aeroplanes and further punitive measures by various columns all tribes had surrendered by 16th November, and the company returned to Hilla from Kifl at the end of November. There only remained now the task of disarming the tribes and impressing them by a show of force in every part of the rebellious area, however inaccessible. By the 25th November columns had visited practically every part of the country, some of the inhabitants seeing the British forces for the first time.

* * * * *

Among the areas still left to be dealt with was the triangle formed by Musaiyib–Falluja–Baghdad. It fell to the lot of 61 Company to accompany this column. The column started out from Hilla on 2nd December, the weather now being very cold, and the ground covered with a thin carpet of snow. The column marched 56 miles up the Hilla branch of the Euphrates to the mouth of the Yusufiya Canal, where it was joined by another column which had been "showing the flag" along the Baghdad railway line as far as Mahmudiya. Continuing on up river to Falluja about another thirty miles, where it arrived on 10th December, the column then proceeded by Nukhta to Baghdad. At Nukhta, Colonel Leachmann had been murdered early in the insurrection. Colonel Leachmann, who was in the political department, was considered to be a second Lawrence and it was said of him that he could stand the rigours of the desert better than the Arabs themselves.

Throughout the march there was continuous work for the company, mainly road work, demolitions and water supply. The obstructions to wheeled transport in the nature of water channels, etc., were perpetual. All the sappers were put in the advance guard, a detachment being in the vanguard.

From Baghdad to Hilla the company travelled by train and was at last able to get a little respite after operating continuously for practically five months.

* * * * *

Shortly after, orders were received for the Company's return to Bangalore, Headquarters Q.V.O. Sappers and Miners, for disbandment. *En route* to India, however, it took part in one more operation from Kut-al-Amara.

This operation consisted of a march through the territory of the Muntafiq Confederation. This group of tribes inhabited the area between the Tigris at Kut-al-Amara and the Euphrates at Nasiriya, their territory being watered by the Shatt-al-Hai which leaves the Tigris at Kut-al-Amara. It was an extremely powerful confederation and had caused the Turks much trouble in the past, more than one Turkish expedition against it ending in disaster. It was considered, therefore, very desirable to give a practical demonstration of our power to move troops through their territory.

In the middle of January, 1921, a column under Brigadier-General Dent set out from Kut-al-Amara to the south, 61 Company being included. The difficulties as regards transport were considerable as the column depended largely on river craft and the water suddenly dropped very low. However, all difficulties were overcome and on the 24th January, at Karradi, the column joined hands with a column which had advanced northwards from Nasiriya.

So ended the 61 Company's activities in Mesopotamia. The campaign had required of them incessant work for seven months, and over 400 miles was covered by route march. The first and most active part of the operations had taken place during the hottest part of the year, the shade temperature averaging 110°F at times. Throughout, all ranks had worthily maintained the traditions of their Corps. Eventually, on 19th March, the company arrived in Bangalore and by 5th May, 1921, its disbandment was completed.

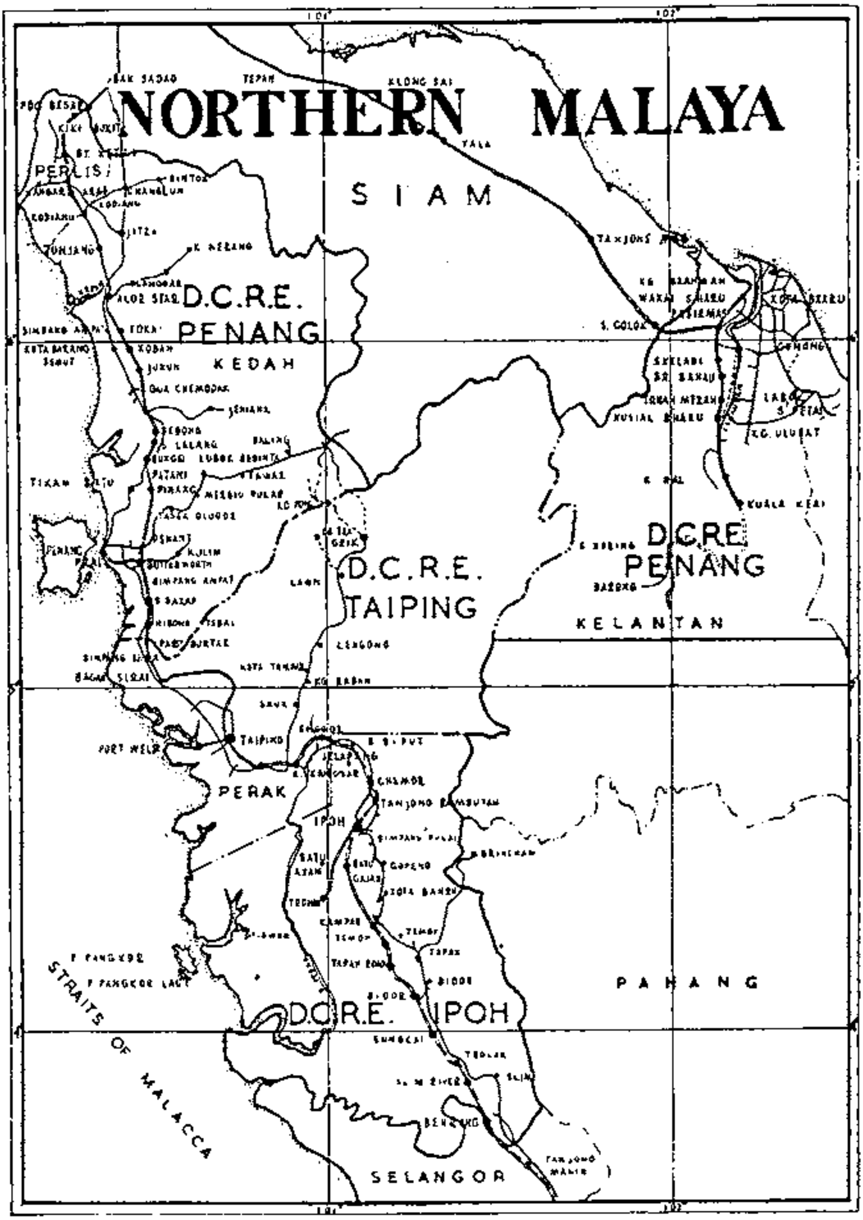
MY INTRODUCTION AS A C.R.E. TO MALAYA

By LIEUT.-COLONEL J. W. BOSSARD, M.B.E., R.E.

NOTE.—This article was written over a year ago. Since then Sir Gerald Templer, a man of great drive and personality, has been appointed High Commissioner. The impact of his advent has been felt throughout all levels of Malayan society, and not least amongst the terrorists. The situation is slowly but surely improving, and if the present trend is maintained the end of the emergency is a foregone conclusion. When, is unpredictable, but confidence in the Government, the Army and the Police is returning. When that is back to normal the bandits' day is over.

I ARRIVED on the *Empire Orwell* in Singapore on 16th June, 1951, as C.R.E. Central Malaya (designate). I was met on board by a Staff officer who told me my appointment had been changed! Colonel Cross had been shot and I was to go as C.R.E. North Malaya in his place. Three days later at dawn I found myself in Taiping, having travelled north by the night train and met C.E. FARELF, C.E. Malaya, and the G.O.C. *en route*. John Cameron, C.R.E. Central Malaya, whom it was first intended that I should replace, welcomed me at Seremban on the way through; brought me breakfast; and told me a little of the personalities I should meet, and something of what to expect. This was a very cordial and pleasant gesture to the "new boy," since I knew little of Malaya. My previous tour had been in Singapore.

That first morning I met my H.Q. Staff, 90 per cent of which were civilians, and of these by far the greatest number were Chinese. My three Staff officers, A.C.R.E., Adjutant and E. & M.O., were all Short Service officers; "ex-boys" and sound reliable chaps. One quickly felt that there was little to worry about in each of their departments, and to a C.R.E. with enough to do that meant a lot. I decided that by and large the civilians were all "over-graded," but any attempt to down-grade them to their real level would mean that they would leave and find new employment. Such is the false level at which labour values stand at the moment. In some ways too they seemed incredibly foolish. Debt amongst them was rife. I found one who had borrowed $800 in 1948 and up to date had paid $2,970 back in interest at 10 per cent per month. He still owed the $800! So my welfare problems had to include civilians as well. The military members of the Staff were keen enough but very inexperienced and, therefore, needed constant supervision. For instance my Chief Draughtsman, in charge of a drawing office of eight others, where all the "horrors" are initiated, was a corporal


NORTHERN MALAYA
SIAM
PERLIS
D.C.R.E.
PENANG
KEDAH
D.C.R.E.
TAIPING
D.C.R.E.
PENANG
KELANTAN
PERAK
IPOH
D.C.R.E. IPOH
PAHANG
STRAITS OF MALACCA
SELANGOR
TAIPING
BUTTERWORTH
ALOR STAR

of three years' total service and three months in his rank! Small wonder then that I had to vet every drawing myself, in detail, and check every dimension, before signing it. Each one had to go back for amendment, and many are the times that I was thankful that in my younger days in civilian life I had drawn my pay as a top rate draughtsman and designer.

I met, too, the Staff of the D.C.R.E. Taiping. The same comments applied to them. Clerks of Works and Foremen of Works in civilian personnel were poor compared with their opposite numbers in U.K. They appeared incapable of exercising real control and command of the job and seemed doubtful of their responsibilities. The general standard of work was much lower than I expected and contractors were taking advantage of the prevailing conditions with a refined form of blackmail. It was necessary to decide whether to accept bad work and have it on time, or ignore our target date and insist on a good job. It needed some drastic action and at the expense of being thought a "new broom" I started. The D.C.R.E., who was there as a learner in "Works" had a tough time. He lived on my doorstep and was badgered from morn till night. Whenever I wished to know how anything was done in Malaya I naturally asked him, or visited his work. I felt really sorry for him. But I needed to be firm since I was making the bed on which I was to lie for the next three years. And three years in Malaya is a long time. I pulled down roofs; I leaned against walls and they fell over; I tore wall brackets and shelving off walls that had not been plugged and adequately fixed; and I had up drainage that had been filled in before the manholes were built, and up which I could not even push my swagger cane without meeting some obstruction. All the old dodges that I learnt in my Y.O. days were too evident—leaving odd screws out of brackets and hinges so that sashes were fixed with eight instead of sixteen screws; the use of steel screws with brass fittings; concrete that was beyond description; and a thousand and one other methods of defrauding the W.D. I had several red-letter days, watched by the contractors' staffs with open-mouthed astonishment. It all had the desired effect!

I also met the Brigadier and the Staff of North Malaya Sub-District—the people with whom I have to work in very close contact. I was told subsequently by one of them that the Brigadier said of my posting "The new C.R.E's. name is Bossard and he is called Bossy. I hope he doesn't boss me!" I, too, had heard a thing or two—that he was a peppery old so-and-so and had made mincemeat of my predecessor. So, working on the basis that you must have your General where you want him, I went about it carefully and so far all has been well. As is so often the case I find him very likeable—and I'm still whole!

I went on tour. My parish extends from the Siamese border in the north to Sungkai in the south, and between the east and west coasts. It is a large area in which travel is not easy. The main road north and south runs through the western half, and minor roads lead into it. In some places it is good and fast, and in others it is very bad and not up to the standard of a second-class English country road. For a main strategic artery it leaves much to be desired. It runs through miles of rubber ; miles of coco-nut palms ; and miles of jungle, " dense and miscellaneous " ; all of it excellent cover and all of it green, and more green, and monotonously so. One longs for the colour and variety of the English countryside. There are no lateral roads from east to west. All roads are classified according to the prevailing bandit activity. On some one can travel solo but armed ; on others a full armoured escort is necessary—and advisable ! Even the main road is " coloured " during the hours of darkness, but that doesn't prevent me visiting Penang for a swim in the afternoon ; a dance in the evening ; and a fast car ride back in the early hours of the morning. All this adds spice and variety to life and one never knows what to expect when rounding the next bend in the road. My staff car has only been involved once to date, and I wasn't in it ! I was flying overhead with C.E. FARELF. The car was following close behind a police patrol when a burst from a bren killed a Malayan constable. I now avoid the company of security forces mounted or otherwise, like the plague, in case they draw fire, and I never tell anyone where I'm going. In spite of that I think that on the law of averages my day will come, and I can only hope they shoot less accurately than usual.

The railway runs from Singapore to Alor Star and is single line. It is often interrupted by bandits. Travel on it, too, has an air of adventure in that you start, but never know when you will reach the other end. One young Signals officer from here was derailed no less than three times in a week, but that was exceptional and occurred in October when the bandits rather let themselves go. A pilot train leads the way and we are all full of admiration for the drivers and firemen of it. Lately the pilot train has been let through and the main train derailed. There are surprisingly few casualties for the number of incidents that occur, and there are surprisingly few incidents. It is my opinion that they could close the railway completely whenever they wish—such is the country through which it runs.

Telephone communications are grim. Daily there is anything up to five hours' delay between here and H.Q. Malaya at Kuala Lumpur, 200 miles away, and a corresponding one between myself and the D.Cs.R.E. And when you do finally get through a female voice keeps cutting in and saying " Your time is up. I must disconnect you now," and then " click," and she has done it. In a sense I am lucky. I am authorized to make priority calls, but I often wonder how my staff ever manage. Wireless communication too is difficult—perhaps because it is a very bad country for it. Fortunately we do not rely on it, and my experiences are confined to sending signals that I will arrive at such and such an operational camp and require an escort and on arrival finding no one knows I am coming. It means that I have to plan my moves well ahead so that people concerned can be warned by normal means.

To get to the more inaccessible places I fly, usually in a little Auster. How I love them ! To get anywhere east I have to cross the mountains that rise steeply half a mile from here to an average of 4,000 to 5,000 feet. There are several ranges of them between here and the Perak River Valley and they are covered in very dense jungle and look most inhospitable. About midday the weather over them deteriorates rapidly so the pilots request that you leave early and plan to return by noon. The aeroplane seems to grind away and struggles up the mountain side, and just when you are certain it can never make it, it skims over the tree tops and down the other side and you sit back and relax, and thank God for that. Occasionally I fly in one to Grik, a place that takes all day to reach by road and is a journey that needs a full escort. It is an even bet that you get shot up. Recently D.C.R.E. Taiping was on his way there and popped round a corner with his armoured escort and there, in the middle of the road, stood a bus with the passengers lined up by seven bandits. It would be difficult to say who was the more surprised. The bandits fled, followed by a hail of bullets, none of which found their mark, and the bus was left burning merrily. Once again the old cry—" If only the standard of marksmanship were better." By air it is but thirty-five minutes. I left Grik on the 1st October on a return flight at 1 p.m., and ran into bad weather when trying to cross the mountains at the usual place. We turned back and tried further south and when that didn't appear possible we climbed to 5,500 ft. above the clouds and altered course for Taiping. We must have been half-way across when we met more cloud and rain and as we came out of one bank we saw two pillars of cumulo-nimbus directly in our path. We missed one but must have run into the other. The aircraft was thrown about like a leaf in a gale and as it was in dense cloud I had no idea whether we were upside down or downside up. I then realized we were out of control and in a power spin and losing height at a fantastic rate. I couldn't hear or breathe and my tongue was jammed against the roof of my mouth. I felt an appalling lurch and feeling in my tummy and realized the pilot had pulled us out. The next instant we broke cloud and there were the tree tops—right at the wing tip. We tore through them obliquely, shedding wings as we went, with a terrible rending crash that seemed to go on and on indefinitely.

When I came to I was hanging upside down in my harness amidst the wreckage, about nine feet from the ground. The pilot appeared to have been catapulted in his harness back behind me into the fuselage. The plane was literally wrapped round the base of a huge tree that must have been at least a hundred feet tall. We struggled out and lay for a time under the pieces ; trying to keep dry in the torrential rain and also collecting our wits ! The time was 1.30 p.m. and we had crashed 3,900 ft. up on a steep slope, from which we could see absolutely nothing through the dense umbrella of foliage above and around us. My companion had a nasty gash over the eye that was bleeding profusely and I appeared to have a broken rib. It hurt abominably and breathing was agony. I found the first-aid kit and dressed his wound and we lay there and discussed what to do. The pilot said we must get a fire going and make smoke so that searching aircraft would find us and direct a rescue party to us. I couldn't see us lighting anything in that weather, let alone a fire ; nor could I imagine anyone seeing us from the air. The jungle was much too dense. So we built a shelter but got soaked to the skin doing it, and then lay under it, bitterly cold and shivering as I've never shivered before. By 5 p.m. I decided there was no future in it, and our only chance of survival was to get out under our own steam. We estimated that we had crashed a little East of Taiping and we could either go west and make for it, or east and make for the Grik Road. I couldn't climb over the top to go west, so we went downhill, east. If we could only strike a stream we were safe. They all went eastward to the Perak River and all crossed the Grik Road. We collected the two jungle survival packs from the aircraft and started. Never have I undertaken such a nightmare of a trek. My rib was hell and my leg ached in no mean way. We stumbled and fell—sometimes as much as thirty feet down the steep slopes—breaking our fall with the thick undergrowth, and after each tumble inquiring if the other was all right. We made the stream in an hour and followed its course for another hour before darkness overtook us. We made a bed of leaves in what little shelter we could find and lay in each other's arms in the rain ; trying to keep warm, and shaking and trembling from uncontrollable fits of shivering. God ! what a night ! Never have I seen such blackness. Never have I been so cold. At dawn it took us half an hour to get up in the standing position and start moving, so stiff were we. It was the only time I thought we should never make it. But make it we did. We kept to the stream and only left it when its course became too rough or impassable, as at waterfalls, and even then we kept within sound of it. At noon we came out into a clearing where there were two or three squatters' huts and some cultivation and we lay for half an hour warming and drying in the sun, and searching the area inch by inch in case there might be bandits. We discovered that we were smothered in leeches. When satisfied we moved on and as we crossed it a " Brigand " flew over and we fired a Verey light which the pilot saw. It came round again much lower and wirelessed back that two people, believed to be us, had been sighted. Back in Taiping this caused much jubilation as everyone by now had given us up. Unfortunately it gave the wrong location so no one met us. We crawled the last mile down a track to the Grik Road and reached it at 1.30 p.m., aching and exhausted, exactly twenty-four hours after crashing. We were picked up by a Chinese lorry whose driver brought us the twenty-seven miles to hospital at Taiping. The bed into which they put me was heavenly. My rib wasn't broken, only badly bruised, but I had a horrible great contusion on my thigh that had to be opened and drained. The pilot had cracked his spine and was put in plaster, and for a week the two of us realized just how much one's body can really ache. A fortnight there and a fortnight's leave in Penang and I was back once more on the job.

No picture of Malaya can be complete without its background of bandits, since it affects our whole life. At the beginning of the war the Malayan Communist Party, unrecognized, and mainly Chinese, offered its services to the British authorities in their fight against the Japanese. These services were accepted and the Resistance Movement was, in a sense, born of the Communist Party. During our absence from Malaya in 1942 and 1943 this movement developed rapidly and was largely organized and controlled by the Malayan Communist Party. It raised the military side that became known as the M.P.A.J.A.—the Malayan Peoples Anti-Japanese Army—whilst the M.C.P. itself concentrated on dissemination of Communist propaganda ; boosting the spirit of resistance ; and supplying the guerilla army. At this time it was already thinking and planning the take-over of the government of Malaya when the war was over, and when the British returned with large military forces it realized that its plans must wait. It therefore adopted a policy of co-operation, contenting itself with obtaining control of labour through the various and numerous trade unions ; forming Communist youth movements ; and infiltrating Communists into public utilities, government departments, education, welfare, and the like. All the top men worked under cover.

Early in 1947 dissension broke out within the party executive and this resulted in the end of Loi Tak's leadership, and his liquidation. It became evident that he had not only defrauded the party of large sums of money, but had collaborated actively with the Japanese during the occupation. Internal criticism within the party grew rife and some change of policy became necessary if the Executive Committee was to maintain its hold over the party. By 1948 the economic and political recovery of Malaya was established, and was such that the Communist Party would certainly lose its influence unless this improvement could be retarded, or even reversed, and, probably in March, the Executive Committee decided upon an armed struggle against the Government. When the British authorities accepted their offer of help early in the war some 200 Chinese were recruited by the Party and trained by us in guerilla warfare. They were subsequently placed in parties behind the Japanese lines and supplied with explosives and arms which were secreted in dumps for use as opportunity arose, and the leader of each party was given a lump sum of money for expenses. These parties formed the nucleus on which the M.P.A.J.A. was built. Early in the campaign they took considerable offensive action against the Japanese, but later passed to the defensive as the Japanese tightened their control of the country. From 1942 to early 1945 our contact with them virtually ceased and in February, 1945, when it was regained we introduced liaison officers to what had become an extensive organization of some eight groups, that in turn were split into a number of small camps hidden in the jungle. Seven of the groups were given British liaison officers, but the one in East Pahang was not, and all but this one changed its organization to co-operate with us in our proposed attack on Malaya. We supplied them with arms, ammunition, and equipment by air and prepared them for co-operation in our coming invasion.

Then came the Japanese surrender, and in December, 1945, the disbandment of the M.P.A.J.A. Unfortunately this disbandment was not complete, and although all the arms supplied through the liaison officers were returned, others were not. These included those obtained from Japanese and other sources during the war, and those that had been mis-dropped from the air and never reached the liaison officers—sten guns, pistols and carbines. They were hidden in caches up and down the country for the future use of the M.C.P. It is estimated that some 4,000 men formed a clandestine organization, many of them trained and experienced, and many from the group that had not been in contact with, and therefore were unknown to the British liaison officers. They were formed into nine or ten regiments, each based on a State, and subdivided into patrols of about a hundred men. This then was the force available to the Malayan Communist Party in 1948, and eventually it became known as the Malayan Races Liberation Army. It obtained its funds and supplies by subscription, and by extortion, to which the Chinese are very susceptible. It is now our present enemy. It is extremely mobile, in that it works from no fixed base and lives as it goes, and it is very elusive. It pays for it to be so and the country lends itself to such

Photo 1.—One of ten new Married Officers' Quarters in the Major Unit Camp at Ipoh

Photo 2.—B.O.Rs. Married Quarters nearly completed at Penang

My Introduction As A C.R.E To Malaya 1,2

Photo 3.—View from the Officers' Mess, Taiping

Photo 4.—The Ghurka Regimental Training Centre at Sungei Patani. This will be our next big job

My Introduction As A C.R.E To Malaya 3,4

tactics. In a pitched battle it would be all over within a fortnight. As it is, it pins thousands of men to the ground. Its personnel come from all walks of life ; some of them very active and some very " under cover." One's own cook or bottlewasher may even be in their ranks. Occasionally a bandit surrenders, and talks, and as a result some quite surprising arrests are made, in some cases within active operational units. One never knows friend from foe !

To combat all this we maintain Federal and British troops in the country. The Federal resources include the Malay Regiment, the Police Force, the Special Constables, the Auxiliary Police, the Jungle Companies, and the Home Guard. Of their efficiency and efficacy I'm not in a position to pass comment. The British Government has very many front-line troops on operations, and the British public pays for them. The Federal Government pay for Federal troops. A sore point with many soldiers is the disparity between the income tax paid by the man from U.K., campaigning under trying conditions, and the civilian who lives and works in the country. Tax evasion by some of the population seems to be the order of the day and the only way to obtain revenue in a country such as this is by direct taxation like purchase tax.

Bandit recruiting probably keeps pace with their casualties and we appear to make but little inroad into their numbers. The rest of the population sit on the fence awaiting the outcome with apathy and indifference. I believe the only answer is to close the country down completely for six, or even twelve months ; put it under complete martial law ; subordinate *everything* to the military needs ; and forbid *all* movement except under military permit. Only in this way can we hope to segregate the bandit, and until we do we cannot " winkle " him out and deal with him.

These then are the conditions and the atmosphere in which we work. I have three D.Cs.R.E.—Penang, Taiping, and Ipoh—and our work varies from building and maintaining operational camps to the latest thing in permanent construction. We are controlled rigidly by normal peace-time accounting and procedure. Our finance is allotted under seven heads—Part I Emergency, Part I Normal, Part II Emergency, Part II Normal, Part III Emergency, Part III Normal, and Agency Services. The Agency Service is used mainly for the Commandos, who function under the Admiralty. The " Emergency " part has nothing to do with time. It is the expenditure incurred on services directly caused by, and charged to the emergency. We work quite hard and if expenditure is any measure of our achievement the following will indicate what we have accomplished to date with one month to go before the end of the financial year :—

EXPENDITURE—FINANCIAL YEAR 1951–2

	Normal	*Emergency*	*Total*
	£	£	£
Part I	603,509	42,569	646,078
Part II	75,159	49,530	124,689
Part III	144,612	38,671	183,283
Agency	6,611	—	6,611
	£829,891	£130,760	£960,661

I had hoped we might reach the million mark but we missed the boat. When it was much too late money was showered upon us and with the best will in the world it was impossible to spend it in the time. We concentrate on the " Service " part of our title, and keep everyone happy by doing all that lies within our power—within the money. That is our *raison d'être*. We have a soldier's job and I find it most interesting.

THE TANK PARK

By MAJOR H. W. PRESSLAND, R.E.

THE PROJECT

IN November, 1950, an Engineer Organization, bearing the old-fashioned title of D.O.R.E., was set up in the Garrison of Fallingbostel, adjacent to one of the large tank training areas in North-West Germany. Political events had ordained that a new armoured division was coming out from England in the following year and an adjustment of accommodation was, therefore, necessary.

This new engineer set-up came under command of a C.R.E. who was even then carrying an extremely heavy works load. The task set was the conversion, rehabilitation and construction of barracks in three garrisons, which were set in the form of a triangle some thirty miles apart. In one of these were three barracks which required conversion and rehabilitation to provide accommodation for a Divisional H.Q. and its ancillary units, which were moving from another area in Germany. Number two was the conversion of a much bombed old Luftwaffe airfield to a R.E.M.E. workshops, whilst the third garrison was at Fallingbostel, the H.Q. of the new D.O.R.E. Here lay the main problem ; the garrison consisted of three barracks which had previously contained successively a German infantry division, prisoners of war of various nationalities (who had left their mark on the camp when the war ended), and then displaced persons.

In 1950 the barracks were occupied by an armoured regiment, a supply depot and the displaced persons. The plan now was to provide accommodation, garages and sports grounds for an additional armoured regiment, two G.T. companies, a tank transporter unit, R.E.M.E. workshops, their artisans, the usual ancillaries to a garrison and, finally, married quarters. Additional minor new services and maintenance were, of course, accepted secondaries, but many of them would be major or normal Part II services by U.K. standards. They included such items as the provision of N.A.A.F.I. shops, a cinema, barrack stores, garrison M.I. rooms, telephone exchange, an educational centre, gymnasium, officers' club, and the complete overhaul of a 12,000-men sewage farm, quite apart from ordinary day-to-day maintenance.

The German authorities, the local government building department, were, of course, brought in and their assistance was invaluable. Their function has already been adequately described by Lieut.-Colonel E. S. Barkham, O.B.E., R.E., in his article " The Hohne Project " in the *R.E. Journal* of March, 1952.

In November, 1950, only one armoured regiment occupied the barracks, the supply depot having moved out, the D.Ps. slowly following suit. The time given for the completion of all work in the area was two years and the obstacles and the thousand and one jobs that cropped up is quite another story. This article merely sets out to tell the tale of the construction of the garage area for one of the armoured regiments, popularly known as " The Tank Park."

At first sight, the area selected, which was next door to the existing garage area, although being ideal for the unit, as it was close to their barrack accommodation, looked a complete bog. Part of it was woodland, part under cultivation by the local farmers, and practically half of it under water. A large drainage scheme was immediately obvious, quite apart from the tussles that were to take place to obtain the ground from the farmers. The felling of trees in the wooded area, levelling and filling in, brought to mind thoughts of the ill-fated ground nuts scheme in East Africa.

The planning, approval of detailed estimates, preparation and acceptance of contracts took approximately nine months. The contract work was phased according to the military necessity, convenience of site, labour, and materials.

The military necessity was priority, as barrack accommodation for the new armoured regiment would be ready first and it was apparent that there would be two major armoured units accommodated in the garrison, but garages only available for one. Summer would be well advanced by the time work got started and the following winter looked grim for some vehicles. In actual fact the two regiments shared the one garage area, as it was not until June, 1952, that it was possible to hand over the new tank park, less the " B " garages which were phased to be done last.

The project was so large that quite a number of contractors were employed, and the storage of materials and setting-out presented an organization problem. This was overcome by allowing the main contractor the whole of one side of the site, with the others grouped at the opposite end.

Labour was really no problem, except that Fallingbostel is only a village and the men had to be brought in from outlying districts. This obstacle was surmounted by providing accommodation and a canteen in an empty barrack block.

MATERIALS

In the case of materials, concrete was to be the main item, as in addition to the " A " vehicle aprons and roads, both the " A " and " B " garages, L.A.D. and washdown, and maintenance ramps were to be constructed in concrete. The maximum supervision was, therefore, necessary to obtain a high quality product.

Cement was brought to the site by lorry and checked and tested periodically. It was found that at times the cement arrived fresh from the factory and to prevent its immediate use the contractor was told that it must be stored at least ten days before use. Storage space hampered this at first, but gradually it became possible to phase the work suitably so that this could be accomplished without interrupting the progress of work.

The purlins for the main buildings were all prefabricated off the site, but the pillars and beams were formed on the job. For these latter, a rapid hardening cement was supplied to economize in the use of shuttering, whilst for the remaining work ordinary portland cement sufficed.

The correct choice of aggregate was also a necessity and the locality of Fallingbostel proved unsuitable, as the local gravel pits often contained layers of clay and no washing plants were available. The Soltau area was tried, but it was found that the aggregate there, in addition to containing a minute amount of clay, also carried a small amount of iron oxide. This, although not really harmful to concrete, covers the grain with a thin film, which prevents correct binding when the concrete is setting. Sand, however, was supplied from the Soltau area.

Eventually, the aggregate came mainly from the River Weser near Eystrup, some thirty miles away. Here it was found to be pure, but rather round and smooth. The Weser gravel is extracted from the bed of the river and on excavation it is sieved and then graded. On the site, it was constantly checked by sieve to maintain the correct proportions.

The project was carried out by contract, and phased, as already stated, to suit the military requirements, i.e., the " A " garage was the first priority. German practice is to let each trade to separate contract so there was a multitude of contractors on the site. The garage floor and framework were done by one firm, whilst the roof covering, roof lights, doors, lighting, plumbing, and decorating were all separate. It was necessary to organize each of these so that they phased properly into the shape of the job. Fortunately, the main contractor responsible for the concrete, was one of the biggest organizations in Western Germany.

Hardcore played a prominent part in all this work, but there were ample stocks to hand at the bombed-out airfield referred to earlier in this paper.

The Project

The Tank Park had to accommodate 72 " A " and 120 " B " vehicles, based on 1948 Barrack Synopsis. This meant cover for all " A ", but only 50 per cent for " B " vehicles. The garage area (see plate facing page 138) consisted of :—

- " A " Garage for 72 " A " Vehicles
- " B " Garage for 60 " B " Vehicles
- Hardstandings for 60 " B " Vehicles
- Aprons and roads in front of garages
- A L.A.D.
- Petrol Point of Two Tanks and Oil Store
- Washdown with 10 hydrants
- Field Miniature Range
- Wireless Wing
- Pump House and Latrine
- Maintenance Ramp
- Ammunition Area of 48 Shelters
- Entrances and exits for tanks in concrete, and for wheeled vehicles in tarmac.

Added to the above were levelling, drainage (an extremely heavy item), internal and external electric lighting, a transformer station for the additional load, water supply, fire precautions, fencing around the whole area, with gates.

The Garage Design

The " A " garage was to be designed to take the largest tank, and the " B " garage had to be of similar design, this latter directive being presumably with an eye to the future.

The design of both garages was influenced by the lack of steel available at the time in Western Germany. The trend previously had been towards steel framed structures, with asbestos cement cladding or thin concrete panels.

Investigations were made into the amount of steel and costs for building the garages and L.A.D. in various designs. Below are some of the findings :—

	Type of Construction	*Tons of Steel Required*	*Proportional Cost in % taking 100 as Index Figure*
1.	Reinforced concrete frame with pre-stressed reinforced purlins	112	100
2.	Reinforced concrete, with steel frame truss	160	102
3.	Steel frame and steel truss, similar to previous structures	210	110

Type 1 was selected as this not only meant a saving in steel and costs, but also ensured that it would be possible to give the major portion of the work to one contractor, thus obviating the delays and misunderstandings that would arise with several firms sharing the responsibility. The German authorities were told to provide the list of contractors who would be invited to tender, as it was necessary that only large firms with established reputations should be considered.

The design of the " A " garage was eventually settled at eighty bays, back to back, partitioned into four separate squadrons, each with a portion of their garage space allotted for Part III Kit Stores and offices, leaving seventy-two open bays for the tanks.

A skylight was let into the roof to enable troops to work inside the garages during inclement weather. This light was sufficient to throw enough natural light down into the well of a tank when the turret was open.

The doors to each bay were of six winged steel folding type, with a catch which allowed them to be locked to an outside bollard when opened. These bollards were to prevent the doors being damaged by a tank entering the garage bay, and four different types were constructed, two of reinforced concrete and two of steel, as a test to find the most suitable. Although all of them have stood up to their task to date, the reinforced concrete bollards appear to be the most efficient.

Each main truss was supported by a reinforced pillar in the centre of the garage. Some doubt was expressed as to whether a tank might not strike one of these when moving in or out. Eventually a small wedge-shaped concrete bollard was placed in front of each pillar to allow the driver of the tank to be warned immediately his vehicle got too close. The size of each bay for one tank was :—

Depth 46 ft. ; width 20 ft. 4 in., centre to centre of door pillars. Height of door in clear 14 ft. ; height of garage 18 ft. 4 in., at apex of roof.

Except for the partitions dividing the building into squadrons, the garage was open. Outside each end of the garage there was an open space which was originally intended to be grassed. As a tank area is invariably littered with spares, such as tank tracks, these areas were consolidated by laying stone setts, a large quantity of which were surplus in the area.

Site Specification

Opinions from all quarters varied as to whether the ground was firm and sound enough as it stood, whether the whole area should be packed with sand, or if it was possible to use the existing area suitably consolidated in the bad spots with sand and rubble. The German authorities went so far as to suggest an 8-in. layer of rubble, well rammed, before laying the concrete. They were convinced that the traffic of heavy tanks, combined with the wet site, would result in the concrete breaking up in winter.

Finally the C.R.E. ruled that a good, hard surface could be obtained by rolling and filling without putting in any special type of bottoming. About this time, however, a sand pit was discovered in the vicinity of one of the 500-yd. classification ranges near the camp. Tests were carried out and as the sand was found quite suitable the pit was operated by D.E.L., the product transported direct to the tank site, and laid on the bad areas. The contractor then rolled and rammed the area thoroughly, using for the latter 1-ton power rammers (see Photo 4), a method which proved most successful. On this sub-base, after laying waterproof paper, the specification for the concrete was finally settled at 8 in. thick, reinforced with one layer of the German equivalent to B.R.C. fabric No. 5, placed 2 in. from the top of the surface. Providing reinforcement in both top and bottom of the slabs had been turned down on the grounds that it was an unnecessary precaution, in view of the difficult steel situation. The decision to place the reinforcement on top was taken after many visits to the site, consultation of text books and specialists, all of whom held various opinions, but the final ruling came in a Technical Instruction issued by the Chief Engineer. After six months hard wear the concrete has not yet shown any signs of cracking, but it will make an interesting comparison with near-by tank roads, which have the reinforcement placed 2 in. from the bottom of the slab.

The slabs were laid in two courses of 6 in. and 2 in., the latter being laid within half an hour of the former. The bottom course proportions were specified at 1 : 2 : 4 by weight, with not more than 5 gallons of water being used to each 1 cwt. of cement and the top course 1 : 2 : 4 with 4 gallons of water to each 1 cwt. of cement.

The aggregate in this wearing course consisted of two parts gravel and one of ¼ in. to ½ in. basalt chippings. The slabs were divided into rectangles, generally 20 ft. in length, with a ½-in. gap for the bitumen expansion joints. The end joints of the slabs for tank roads and aprons were dowelled with ⅞-in. steel bars in paper sleeves.

Curing in warm weather was effected by using portable light covers, immediately the concrete hardened it was covered with sand and the surface periodically hosed with water.

The mix for pillars and beams of the "A" garage was 1 : 3 : 4 by weight, with not more than 5½ gallons of water to each 1 cwt. of rapid hardening cement. The pillars and beams were reinforced and a small size aggregate was necessary to ensure close binding of the concrete. The largest size of aggregate used in this operation was ½ in.

For the foundations, ordinary portland cement was used and the proportions were 1 : 4 : 7 with not more than 4½ gallons of water to each 1 cwt. of cement. The largest size of aggregate was 1¼ in.

These specifications applied also to the structure of the L.A.D. and the "B" vehicle garage. However, for the floors of the "B" garage and hardstandings, 6 in. of unreinforced concrete was specified, with a mix similar to that of the "A" garage floors and aprons, including the wearing surface. The apron to the "B" garage and hardstanding, which extended the length of the vehicle area, was, however, of 9 in. unreinforced concrete, with mix proportions as before. This precaution was taken as the area involved was quite close to the tank road, and some concern was felt that the armoured vehicles might run off the road.

Much discussion had already taken place on the subject of the width of the apron and road for the tanks. The local regiment helped by giving practical examples of a tank leaving a garage and wheeling on to a road. The point at issue was that during fine weather most armoured vehicles receive their ordinary maintenance outside the garage. If one has a row of, say, three tanks placed outside of the garage doors, and the centre one requires to move, whilst the other two for some reason are unable to do so, then obviously more space is required to run out and wheel. Here again, the C.R.E. took a hand and laid down specific widths ; these were, apron from edge of garage to edge of road 31½ ft., road 16½ ft., and approximately 3 ft. of stone setts as an edging to protect the concrete.

In April, 1951, a detachment of a mechanical equipment unit was provided by the Chief Engineer for the purpose of levelling the site. Previously, tests had been made on the site with a view to ascertaining the exact nature of the soil. The results were on the whole fairly satisfactory, but in addition to a fairly extensive portion of marshy ground, there were several odd layers of clay in the most

Photo. 1.—"A" garage with L.A.D. on right.

hoto. 2.—View from Maintenance Ramps, "B" garage on right, "A" garage centr Petrol Point extreme left.

The Tank Park 1,2

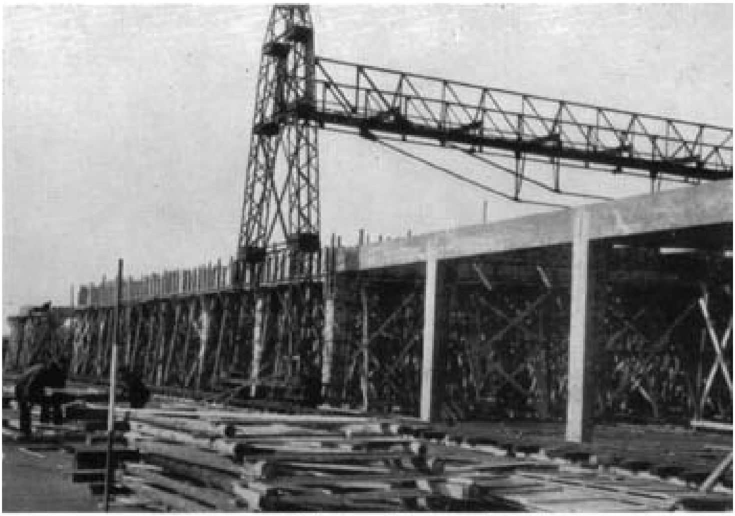


Photo. 3.—"A" garage with gantry in position.

Photo. 4.—One ton power rammer in operation.

The Tank Park 3,4

unexpected places. This caused a switch around of the layout of the garage area to get away from these bad spots.

The mechanical equipment unit did a splendid job and finished the site by late June, 1951.

Site Organization

By the end of July the tenders for the "A" garage, drainage, water supply, roads and maintenance ramps had been received, and they compared very favourably with the original estimates. There had, of course, been many delays before these were finally received. The road contractor did not have enough reinforcement and the steel mills did not appear to be able to produce the requirements in time. Fortunately, it was possible to draw on stocks in the Engineer Stores Depot and this enabled work to get under way until supplies eased.

In the middle of August work started in earnest, and the main contractor set about his business in a most workmanlike fashion. He first laid a corduroy road on a prepared embankment into the site and constructed the various bays for reception of aggregates. A thin layer of concrete was placed to protect these materials from the earth. The gauge boxes were placed in pairs at each bay. By the side of these ran two rows of decauville track leading to the cement shed which was completely waterproof, and in front of which stood two large concrete mixers. The cement shed contained two tracks on which were skips which were run forward with the prescribed load of cement as the aggregate arrived in front of the mixers. Water, which was adjacent to the site, was tapped and fed direct to the mixers.

On the other side of the corduroy track were laid out the carpenters benches and sheds, steel bending, cleaning shelters, and the various store huts. The usual offices of a builder took up the remaining portions on this side of the site. In one of these offices a room was set out in the form of a laboratory where slump and soil tests, checking of gravels and reinforcing bars were carried out.

One could, therefore, walk on to the site, and from the boards on the concrete mixers, which detailed the type of mix going in, check at each stage that the specification was correct.

Work ran like a clock. Side-tipping lorries ran into the area up the timbered track and unloaded their sand and gravel at the appropriate bay. Being on a raised road it was a short job to unload and be off again. By using a steel sheet, formed like a bulldozer blade, attached to a cable and powered by a small motor, one man here was able to push forward all the gravel to the front of the grading bays for loading into the gauge boxes. This undoubtedly saved time and labour which would have been necessary if the material had been man-handled forward. Cement in bags, of course, took longer to unload, as also did the steel and timber on the other side of the road.

Meanwhile the actual mixing team set to work. One man stood in each bay of aggregate that was due to be used and filled both gauge boxes whilst a team of decauville bogies was pushed up to each bay. The man in charge of each bogie tipped the contents of the gauge box into his transport and wheeled on to the next, finally coming to rest at one of the concrete mixers outside the cement shed. The cement was tipped into the mixer at the same time as the aggregate, whilst the required amount of water gauged at a tank on the mixer was poured in by the mixer operator.

On completion of the mix, which took approximately two minutes, the matrix was poured straight down a chute into skips which ran it by decauville track direct to the job. In addition to these, there were a number of power-operated rubber-tyred barrows employed for the same purpose. These rubber-tyred vehicles reduced the possibility of segregation of the concrete mix on its run. In the opening stages of the work this was extremely important as the run then was some 350 yards.

When work on the actual building started, the contractor introduced to the site a large travelling gantry spanning the width of the proposed garage. This was used in the construction of the pillars and trusses. The concrete mix for these was carried in a conveyor that had to be removed from its carriage on reaching the gantry. The gantry was fitted to take the conveyor which was then raised and traversed to its required position and poured. To prevent segregation it was ruled that no concrete would be poured at drops of more than 4 ft. This applied, of course, to the pillars, and suitable vents were made in the shuttering to ensure this rule was observed. The timber had previously been coated with oil to prevent water absorption from the wet concrete. Throughout the operation mechanical vibration was used for compaction, by using flexible handled internal vibrators. Mechanical vibrators were also used on the laying of garage floors, hardstandings and road. Much care had to be taken here in the laying of the reinforcement which required pegging down to prevent the vibration bringing it through the surface.

By using such labour- and time-saving methods the shell of the garage was completed within thirteen weeks. Unfortunately, by then, the weather had broken and although the roof slabs were on, waterproofing had become impossible, although many attempts were made.

The roof construction consisted of prefabricated breeze slabs suitably grooved so that they interlaced. These were then covered with two layers of two-ply roofing felt, but as already stated the weather broke, temperatures fell, and it became impossible to lay the felt. It was the following spring before this could be carried out satisfactorily.

Another hold up was caused by a delay in the supply of doors. The brickwork on the gable ends could not be rendered due to frosty weather, and this, combined with other minor delays, held up the completion of the "A" garage by the other trades until June, 1952.

Meanwhile, the floors, aprons and roads had been completed. Of the remaining work, the drainage, water supply and maintenance ramps were finished, and progress on the other items of the Tank Park area was most satisfactory.

Experimental Road

The provision of a new garage area offered scope for experiments on the roads to see what minimum thickness of concrete would stand up to the wear and tear of tank tracks. A stretch of road, 344 ft. long, was therefore constructed in six different types of bays, of two thicknesses, 6 and 8 in.

This experimental stretch of road was placed at the exit to the garage area, but to date has been very little used and shows no signs of breaking up in any part.

Double reinforcement was placed in two slabs, single reinforcement set 2 in. from the top in two more, the other two being unreinforced.

The L.A.D.

Fortunately, the L.A.D. contract was also let to the same firm who had erected the "A" garage structure. The plant remained on site and it merely became a matter of transferring the gantry and its railway to the L.A.D. The layout consisted of seven repair bays, including three inspection pits, four bays for the stores section and binned lorries, a recovery section, blacksmiths' and fitters' shops, battery charging area, stores, offices, and ablutions. A cellar was also constructed to provide fuel storage and heating equipment for central heating throughout the building.

In the original scheme, an overhead crane had been allowed for, but R.E.M.E. authorities said this would be unnecessary as the work involved in a regimental L.A.D. did not justify its inclusion. When the L.A.D. was finally completed the E.M.E. complained that he was severely handicapped through lack of adequate lifting facilities. The result is that a crane has now been approved and work on this is at present in hand. The scheme envisaged is to provide a travelling crane over the five main bays, but due to lack of height in the building and the layout of central heating, the size of the crane is restricted to $1\frac{1}{2}$ tons. This, however, will be electrically operated, and will take the largest load dealt with in a regimental L.A.D. ; any heavier work being carried out in the new Armoured Workshops, recently constructed in the garrison.

As winter had arrived, the problem of mixing concrete in cold weather had to be faced. It was agreed, after several tests had been made, that heated water could be used when the thermometer fell between 39° and 23° F. Below the latter temperature work stopped, but on checking back through the Works Diaries it has been found this was seldom necessary, although a hard winter had been expected. The contractor installed a large boiler near the mixers, which kept the water in the tank at approximately 120° F., and also ran a steam pipe to each bay of aggregate. A perforated pipe then ran off this into each pile of gravel at periodic intervals. This immediately defrosted the material, but, of course, increased the water content, so that an adjustment of the mix became immediately necessary. The site laboratory was very much overworked at this particular stage, and frequent slump tests were taken to keep the water ratio adjusted correctly. The mixing of the concrete was carefully watched ; the heated aggregates and water being mixed first before the cement was added.

The experience gained in the erection of the "A" garage was now of great value. The laying of roofing felt, which had presented a problem on the garage roof, was a much better job. It had also been found that the framework of the garage doors, whilst being adequate to their task to date, left a suspicion that they were not quite strong enough. The door frames in the L.A.D. were therefore made slightly wider to make comparisons.

Concrete was protected during the curing period by the provision of straw mats and there was never a case of rejecting any of the work, except a few courses of brickwork on the gable ends which had been attacked by frost.

The work was finally completed and handed over in mid-July, 1952.

THE WASHDOWN

The washdown was planned and re-drawn several times before an agreed design was found. At the time this was being prepared experience on other washdowns in the garrison showed that a satisfactory solution to getting the mud and water away from an armoured vehicle washdown had not been discovered. During bad weather, a tank on the training grounds adjacent to the camp, would collect an enormous amount of mud which caked the tracks and bogie wheels. It was a lengthy procedure to remove this mud, and when several tanks were involved the drains were quickly blocked, thus turning the garage area into a sea of mud.

The drainage of the new area had already been carried out and some 14,000 ft. of trenches were excavated to provide 6,000 ft. of open ditches, the remainder being laid with concrete piping, the size of which varied from 2 ft. 8 in. to 8 in. diameter. The problem now was to ensure the minimum amount of silt reaching these drains.

The washdown was designed with ten hydrants, four of which were high pressure and six low pressure points, all of which were self-draining to avoid freezing up in winter. From the plan enclosed with this article it will be seen that a row of four hydrants was placed on a concrete platform at the edge of the tank road south of the " A " garage. Approximately fifty feet away stood the settling tank, flanked on either side by six more hydrants. This enabled six vehicles to be washed down at the same time. The hydrants were fed from the main garrison water supply and the H.P. points were boosted by two pumps from the near-by pump house, giving a maximum pressure on them of 300 lb. per sq. in.

The actual wash-down was graded to flow into a main channel towards the settling tank, and this in turn deposited the water and silt into one large compartment, which, in effect, became a sand catch. As this filled up, the overflow ran through small channels to the next three compartments, which were proportionately smaller. By this means the silt gradually settled to the bottom of the larger compartments, leaving a flow of almost clear water to the drain to which it was connected by a 12-in. diameter pipe. In the channel to the third compartment was fitted an overflow pipe to serve as an oil catch, thus controlling the flow of any oil that might inadvertently get into the settling tanks.

The settling tanks were served at the back by a stone sett road to facilitate clearing of silt when required. All that was necessary to clean the tanks was to pump out the water by using the local A.F.S. equipment, the pump being fitted with a filter on the end of the hose. After pumping, it was a simple matter to bale out the silt into a lorry and dispose of it.

Maintenance Ramps

The number of ramps on the site was calculated on the vehicles on establishment, as at the time Barrack Synopsis 1948 had not been received. Technical Instructions merely laid down that a maintenance area would be provided, and it was agreed that seven ramps for tanks and two for wheeled vehicles would be constructed. Their size was approximately 69 ft. long, 5 ft. high, and 4½ ft. wide on each structure. An iron railing at the end served as a guide to ensure a vehicle did not run off the ramps, which were constructed of unreinforced concrete.

Several people expressed doubt as to whether these would ever be used, but tanks have constantly been run up them to enable the mechanic to carry out maintenance, such as greasing of wheels. The height of the ramps ensures that a man can stand in an upright position whilst working, and there is adequate natural light for the work, as both ends are open. There are actually too many ramps and the new Barrack Synopsis now lays down an adequate scale.

Petrol Point

This consisted of two large cylindrical tanks of 11,000 and 5,500 gallons capacity, four pumps, an office and an oil store, with a run in and out on both sides. The office and oil store were constructed in ordinary brickwork, with a close boarded roof covered in roofing felt. The larger tank was required to contain the petrol for the "A" vehicles and the smaller for the "B" vehicles.

Two large pits were excavated, concreted, and bitumenized. Due to the shortage of steel there was a long delay before the petrol tanks arrived on site. Lorries eventually brought them in, and they were unloaded close to the empty pits and immediately insulated. The pits were then filled with water and the sides lined with fenders of rubber tyres. The tanks were rolled to the pits and lowered into the water, which was eventually pumped out. The tanks were then subjected to further insulation, the filling and draw off fittings fixed for the pumps, and the pits filled.

This petrol point now allows two tanks and two "B" vehicles to be filled at the same time in a matter of three minutes.

Although the winter and shortage of steel had retarded work considerably on this project, it was handed over at the end of July, 1952.

Wireless Wing and M.T. Office

This building was erected for battery charging and repair of wireless sets, offices for Regimental M.T. and the Technical Adjutant. It was also required to have a garage of one bay.

The construction here was similar to the petrol office and oil store. All floors had to be of concrete, with the exception of the offices which were in timber, and the battery charging room which was tiled. In the latter, two concrete benches were erected to carry the various batteries whilst under charge.

Outside the building, a tarmac apron was laid, this being the only area, apart from the "B" garage entrances and exits, in which tarmac was used in the Tank Park.

By September, 1951, the German authorities were wilting under the load of work which they had to carry. The commitments in the rest of the garrison had left their mark, and the quantity surveyors branch, quite understandably, could not cope with this rush of work. In the case of this particular building, the details and plans had been handed to them early in September, but it was the following March before the contract was submitted for acceptance. Work started early in April, 1952, and was not finished until late July due to delays in supplies of stores.

Ammunition Area

This consisted of forty-eight elephant shelters built on concrete floors and placed to the south of the Tank Park. They were all fitted with lightning conductors to conform with German standard practice which requires this precaution on any form of shelter containing explosives. Four of the shelters which contain high explosives, were protected by high traverses, and situated at the farthest point from the Tank Park. The remaining shelters were grouped in seven sets of six and one of two.

A slag road for the use of wheeled vehicles only, served the area, flanked by open ditches on each side. Originally, a concrete road had been considered, but this was vetoed by the Chief Engineer in an effort to bring down costs. Three concrete turning points were incorporated in the road, and as an extra insurance, loads of rubble dumped at various points in the area. When bad weather set in, this rubble was invaluable for filling in worn patches.

Perimeter lighting to the area was included as a special case, as the site was isolated and several thefts of ammunition had taken place in the camp.

Fire Fighting

Seven fire hydrants were placed in the vital spots of the Tank Park, and in addition a static water tank near the entrance. This water tank can serve both the old and new garage areas, as they are sited adjacent to each other.

Field Miniature Range

A pellet range, on which .22 rounds could be fired from tanks down a 30-yd. range, suitably scaled down to represent 5,500 yds., was sited at the exit to the Tank Park. This merely consisted of providing an earth traverse 14 ft. high, with covered accommodation at the firing point. The traverse was graded and then covered with grass sods to ensure solidity. The cover was constructed in timber, with one open end. This enabled three tanks to move in and fire at the same time.

The "B" Garage

The "B" garage was the last building to be erected on the Tank Park. The design was a single strip garage with entrances to the south side, the rear being filled in with a brick lining and windows beneath the eaves, stretching the length of the garage. A skylight in the roof, as incorporated in the tank garage design, was omitted. The size of the garage bays, however, like the construction, followed the principles of its counterpart.

Scales at the time laid down 50 per cent cover for " B " vehicles ; and doors only to 5 per cent, plus repair bays. Four 3-ton lorries would be garaged in one bay, therefore a garage of sixteen bays with doors on three, was constructed. After completion and hand-over of the garage in October, 1952, a special authority was granted for the fitting of doors to the remaining bays, and this is now in hand.

The repair bays were constructed with inspection pits and also partitioned off from the remaining portion of the garage. The floor was constructed of 6 in. unreinforced concrete. The aprons and hardstandings for these vehicles were also of unreinforced concrete but 9 in. thick, laid in two operations of 6 in. and 3 in. layers.

The entrances and exits for the " B " vehicles were placed at the side of the garage and hardstandings. Both were constructed in tarmac, as they led direct into the barrack area.

Again it was fortunate that the firm who built the " A " garage and L.A.D. secured the " B " garage contract. As their equipment and labour was still on site, work began almost immediately the contract was let. The spring and summer of 1952 in Fallingbostel were not particularly good but progress was excellent, and by August the main contractor had finished his work and cleaned up his portion of the site. The garage was handed over to the unit in October, 1952.

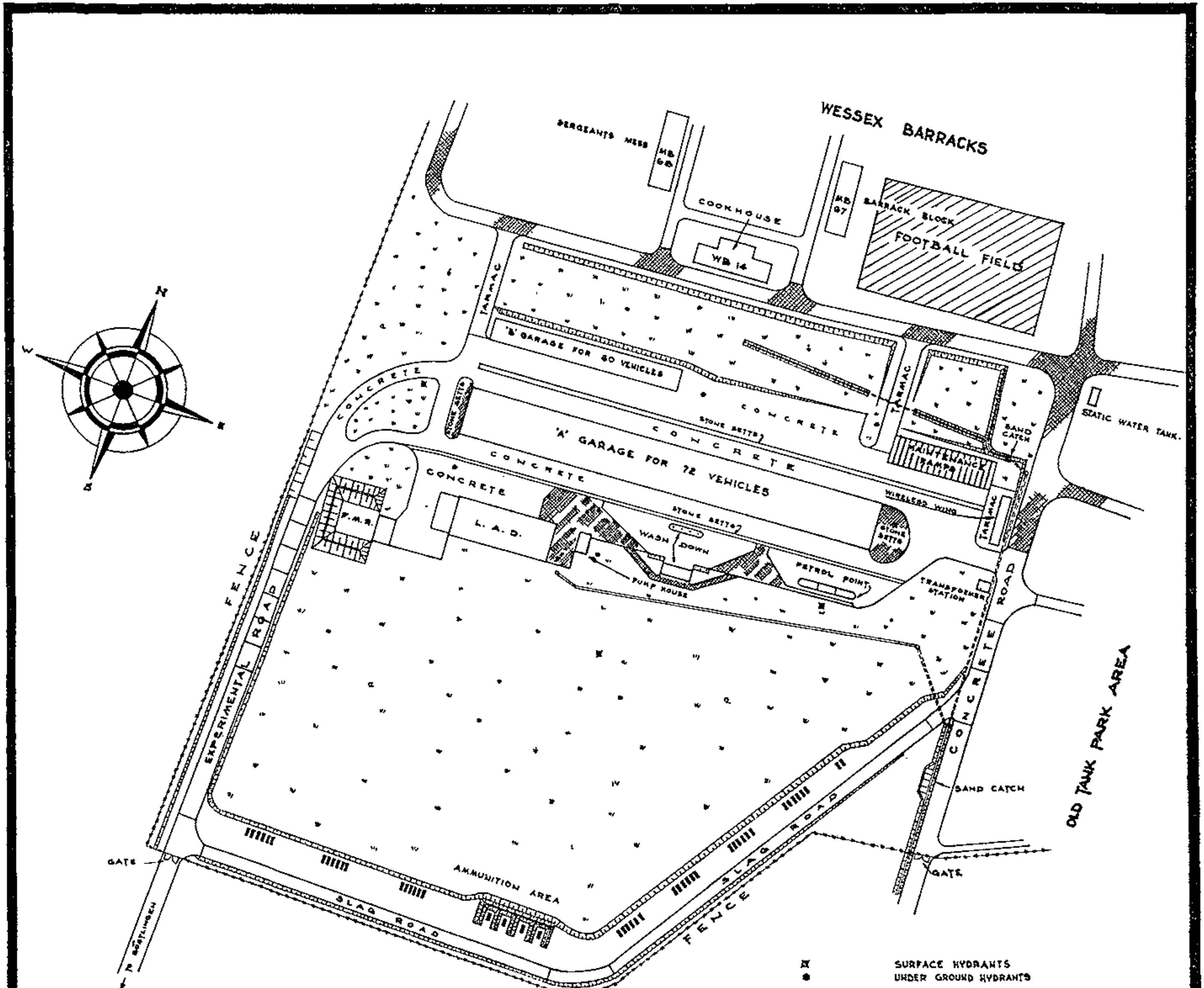
Training Wing

A Training Wing had also been visualized for incorporation in this project, but was turned down on account of high costs. Eventually a barrack block was gutted and converted to provide the necessary accommodation for two 20 and one 17 pounder gun mountings, a scout car, a 3-tonner chassis and components for the D. & M. wing, Besa bays, lecture and model rooms, offices and stores. This service was treated separately from the main project.

Conclusion

Measurements given in this article are in many cases approximate, as they are the conversion figures from the metric system. The cost of the project was 2½ million marks, or approximately £220,000.

Throughout the progress of the work many important personalities, including the War Minister, C.-inC. B.A.O.R., C.E. B.A.O.R. and the G.O.C. 7th Armoured Division, toured the site at various times and were greatly impressed by the project.



R.A.C. TANK PARK

REALISM IN TRAINING

By Major J. H. Clark, M.C., R.E.

THE National Service Officer Cadets were on parade in battle order. The Squadron Commander was talking. "This morning we are going out to help some Home Guard defend an airfield." (It was a Saturday morning. The last time they had done one of these exercises it had been on a Wednesday afternoon—recreational training afternoon. But it had rained that afternoon. Perhaps it wouldn't rain to-day. But it would still be dirty and cold, crawling about in ditches and hedges, and all their kit would have to be cleaned again. Oh well, they must not forget their character grading, so look cheerful !)

The trucks full of cadets were trundling along a by-road down near the river on their way to the airfield, when a figure in trilby and mackintosh came into the road from a side turning just ahead and frantically signalled the leading vehicle to halt. The O.C. was in the second vehicle, so he wandered up to see what the trouble was. The figure turned out to be a warder from the Borstal Institution only a few miles away on the outskirts of Rochester. He was waving a revolver rather excitedly, and it seemed that there was a Borstal boy at large in a near-by quarry. Would the Army help him and a second warder to round the chap up ? The O.C. said the Army would be delighted, but what about the Police ? They had been through on the telephone to the Police and they were organizing an armed squad at the moment, but as the Army were here. . . . "Why an armed squad ?" The boy had raided the guard-room and had a rifle and quite a lot of live ammunition.

The whole picture was now clear. Fifty officer cadets with rifles and bayonets, but without a single round of ammunition (not even blank), were required to capture a dangerous criminal armed with a rifle and ammunition, who was prepared to use it effectively apparently. The warders had had close shaves, and could not get close enough to use their revolvers. They were disappointed to hear that the Army had no ammunition.

The O.C. decided to do a recce. Actually he knew the ground well enough. The quarry was a field-firing area which the squadron used for mine warfare training sometimes, but he wanted a moment to himself to think this thing out. It was no light decision that he had to make, risking the lives of these rather important chaps. Questions in the House were all right—they often made good reading in the papers. But court-martial proceedings might not make quite such enjoyable reading. What was it that that little green book said on "Duties in Aid of the Civil Power" ? "Every citizen is bound to come to the aid of the civil authority to enforce law and order when called upon to do so, or even, in exceptional emergency, on his own responsibility." That was the common law. And further, "if he takes such measures as he honestly believes are necessary to effect the immediate object, and acts with due care and attention and in good faith, he will be covered by the law and need not fear the result of inquiry into his conduct." That should take care of the court-martial. And anyway these youngsters needed livening up.

The O.C. had walked down the side road between high banks and it now opened out into a vast quarry, nearly three-quarters of a mile long and nearly half a mile across. There were steep cliffs all round and the bottom was covered with thick bushes and young trees, in parts, whilst other parts were open. The track ran down the middle and then across to the right-hand cliff where it petered out into open ground. The first quarter of a mile was through thick strong bushes and the boy was in there somewhere. The second warder was in the bushes trying to keep contact with the boy. The O.C. pushed through some bushes to join him when the first shot was fired. It went high and smacked into the cliff behind, but it was tracer ammunition and the illuminating part of the round separated from the ball and went hissing and flaring into the bushes. The O.C. lay down in the mud very quickly to make a plan in comfort. Must put up a good show in front of these officer cadets. There was that little bit he used to say in the class-room. It came from *Training for War*, and was on the subject of leaders. "Only too often the hero of the barrack square turns out to be not quite such a hero when it comes to the empty but noisy battlefield with danger lurking behind every hedgerow." But then there was another bit, which was perhaps more applicable. "Even a poor plan if carried out with decision is better than no plan at all."

The boy would have to be surrounded and the circle drawn slowly tighter until the warders could make use of their revolvers. After all, the boy didn't know we hadn't got any ammunition, so he was only likely to fire at us from a distance with a view to keeping us away. If he thought he was likely to get shot at from all sides, he would be sure to give himself up. 1 Troop would have to do a wide left-flanking movement and get round behind the boy, 2 Troop would have to do a frontal advance keeping contact with 1 Troop on the left, whilst 3 Troop would have to do a closer right-flanking movement keeping contact with 2 Troop in the centre. Squadron H.Q. would go straight down the track. The aim would then be to surround the boy and force him back up against the cliff, about where the track petered out and where the thick country started opening out and affording more visibility. The only difficulty would be getting 1 Troop round behind the boy from the narrow opening of the quarry where they would be a sitting target. 3 Troop would have to draw his fire by letting themselves be seen starting their right-flanking movement, and then 1 Troop could slither in and round the corner. Communication would be by 88 set.

The O.C. crawled back to the quarry entrance where his "O" Group was waiting for him. He gave his orders and then went back to the squadron on the road. When the three troops were assembled, he explained quickly what had happened and what he was going to do. He also arranged for a message to go back to R.H.Q. on the rear link, explaining the situation, asking for police aid quickly, asking for live ammunition and finally asking them to cancel the Home Guard exercise at the airfield. Some cadets were heard to ask whether this was all a hoax or whether it was the real thing—after all, one doesn't have to be an officer cadet very many weeks to find out that instructors play tricks to test cadets. However, one didn't usually expect gross deceit from the O.C., and judging by his long anxious face, his ceaseless pacing to and fro, and by the way he was snapping at people, he was obviously pretty worried. "For Heaven's sake, gentlemen, don't show yourselves more than you need. Remember also that bushes are not cover from fire. When you cross open ground, double fast in bounds. When you stop and take cover, make use of the folds in the ground. I don't want anyone hit, because I don't like writing apologetic letters to doting parents. Take that silly smirk off your face, Smith. I assure you that you will find no cause for amusement in that quarry. This is a serious matter and I don't want any casualties. Nor do I want any dashing bravado, trying to capture the chap single-handed by jumping off a tree, nor any other V.C. exploit you may have seen Gary Cooper perform."

3 Troop went into the quarry first and started right-flanking. There was open ground to be crossed, and they were just coming to it when the firing started in earnest. Tracer after tracer was going across into the cliff or ricocheting around with the illuminating pieces sizzling away in the bushes. The officer cadets could hardly be seen anywhere, but in a moment they were doubling across the open space keeping good intervals and moving like the wind. The firing started again, but it was too late—the cadets were all down. After a short wait this was repeated by the next section. Meanwhile 1 Troop had started their left-flanking movement, whilst the boy's full attention was concentrated on 3 Troop. "I think 3 Troop did that very well," said the burly sergeant in the O.C's. H.Q. "So do I," said the O.C., "much better than on an exercise." Then a bullet passing close reminded them that bushes were no cover from fire. When they had scrambled into a safer place, the O.C. told his wireless operator to find out if there had been any casualties. Communication was excellent and the answers came in quickly. There were only slight casualties due to scratches and falls.

One of the warders now reported that the boy was withdrawing through the bushes to the left of the track. By this time 2 Troop had room to extend and move forward through the bushes. The boy was seen momentarily on a small ridge running parallel to the track and to its left. He fired some shots at 1 Troop encircling, then disappeared again down the bank, heading out of the trap. The troops were told to push forward faster, particularly 1 Troop who had a long way to go over bad ground. But the boy played into the squadron's hands. Instead of " getting to hell out of it," he decided to climb one of the only two hills in the bottom of that quarry. It certainly gave him a perfect view of the squadron deploying towards him, but he could not resist blazing away at what he could see, and this was to give the squadron time to close the trap by getting behind him. 1 Troop were out in the open country on the far side of the hill moving by bounds beautifully. 2 Troop were scrambling through the bushes and extending both flanks to keep contact with 1 and 3 Troops. 3 Troop had accomplished its right-flanking movement successfully and was now moving up towards the cliff face where the track petered out. However, they were now disturbed by a civilian figure carrying a large sack scrambling down a cliff face at the rear, a cliff face on which much tracer was playing. 3 Troop sent him across to the O.C., who asked him what he thought he was doing there. He said he had come to see whether it was poachers firing at rabbits. The poor chap was in a terribly nervous state, so the O.C. dismissed him without looking inside his sack.

Shortly afterwards a Police car was seen moving slowly down the track. The driver was a Police sergeant who had come ahead for liaison purposes. He was shown a safe place to park his car just off the track behind some cover, from where he observed the operation with great interest. The boy was now firing wildly in all directions from the top of the small hill, and it was clear that he had no way of escape—except up the nearest cliff face, which was at the end of the track. Suddenly there were shouts on all sides. He could be seen running down the hill towards the cliff face. The warders, who had been close to Squadron H.Q. on the track, started doubling forward with their revolvers ready. The boy fired two more shots from the base of the cliff and then there was the unmistakable sound of " easing springs." " He is out of ammunition," shouted a warder and burst out into the open, followed closely by the other warder. 2 Troop was still pushing forward through the bushes, and there was still no cadet within a hundred yards of the boy, though 3 Troop were emerging from the bushes farther back along the cliff face and 1 Troop were just coming into view across the open ground straight ahead, moving back now towards the boy.

The trap had closed. The boy abandoned his rifle and started scrambling up the cliff face which sloped conveniently here and was covered with small bushes which gave him hand-holds. The warders shouted at him and gave chase. The Police car came roaring down the track skidding drunkenly from side to side. Everyone began to run. But in fact there was nothing to get excited about, the boy could not get out. Half-way up, the cliff became vertical and there were no more bushes for him to hold on to. The warders caught him up, took him by the ankles and delighted in yanking him down to the bottom, where they fastened such a head-hold and arm-lock on him that he was more or less carried to the Police car. The Police sergeant deposited him on the floor at the back of the car, the warders jumped on top of him, and the car departed at top speed without a single cadet ever getting a glimpse of the face of their quarry.

The squadron soon concentrated at the scene of the capture. Casualty returns were again called for, and again it appeared that officer cadets bore charmed lives. Yarns were being swapped about "the one that nearly got me," and there was considerable speculation about the possibility of a write-up in the newspapers. The O.C. found some questions rather embarrassing, so packed the cadets off to their trucks, as he had to call in at the Police H.Q. on the way back.

The squadron returned to barracks, de-bussed and fell in. The O.C., after some consultation with Officer and Q.M.S.I. instructors, came over to speak to the cadets. "Gentlemen," he said, "how many of you were taken in?" The Cadets gaped and then smiles started spreading on their faces. All had fallen for the hoax. The O.C. continued. "Some of you may think that a large-scale hoax of this sort is rather a dirty trick when the instructors hold all the cards and you hold none, and in some ways it is. However, I could think of no other way of achieving my object of:—

(*a*) Giving you some really realistic training, instead of the usual boring old exercises.

(*b*) Giving you some experience of the exhilaration of being really under fire, in fact, of being fired at in anger, as opposed to battle-inoculation.

Lastly, one of the principles of war is surprise. The elements of surprise are secrecy, concealment, deception, originality, audacity and rapidity. The moral effect of surprise is very great and a powerful influence in war. By the use of surprise, results out of all proportion to the effort expended can be obtained. I have nothing further to say, Gentlemen, except—did you enjoy yourselves?"

The chorus of "Yes, Sir," was sufficiently spontaneous and enthusiastic for there to be no doubt that it had not been said with a view to an improved character grading.

The O.C. went away well satisfied.

LATEST TRENDS OF DEVELOPMENT IN PILE DRIVING EQUIPMENTS AND METHODS

By Lieut.-Colonel A. W. E. Kirkpatrick, R.E. (A.E.R.)

Introduction

PILING has been known since ancient times as a means of supporting the weight of structures built on soft water-bearing ground, and it has been referred to in many of the earliest books on Civil Engineering.

Improvements in equipments and in their method of use are continually being brought out and this article is written with the object of bringing to the notice of Royal Engineer officers some of these innovations. Many of them bear little relation to the type of construction likely to be encountered in the field, but no one can ever foretell the extent to which technical knowledge can be adapted for use under field conditions.

Pile Frames

Many of the latest improvements in equipment have been developed of recent years in the United States of America, where wage rates are so much higher than in Britain. Where these conditions apply, plants built exclusively for pile driving are designed for mobility and high rates of progress, with very little regard to weight and expense. This has resulted in a tendency to what we might consider to be a more extravagant use of plant. Many contractors in this country object to the use of excavators for pile driving for this reason, but high rates of wages in this country are making it worth while owing to the mobility and, consequently, better progress which can be attained with an excavator fitted with hanging leaders suspended from the jib, in comparison with the conventional type of piling plant. On an excavator the leaders are held at the bottom by a fixed or telescopic strut, thus permitting them to be adjusted to a slight rake if required. They can be used with drop-hammers, single- and double-acting hammers (see Photos 1 and 2).

Modern pile frames of the conventional type used in this country are designed to handle piles of larger dimensions than would normally be possible for piles driven from an excavator fitted with hanging leaders. Photo 3 shows a 75–100 ft. Universal pile-driving plant. It will be observed that this frame possesses the following useful characteristics :—

1. Self erection, the frame being raised into the vertical position by means of the power winch which forms part of the plant.
2. Telescopic leaders.
3. Power-driven slewing gear.
4. Power-driven travelling gear.
5. Power-driven raking gear.

Photo 1. — 11.B.3 Double-acting McKiernan Terry hammer driving steel tube for sand drains.

Photo 2.—Hanging leaders and drop hammer with Koehring excavator.

Photo 3.—75/100-ft. Universal pile driving plant.

Latest Trends of development in pile driving equiptments and methods 1,2,3

Photo 4.—50/80-ft. pile frame on rollers.

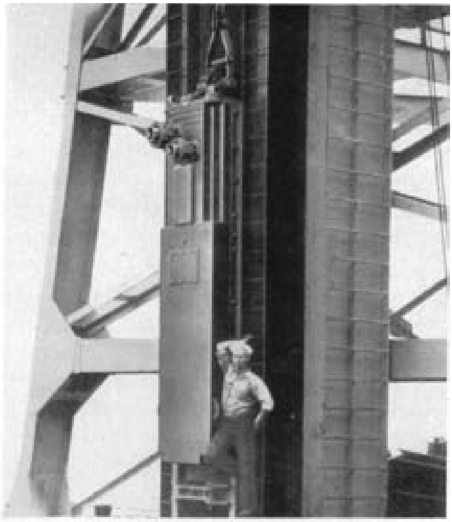


Photo 5.—Single-acting heavy hammer.

Photo 6.—Pre-stressed sheet piles.

Latest Trends of development in pile driving equiptments and methods 4,5,6

Latest Trends of development in pile driving equiptments and methods 7

Such an item of plant to-day costs in the region of £15,000, but under suitable conditions would be an economic unit. Photo 4 shows a 50–80 ft. pile frame mounted on rollers, which is becoming increasingly popular.

Compressed Air

There is a tendency in the United States for all power-operated piling equipment to use compressed air, both for operating single- and double-acting hammers and winches. In this country these are normally operated by steam. For the larger hammers a very large quantity of compressed air is required, and it is common in the U.S.A. to see pile driving-installations with their attendant batteries of mobile compressors. The tendency for ice to form is counteracted by the use of "after-coolers" in the compressors which remove the damp particles of air prior to their entry into the hammers. It is, however, important to change the lubricant when using compressed air. The economics of the use of air will vary from country to country and even site to site.

Hammers, Steam or Compressed Air

Up to the present time the largest McKiernan Terry double-acting hammer, manufactured in Britain, has been the 10B3. The 11B3 hammer will be manufactured by the British Steel Piling Company Limited in the near future. This hammer has a ram weight of 5,000 lb. as compared with 3,000 lb. of the 10B3, and an energy per blow of 19,156 ft./lb., as compared with 13,100 ft./lb. for the 10B3, both working at their maximum speeds of 95 and 105 blows per minute respectively.

A new single-acting heavy hammer has recently been introduced in the U.S.A. (Photo 5). This hammer is totally enclosed and able to operate under water, a feature applicable to some types of double-acting hammers. It is made in various sizes with rams weighing up to 14,000 lb. and a stroke of about three feet and gives a higher rapidity of blows than the British type.

Hammers, Diesel

Single-acting hammers of the internal combustion type, in which the ram is raised by the explosion of the mixture and falls by gravity, are of relatively recent production. They have the attraction of being self-contained and require no boiler or compressor, but up to now have not been made in sizes large enough for anything but rather small timber or concrete piles. They range from the small Lagonda to the Syntron. Comparative maximum ram weights are :—

Syntron	5,600 lb.	Johnson	1,980 lb.
B.S.P.	2,464 lb.	Lagonda	323 lb.

Dollies, Plastic Composite

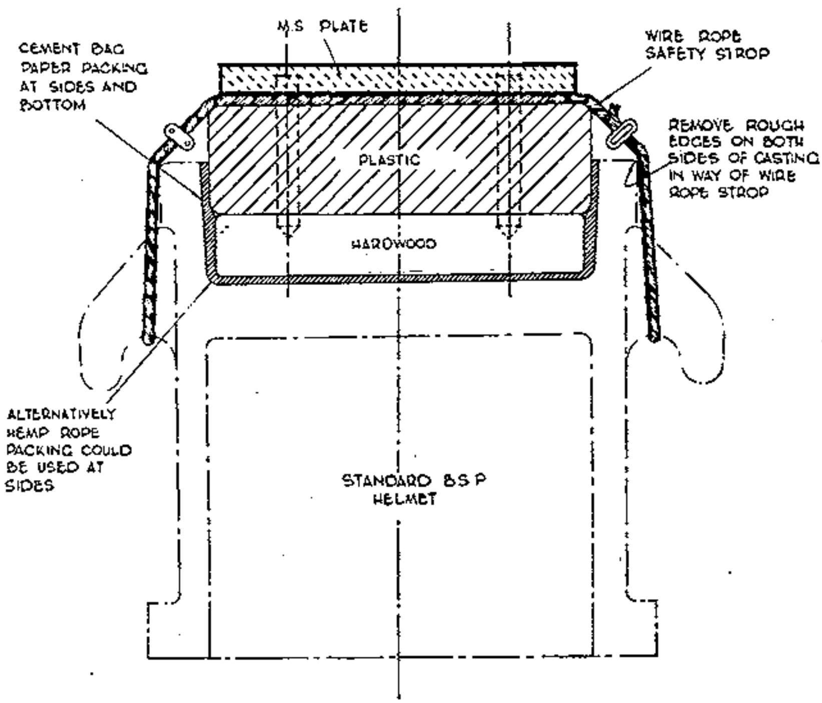
The packing on top of a reinforced concrete pile, usually in the form of hessian sacking, is held in position by the helmet. The helmet in turn must be protected from the blows of the hammer and is therefore provided with a cushion or dolly, generally of some hardwood such as elm or pinkado. The dollies are expendable and the cost of their replacement in materials and delays may form an important item in a contractor's costs in difficult driving conditions. Under such circumstances a dolly can only be expected to last two or three piles, and sometimes may have to be replaced at least once in the driving of every pile. Since the war, the scarcity of good imported hardwoods has emphasized the necessity for a more durable material—even if it is more costly. The qualities required are toughness and resistance to impact rather than high compressive and shear strengths. Experiments have been going on for some time with plastic materials and it has been found that a laminated material, consisting of layers of fabric impregnated with a thermo-setting resin, produces a hard and homogeneous product. Up to the present time the most suitable plastics for dollies have been found to be those covered by British Standards 668 and 972/1941, Type C. It has not yet been found practicable to make dollies consisting entirely of plastic, but a type now in use consists of an upper layer of plastic and a lower layer of hardwood (Plate 1). The top surface of the plastic is protected by a thick steel plate held in place by spikes with counter-sunk heads, the spikes passing through the plastic and penetrating into the hardwood. The disadvantages of timber are not entirely eliminated by the use of composite dollies and research for a suitable self-contained plastic material is continuing. The performance of plastic dollies already in use has proved that, although their initial cost is high, the cost per foot of pile is likely to be considerably less than for hardwood. In moderately hard driving a plastic dolly will last for several hundred piles, when one made in hardwood will be destroyed after a dozen piles have been driven. On a recent contract at Beckton approximately 4,000 piles have been driven for the use of three plastic dollies ; but here it was found that the oak used as the hardwood layer had to be replaced after every eight piles. The final stage, therefore, appears to be an all-plastic dolly to save the 2½-in. layer of replaceable oak and experiments are continuing on these lines.

Cast-in-Place Caissons

An interesting development in the United States has been the use of what is known as the Gow Caisson pile for building foundations (see Plate 2). This method is useful in distributing heavy loads on the selected bearing stratum, but can only be used when this is

PLATE 1

NOTE.- THE DOLLEY SHOULD ALWAYS BE TIGHT IN THE HELMET. IT SHOULD BE PACKED WITH PAPER BAGS OR ROPE AS SHOWN. IT SHOULD BE REPACKED IF THE TOP OF THE PLASTIC APPROACHES WITHIN ONE INCH OF THE TOP OF THE HELMET. A NEW OR REPACKED DOLLEY SHOULD BE FITTED ONLY WHEN STARTING TO DRIVE THE PILE AND NOT WHEN DRIVING RESISTANCE IS SEVERE



ASSEMBLY OF
COMPOSITE DOLLEY FOR PILE HELMET

THE BRITISH STEEL PILING CO. LTD
LONDON AND CLAYDON, SUFFOLK

sufficiently firm and free from ground water to permit a man to excavate the bell at the base. The caissons are cast-in-place inside a set of nestable steel casings of 2 in. diminishing diameter for each 16-ft. section. Top diameters of the caissons vary from 58 in. to 82 in. They are belled out at the bottom.

Caissons are drilled with a $1\frac{1}{4}$ cu. yd. bottom dump auger, mounted on the bottom of a telescoping spline shaft that has a 120-ft. maximum extension. This drilling rig is mounted at the front of an all-electric crane, and the spline shaft and auger are powered by a 75 h.p. electric motor. The auger has a nominal cutting diameter of 48 in. and for drilling holes larger than 48 in. two adjustable reaming knives at the top of the auger are adjusted to the proper length. During clockwise rotation these knives turn out and cut to the required diameter, dropping the material into the top of the auger. During counter-clockwise rotation, the knives fold in against the auger.

When the top 16 ft. of hole has been drilled the first 16 ft. section of steel casing is lowered into position, cutting knives of the auger are retracted 1 in., a second 16 ft. depth of hole is bored and encased with the second section of casing which is 2 in. smaller in diameter than the top section. This procedure is followed until the hole is bored to the full depth and lined with the number of sections of the nestable casing to be used for the required foundation. When the hole has been bored to its full depth, tests are carried out on the bearing stratum to determine the diameter of the caisson bell.

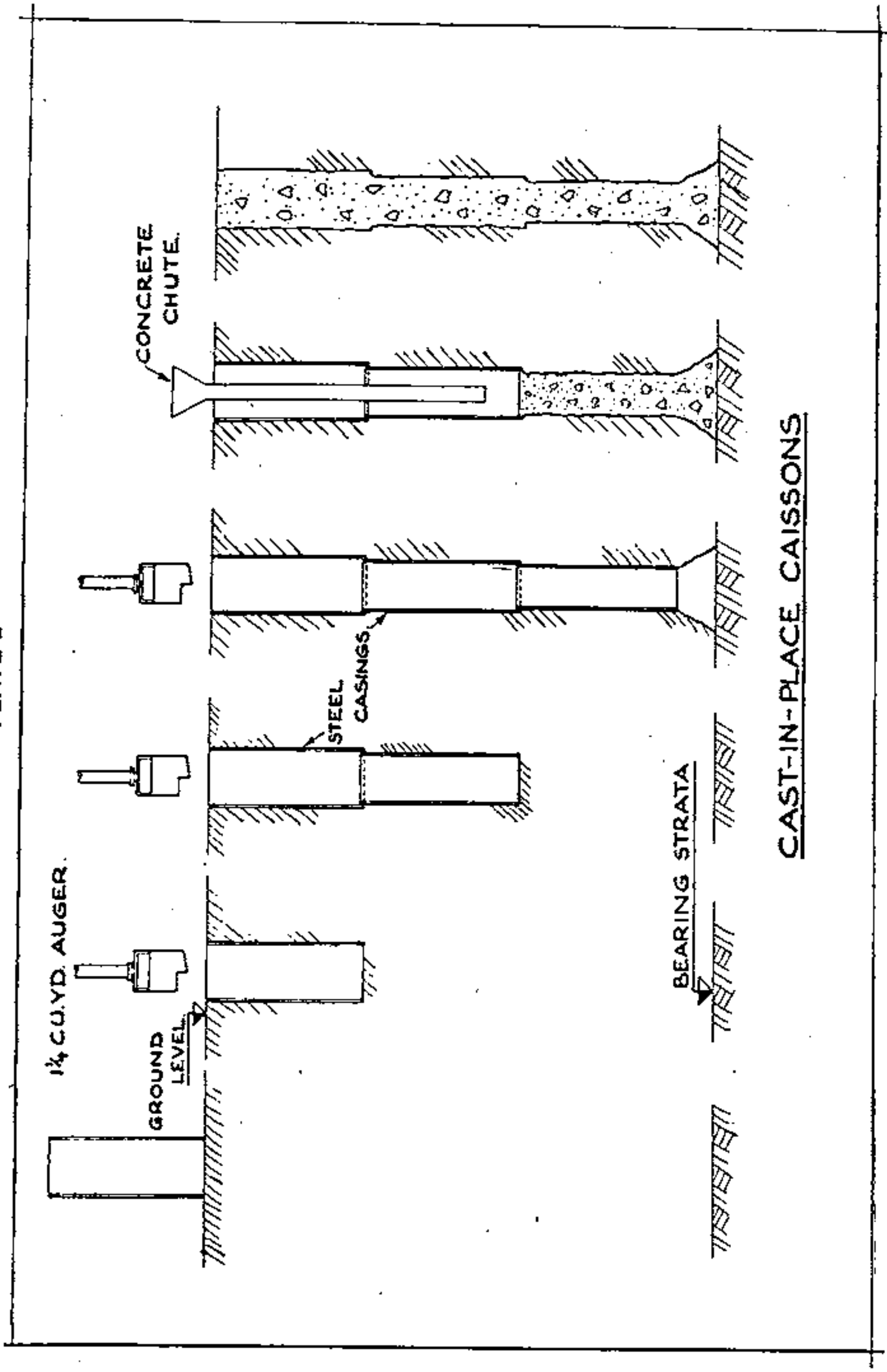
Concrete is placed down a telescoping concrete shute. Concrete is not tremied into position but the bottom of the chute is kept about four feet above the top of the concrete. The casings are retracted as the hole is filled with concrete each telescoping into the one immediately above, the bottom of the casing being always kept 4–6 ft. below the top of the concrete. They are retracted with a special pulling rig mounted on sheer-legs with a maximum pull of 100 tons.

These caissons are also made in nestable lengths of 8 ft. in 2-in. diminishing diameters. They are installed by the Gow Division of the Raymond Concrete Pile Company of New York.

Prestressed Reinforced Concrete Piles

A comparatively new development is the use of prestressed concrete piles. The main advantages of these over the more traditional type of reinforced concrete pile are their economy in steel (approximately 60 per cent of normal reinforced concrete pile), no shear reinforcement is required and lateral binders can also be dispensed with where driving is not unduly hard, smaller comparative dimensions and, therefore, economy in aggregate and cement. The portability of reinforcement which consists of high tensile wire with

PLATE 2



CAST-IN-PLACE CAISSONS

Fig. 11.

an ultimate tensile stress of 70 tons/sq. in. is also a great advantage. The disadvantages appear to be in the magnitude of the area required for a casting yard, the great care necessary in the mixing of the concrete, which has to be capable of a crushing strength of up to 5,000 lb. per sq. in., and the exactitude required in the prestressing of the wire to prevent hogging occurring in units of long length.

The system is based on the long line method of production in which the reinforcing wires pass continuously through a line of moulds and are secured under tension to heavy anchorages at each end of the line. The length of the lines is determined with reference to the length of the product, the output required and the length of wire available. Photo 6 shows an example of prestressed sheet piles. Prestressed 12 × 12 in. piles up to 65 ft. long were recently driven in the Queens Dock, Swansea, for the National Oil Refineries.

Comparative weights of steel for prestressed and ordinary reinforced concrete piles are shown herewith :—

Length of pile	Up to 40 ft.	40–50 ft.	50–60 ft.	80 ft.
Cross section of prestressed pile	12 × 12 in.	12 × 12 in.	12 × 12 in.	14 × 14 in.
Total weight of steel per lin. ft. of prestressed pile	3.97 lb.	4.52 lb.	6.12 lb.	15.16 lb.
Cross section of Ordinary R.C. pile	12× 12 in.	14 × 14 in.	16 × 16 in.	18 × 18 in.
Total weight of steel per lin. ft of ordinary R.C. pile	11.75 lb.	14.87 lb.	18.35 lb.	26.55 lb.

Conclusion

It is hoped that the foregoing information will give some idea of the lines along which development has taken place in recent years.

There is still much scope for further improvement in the ability to place a pile-driving plant on a site and get it to work within a matter of a few hours of arrival. Photo 7 shows one such self-erecting plant loaded for transport.

It is to be hoped that this trend will be further developed as it obviously has certain advantages from a military engineering standpoint.

Acknowledgements

The author is indebted to the following firms who have kindly assisted him in the provision of information for the production of this paper :—

British Steel Piling Company Limited.
Dow-Mac (Products) Limited.
Woodfield Hoist Company.
Liner Concrete Machine Company Limited.
Road Machines (Drayton) Limited.

DIVING

By MAJOR R. M. POWER, R.E.

INTRODUCTION

THE ability to perform work under water is an obvious requirement in many civil engineering tasks in both harbours and bridge piers. Tasks come to mind such as examinations of existing works for damage or deterioration, the clearance of obstructions and the repair of unsafe structures, besides new construction. In the last war divers were included in the war establishment of Port Repair and Construction Companies R.E., and they are now included in those post-war Construction Regiments R.E. earmarked for port work. Many officers will also recall incidents when they have had to improvise diving apparatus from gas masks connected to compressors.

Diving is included in the curriculum of the 17 Port Training Regiment R.E. at Marchwood. A nucleus of sapper divers are trained at the Royal Navy Diving School in H.M.S. *Vernon* and thereafter are used to give instructional dips in the Marchwood diving tank, besides carrying out a variety of tasks as they occur.

The object of this article is to explain some of the principles and problems involved in diving so as to acquaint officers with this comparatively unknown yet, at shallow depths, simple engineering requirement. The article refers mainly to the familiar standard suit and equipment. Where shallow water is mentioned, it implies depths down to 60 ft., for which there is no time limit for diving. Normal diving is taken as down to 180 ft., the limit for manual pumps and standard equipment. Deep diving (for flexible suits) is below 180 ft. to the present practical limit of 300 ft. ; at these depths special precautions must be taken to guard against nitrogen narcosis.

PHYSIOLOGY OF DIVING

Firstly a few remarks on the effects of pressure on the human body. We all know that as you descend in water so the pressure increases, depending on the depth of water. For sea water, weighing 64 lb. per cu. ft., a head of 33 ft. is equivalent to a pressure of 14.7 lb. per sq. in., or one atmosphere. Now the standard diving dress consists of two parts, an uncompressible helmet and a compressible suit, so that as the diver descends the air in the suit is compressed by the water

Photo 1.—Diver Front View.

Photo 2.—Diver Back View.

Photo 3.—Preparing for a Dip.

Photo 4.—Marchwood Diving Tank.

Diving 1,2,3,4

pressure. This compression follows Boyle's Law that pressure multiplied by volume is constant: the pressure being the absolute pressure, that is, the sum of the atmospheric and gauge pressures. Hence in descending there is a tendency for the diver to be squeezed into his helmet. This squeeze effect can only be overcome by pumping more air into the suit in order to raise the pressure.

There is, of course, a pressure difference between the diver's head and feet of about three pounds per square inch. The ideal is to retain air inside the suit down to the chest so as to equalize the pressure inside and outside the lungs so making breathing easier. An adjustable valve in the helmet exhausts the surplus air to the outside, thus ensuring the circulation of fresh air for breathing and also providing a means for adjusting the pressure inside the suit.

When descending, the air supply has to be considerably increased to compensate for the diminution in volume, but when the bottom has been reached the supply can be reduced to provide enough air for breathing and to replace leakages. On the other hand, should the diver fall under water, say off a platform or into a pothole, he will be "squeezed" because the pumps cannot be sufficiently speeded up to compensate for the diminution in volume. This "squeeze" can be quite dangerous and even fatal. The effects, of course, depend on the height of the fall and the depth: a fall of 20 ft. being more severe from a depth of 20 ft. than from 60 ft.

Conversely, when ascending, the air in the suit expands and, if it cannot escape, the diver will be "blown up" and shoot to the surface inflated like a balloon with his arms stretched out and unable to reach the valve on the helmet. These effects, both ascending and descending are cumulative. For instance, as the diver descends the contracting air reduces his buoyancy and hence his speed of descent increases rapidly unless he can check himself or the air supply be increased. Conversely, when coming up there is a tendency to shoot up out of control once he starts rising.

Another effect of a rapid descent is to produce discomfort in the ears because of the increased pressure not being balanced on both sides of the ear-drum. The inside of the ear-drum is connected to the throat through a passage called the "eustachian tube." This is normally closed and unless opened the excess pressure on the outside of the ear-drum will cause acute pain and may eventually burst the ear-drum. Swallowing is the recognized means of opening these tubes, but with some people this has no effect, especially if they have a cold. Similar ear trouble is experienced in rapid descents in aircraft and even down mountains. Many no doubt have experienced this trouble and been advised to hold their nose and blow hard, but the diver has no access to his nose and if swallowing is of no avail, he must come up.

The breathing of compressed air produces other complaints, of which the most usual is probably the "bends," also called diver's palsy, etc. It is caused by the greater quantity of air being absorbed under pressure into the bloodstream through the lungs. The oxygen is used up leaving the nitrogen dissolved in the body. If, therefore, the pressure is suddenly released, the dissolved nitrogen appears as bubbles in the bloodstream, producing in elementary stages a tingling sensation under the skin, but in more advanced stages severe rheumatic-type pains in the joints, hence the name "bends," and in extreme cases paralysis and death. The effects can be best likened to a soda water bottle which is made to dissolve gas under pressure, but on release of this pressure effervesces according to the manner in which the cork is removed. The only cure is rapid recompression until the pain disappears, and the only antidote is slow decompression to allow the nitrogen to disperse, assisted by exercise.

It has been found that the human system can absorb without risk double the quantity of nitrogen. Hence there is no risk in descending to 33 ft., i.e., one atmosphere, and during decompression the pressure can be rapidly reduced to half the absolute pressure without fear. It has also been found that at depths beyond 60 ft. the liability to "bends" is increased by prolonged exposure under pressure. Based on these two facts, the Royal Navy have produced diving tables showing the duration of stops during ascents at different depths, depending on the duration of the dive; and they have also limited the duration of dives at depths below 60 ft., beyond which the diver should not stay down except in exceptional circumstances e.g., when fouled, very important work, etc.

An example of this table for 60 ft., which is about the limit for civil engineering diving, is :—

Depth	*Pressure*	*Duration of dive*	*Stops in minutes* 20 *ft.*	10 *ft.*	*Time for ascent*
60 ft.	26½ lb. /sq. in.	Up to 15 min.	—	—	2 min.
		Up to 30 min.	—	5	7 min.
		Up to 60 min.	3	10	15 min.
		Up to 2 hrs.	5	15	22 min.
		Up to 3 hrs.	10	20	32 min.
		Over 3 hrs.	10	30	42 min.

At greater depths the time under water is limited and the stops more numerous and longer, till at 180 ft., which is the limit of ordinary diving, we get :—

Duration of Dive	*Stops in minutes* 70 *ft.*	60 *ft.*	50 *ft.*	40 *ft.*	30 *ft.*	20 *ft.*	10 *ft.*
5 min.	—	—	—	—	2	3	5
10 min.	—	—	—	2	3	5	5
15 min.	—	—	2	3	5	7	10
30 min.	—	2	2	3	10	15	25
1 hr.	3	3	7	10	20	30	35
over 1 hr. 45 min.	15	25	30	30	35	40	40

The normal time limit at this depth is 15 minutes.

In order to save time and the discomfort and risks of stopping on the shot rope, a diving bell type of decompression chamber can be used when diving at great depths. It is lowered overboard with an attendant inside and the diver enters it at the first stop. The entry hole is then closed and the whole chamber hoisted inboard where the diver completes his decompression in comfort and unhindered by tides or bad weather.

Should for any reason the diver be unable to complete his requisite stops on the shot rope, and subsequently suffer from an attack of the "bends," his only cure is to be put into a compression chamber. This is a steel chamber large enough for a man to lie down and fitted with locks through which the attendants can enter.

The other most prevalent risk from breathing compressed air is CO_2, carbon dioxide, poisoning. There is always a small percentage of free CO_2 in the air and the amounts breathed in and out are about :—

	In	*Out*
Oxygen	21 %	16.5 %
Nitrogen	79 %	79 %
CO^2	.03 %	4.5 %

At atmospheric pressures the effects of CO_2 are :—

3 % causes panting and heavy breathing
10 % causes distress
25 % causes death.

Under pressure a smaller percentage causes the same effect, according to Boyle's Law, e.g., 1 per cent at 33 ft. is equivalent to 2 per cent at the surface. CO_2 poisoning, therefore, becomes a distinct risk at depths below, say, 60 ft., especially if the diver is working in such a position that there is a pocket of undisturbed air inside his helmet in front of his face. The diver will notice that his breathing becomes short and heavy. He has only to keep quiet and signal for more air to flush out his helmet.

From tests it has been found that a diver requires about 1.5 cu. ft. per min. of compressed air at all depths to prevent CO_2 poisoning. He will never fear for want of oxygen for the deeper he goes the more oxygen he breathes with each breath.

At greater depths, starting about 150 feet, one begins to get nitrogen narcosis caused by excessive absorption of nitrogen in the brain. Its effects are similar to alcohol, causing excessive hilarity, cheerfulness and unco-ordination between brain and muscle: a dangerous condition for a diver who is required to operate his own means of ascending and descending.

It is not fatal and has no after effects. In fact the symptoms come on quickly and pass off equally quickly on decompression. The diver may have no recollection of it and probably the only conclusive evidence that a diver is suffering from it is shown by his answers on the telephone.

Standard Equipment

The standard equipment consists of a waterproof dress on to which fits a metal helmet secured to a metal corselet or breastplate around the neck of the dress. The suit is entirely enclosed apart from the elastic cuffs for the diver's hands.

Special strong heavy boots—16 lb. each—are worn, and together with the front and back lead weights of 40 lb. each, they help to overcome the buoyancy of the diver caused by the water displacement of the helmet and the inflated dress. The total weight of the equipment worn by a diver is about 175 pounds.

The helmet is connected to the surface by an air line and a life line, or breast rope, in which is incorporated a telephone line. Where no telephone is provided signals are passed by pulls on the air line and the life line: there are some fifteen signals to be learnt.

The standard air pump is a two-cylinder reciprocating hand-operated air pump.

Helmet

This has two valves, an inlet and an outlet. The inlet, to which the air line is connected, has a non-return valve to retain the air in the suit should the air supply fail.

The outlet valve is an adjustable spring-loaded non-return valve, which exhausts the air to the water. The adjustment is necessary to suit the diver to his convenience. The amount of inflation in the suit is varied by altering the size of the outlet by screwing in or out the valve. In addition there is a plunger operated spindle by which the diver can stop the escape of air. He uses this when coming up or to make himself light for moving around; compared to the screw adjustment it has the advantage of being more positive and immediate in action.

Pump

The standard hand pump delivers theoretically $\frac{1}{10}$ cu. ft. of free air per revolution per cylinder. The two cylinders can be either connected in series to one diver or in parallel for two divers at shallow depths. For greater depths two pumps can be connected by means of a special four-way junction. There are gauges on the pump to show the pressure of the air being supplied.

Based on the diver's requirement of 1.5 cu. ft. of compressed air per minute to avoid CO_2 poisoning, and after making an allowance for pump efficiency, we get the following table for pumping :—

Depth	*Free air per minute*	*Cylinders*	*R.P.M.*	*Men per shift*
0	1.5 cu. ft.	1	15	2
33 ft.	3.0 cu. ft.	1	30	2
54 ft.	4.2 cu. ft.	2	20	2
78 ft.	5.0 cu. ft.	2	25	4
96 ft.	5.9 cu. ft.	2	30	6
120 ft.	7.0 cu. ft.	4	20	12
156 ft.	8.5 cu. ft.	4	25	12
180 ft.	9.7 cu. ft.	4	30	12

180 ft. being equal to pressure of 80½ lb. per sq. in.

In commercial practice the tendency now is to use compressors in place of manual pumps and so save the labour costs. Quite a small compressor suffices as it has only to produce a small volume of air, but it is important that it has a reservoir large enough, in case of breakdown, to inflate the diver to the surface. The reservoir will probably work between 80 to 100 lb. per sq. in. through the normal unloader, but thereafter the air must pass through a filter to remove oil which is injurious to the lungs, and also through an adjustable reducing valve. Before descending the diver will adjust this valve to a few pounds over the maximum that he is likely to require. For deep diving, however, the air pressure must be adjusted as the diver descends and ascends, keeping it just above that corresponding to the diver's depth.

Diving Drill

Whenever diving is being carried out there must be a qualified attendant on the surface and also, in all except the most simple fool-proof dives, a spare diver ready to go down to the assistance of the diver should he get into difficulties. The duties of the attendant are very responsible. He must himself be a diver, who therefore will understand the difficulties of his charge below. Similarly the diver is very dependent on his attendant and must have confidence in him. Each diver must have a separate attendant on the surface.

The other important consideration is a means of getting into and out of the water. Weighed down with 175 lb. of kit, the diver cannot just clamber over the side of any boat. To begin with, the boat or craft must be big enough, and steady, to hold the pump, the pump hands and the variety of gear. A large rowing cutter with seats removed or decked over is about the minimum size. In addition it must have a steel ladder projecting three or four feet into the water and with a hand rail above the gunwale for the diver to steady himself. Rope ladders are useless.

In some places the diver can wade out from the shore but until he is under water he must carry the full weight of the equipment which is most tiring and also unsteady. There is no question of his climbing up and down ladders from the quay when fully dressed.

Before diving, the first thing is to test the equipment. After connecting up the air line to the pump, the end should be blocked with the palm of the hand and the pump hoved round till the gauge shows a pressure in excess of that required. The pump is stopped and any leaks are soon apparent. The valves on the helmet should be inspected and the inlet valve non-return spring tested by finger. The rest of the equipment should be examined for serviceability and wear and tear.

The diver then dresses, assisted by his attendant. This should be done as near the ladder as possible, as the suit is heavy and awkward to move about in. In cold weather it should be done preferably in a warm place or at least out of the wind.

Normally the diver wears long woollen stockings to counteract pinching by water squeeze around the legs. Otherwise he wears clothing depending on the water temperature, adding layers of thick sweaters in winter, and finishing with the traditional red woollen cap, taking care that the tassel will not dangle in front of his eyes under the helmet.

He climbs into the diving dress, forces his hands through the cuffs and puts rubber rings round his wrists to make them watertight. A shoulder pad is slipped into the dress to take the weight of the helmet and corselet. The diver sits down and the corselet is slipped inside the collar of the dress and the nuts screwed up to make the joint watertight. Suits are supplied in three sizes, and whilst a man cannot get into a suit too small, he can wear a large suit with a jock-strap passed between the legs and holding the corselet down so that he can see out.

The diver then moves as near as possible to the ladder, sits down and the boots are put on. The helmet is next screwed on to the corselet, without the front glass. The air line and life line, which are screwed on to the helmet, are passed from behind up under the arms and secured by lanyards to the corselet. A belt with sheath knife is buckled on.

The next stage is to clamber on to the ladder, using the handrail as support, and to climb down as far as possible so as to squeeze the surplus air out of the legs. The chest and back weights are added and secured by slip knots so as to be easily jettisoned. The pump is hoved round to make sure the air is coming through, the front glass screwed into the helmet and, with two pats on the helmet, the attendant signals to the diver that all is ready for his descent. As a final test the diver may close his spindle valve, get his body and head under water whilst the attendant looks for leaks.

Practical Work

For going up and down and also for passing small tools, the diver uses a shot rope, a 3-in. cordage with a ½-cwt. sinker. In muddy water a distance line is attached to the bottom of the shot rope. The shot rope must always be used. If not the diver cannot check his descent and he may suffer severe pain in the ears, and conversely get blown up and even strike the bottom of the boat.

From the time the diver gets on the ladder till he comes up, the attendant must concentrate on his duties. The air line and breast line must be held moderately tight so as to follow the diver's movements yet not restricting him. It is best to have a few feet slack and take a feel from time to time. He must answer all signals, keep an eye on the gauges if there is risk of a fall, and he must adjust the shot rope for tide changes. He should follow the diver's position from the train of bubbles and from time to time signal or telephone him whether he is all right.

From the ladder the diver floats himself off on to the shot rope, being pulled if necessary by the attendant. He grips the rope between his legs and with one hand, and slides down. The pumps should be speeded up during descent to avoid a squeeze, and possibly the outlet valve closed. The rule is, the faster the pumps the quicker the descent. Maximum normal depth of 180 ft. should be reached in 1½ minutes with two pumps, that is, four cylinders, connected for one diver.

On the bottom the diver signals his arrival then adjusts his valve. There should be enough air in the suit to support the helmet and weights, yet not to make him too light on his feet. Each change of position from standing to sitting, etc., needs an alteration in valve setting, which can only be learnt by trial and experience. When sitting or standing the adjustment once made can be left, but when crawling or lying on his side with the valve downwards, excess air may accumulate in the baggy part of his suit sufficiently to make as much as possible. Another disadvantage is that one is at the mercy of the diver, and should he prove troublesome or noncooperative, he can cause very considerable delays on the whole works. For this reason and also the difficulty in supervising under-water work, it is most important that divers are selected from trustworthy and dependable men. In fact their qualifications in order of preference are—reliability, skill and physical fitness. Any active, fit soldier with average physique—not too short or tall or fat—can be trained as a diver provided he has the right temperament and does not suffer from ear trouble.

Most ordinary hand tools—saws, hammers, chisels, picks and shovels—can be used under water with a certain amount of slowness and difficulty. Pneumatic tools, of course, lose a great deal of efficiency on acount of water back pressure on their exhaust unless fitted with an exhaust pipe leading to the surface. In any case it is advisable to have this extension, as otherwise the great mass of exhaust bubbles makes work extremely difficult.

For cutting steel special gas-burning torches must be used. They are similar to the ordinary acetylene torch, but with an annular nozzle round the flame through which compressed air protects the flame. Hydrogen is used in preference to acetylene as it is less prone to backfires, though it does not produce so much heat. The torch can be lit under water by the sparks produced when it is rubbed on a serrated striking plate connected to a battery. Electric welding is done with special rods held in insulated holders.

Deep Diving

Deep diving beyond 180 ft., requires special equipment and techniques. Apart from the mechanical difficulties in such depths, there is the much greater risk from "bends," being blown up and CO_2 poisoning, besides nitrogen narcosis. The standard suit is used, but with a circulating breathing set designed to give the diver air as free from CO_2 as possible. Air is supplied from the surface from industrial gas cylinders at 120 atmospheres.

Decompression is normally done in the special decompression diving bell lowered down to the first stop. Yet in spite of all these special precautions, the useful time on the bottom is so extremely limited—about fifteen minutes at 300 ft., followed by one hour decompression—that deep diving has very limited uses.

Self-Contained Diving Suits

The last war produced many types of self-contained diving sets, such as used by frogmen, human torpedomen, etc. They all worked on the same principle as the Davis Submarine Escape Apparatus, namely, a small oxygen bottle, an artificial lung and a CO_2 absorbent canister.

him buoyant and blow him to the surface. In these positions the diver must take care to spill out the surplus air, when he feels himself becoming buoyant, by raising his head and opening his valve. To minimize the risk of being blown up, the legs can be laced up behind ; this is usually done in deep diving where the effects of being blown up can be more dangerous.

For the first time the beginner feels very ungainly. The suit over the chest and arms is puffed out, he has to force his arms down to his side and there is considerable resistance of the water to movement. All moves are slow and even lying down and getting up requires quite a knack. Mud and darkness add to the feeling of isolation.

To ascend the diver first signals his intention, then closes his spindle valve. After a while he feels himself becoming light, then when he takes off he rises up the shot rope without effort. The pumps should be slowed down during ascent. There are no restrictions on the speed of ascent, apart from stops required to counteract the " bends."

Tide, bad visibility and cold are the divers greatest difficulties. A tide tends to sweep him off the bottom, if he can get there in the first place. The limit in tides is about 2 to 2½ knots. Even at 1.5 knots he may have to add weights to get down, though once on the bottom he may be able to avoid the current by crawling. Bad visibility makes work slow and more difficult as the diver will have to work by touch. On muddy bottoms he should keep to the leeside and avoid floundering about. Sometimes it is better to spread over the top of the mud and keep himself light rather than stand upright, in which position he is likely to get his legs stuck in the mud. The cold he will feel through his hands and partly through the suit, though he can overcome the latter by wearing more clothes. No really effective gloves have been invented that will keep out the cold yet allow enough freedom to fingers for work especially by feel.

If fouled there is no need to panic, provided, of course, he has observed the normal precautions. The advantages of the standard suit over self-contained breathing apparatus is that he is assured of his air and also communications by telephone to the surface. The diver can afford to take his time, think out why he is foul and if necessary wait for another diver to come down and clear him.

If the pumps or airline should fail, it means that the extra air cannot be supplied to bring him up. However the non-return inlet valve in his helmet will hold the air in his suit which will be enough to float him up when he slips the chest and back weights.

Generally all types of civil engineering work can be done under water—concreting, masonry, clearance and demolitions, timbering, steelwork—though at a much slower rate and often not so well. Due to this, and also the extra costs, the use of divers is to be avoided

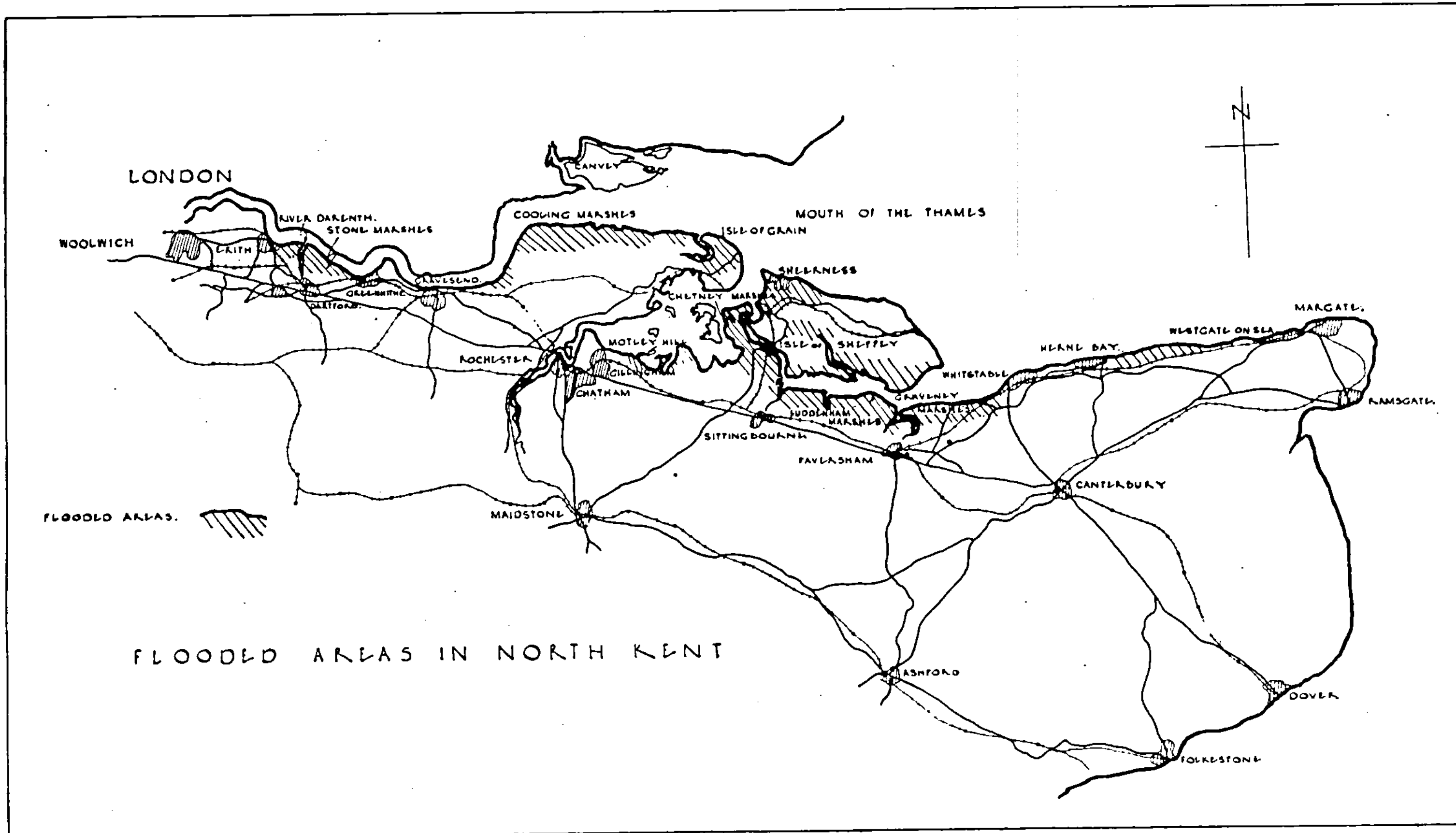
The oxygen is delivered through a reducing valve to the lung which acts as a reservoir. The diver breathes from and back into the lung through the canister which removes the CO_2. There is no wastage of oxygen, but even so the endurance of the sets varies from 40 minutes to $1\frac{1}{2}$ hours.

The diver breathes from a mouthpiece, so the set is independent of the suit. The latter is intended for protection against cold, abrasions, etc., and can be dispensed with in warm waters. Suits are much less robust and lighter than the standard suits. They can be either one- or two-piece.

The advantages of these sets are their lightness and simplicity in operation compared with the standard equipment with its pumps, airlines, weights and attendants. They are most useful for reconnaissances or light work, as a diver can be so easily transported to the site and put down, but they are not a reliable substitute for continuous or hard work.

Their chief disadvantages are that the sets are fragile and somewhat complicated ; there are more gadgets, such as valves and canisters, to go wrong and requiring careful maintenance. Again, in operation they are not so foolproof as the standard equipment. The diver requires more training and constant practice and if anything should go wrong during a dive, he will find himself in a worse predicament.

Another disadvantage is that on account of breathing pure oxygen their use is limited to depths of 33 ft. Below this there is a risk of oxygen poisoning. This affects individuals at different depths—33 ft. is a safe maximum— and its effects are most unpleasant besides being dangerous. It starts with a slight twitching, then very rapidly convulsions set in and the divers get fits similar to epilepsy. As yet very little is known about oxygen poisoning, either its cause, or its cure or antidote.



FLOODED AREAS IN NORTH KENT

THE FLOOD DISASTER IN NORTH KENT

By Major J. C. Woollett, M.C., R.E.

Introduction

THE recent flood disaster on the east coast gave rise to large-scale Service aid to the Civil power. In north Kent a Flood Control H.Q. was set up at S.M.E. and this account is based on the writer's exprience as a member of that organization. There were few points of technical interest, but many other lessons were learnt which should be of value in the future.

The Flood

On the night of 31st January the combination of a normal spring tide, a northerly gale, and exceptionally low barometric pressure over the North Sea caused a tidal surge which swept south. This surge raised the level of the sea at high water by six to eight feet, overtopping the sea defences of low-lying ground and at the same time damaging and in places destroying the walls.

The map shows where the flooding occurred. Beginning in the Erith–Greenhithe sector, where there is much industrial property, it continued along the south bank of the Thames to the Isle of Grain, where the oil refinery is being built. Low-lying parts of the Isle of Sheppey were under water and Sheerness was cut off. The whole of the marshy areas of the lower Medway were flooded, as were the marshes between Sittingbourne and Faversham, whilst the railway was washed out at Seasalter and between Herne Bay and Margate. The loss of human life was very small, but thousands of sheep and cattle were drowned, public utilities were endangered, and much valuable farm land was under water. In places where the walls had not been broken by the tidal surge they were retaining millions of tons of water which could not get away when the tide receded.

The Civil Authorities

Under the River Boards Act of 1948 the control of the sea defences of Kent, except in the areas of county and municipal boroughs, is vested in the Kent River Board. The executive side of this organization is analogous to a C.R.E. Works establishment. There is a Chief Engineer at Maidstone, assisted by a Deputy (cf., C.R.E. and D.C.R.E.). The coast is divided into areas and these areas are sub-divided into divisions. The area and divisional engineers may be said to correspond to G.Es. and A.G.Es. ; they have under them foremen and some directly employed labour, but most of their work is executed by contract. On the administrative side the principal figure is the Clerk to the Board. It is difficult to find a military parallel for him.

Other authorities and officials affected are the Municipal and County Borough Councils, the Agricultural Executive Committee, the County Surveyor, local representatives of the Ministries of Food, Fuel and Power, Health and Labour, and the County Police. In theory, the co-ordination of all these interests is a regional responsibility. The Regional Commissioner does not function in peace, but the Principal Regional Officer of the Ministry of Town and Country Planning at Tunbridge Wells deputizes for him.

Service Authorities

The senior Naval authority in Kent is the Commander-in-Chief the Nore, with his H.Q. at Chatham, but the Marines at Deal are under command of the Major-General, Royal Marines, Portsmouth. As far as the Army is concerned Kent is included in Home Counties District, with its H.Q. at Shorncliffe, whilst the various R.A.F. stations owe allegiance to different Group H.Q. Some flooding occurs on the east coast almost every year, and a number of plans had been prepared to provide Service aid if required. Two of these plans affected the S.M.E.; one involved sending soldiers to Essex and was known as "King Canute," the other called for troops to be sent to the Fens and was known as "Flood."

The First Days

At the unfortunate hour of five o'clock in the morning of Sunday, 1st February, H.Q. Home Counties District ordered H.Q. S.M.E. to put "King Canute" into operation. The machinery began to turn and by ten o'clock eighty men were on their way to Essex. During the morning the full extent of the disaster became known, and on the initiative of local commanders parties were sent off on urgent work, such as the rescue of cattle. The bulk of the troops were, however, kept ready in barracks for dispatch to the Fens, in accordance with the plans for operation "Flood." At midday Home Counties District ordered the Commandant S.M.E., Brigadier Browning, to provide support to the Kent River Board in the sector from Whitstable to the west, including the Isle of Sheppey; Dover garrison being responsible for the Whitstable–Margate sector. Shortly afterwards the S.M.E. was released from "Flood," and the afternoon was spent in getting stores and tools together and in collecting information from the Kent River Board.

The office of the North Kent Area of the Kent River Board is at Admiralty Pier, Gillingham, where the Area Engineer and two of his Divisional Engineers are established, another Divisional Engineer being at Dartford. This office was being assailed from below by farmers, factory owners and local authories, and from above by ministries and county authorities. As their single telephone line was blocked with calls and their clerical staff was overwhelmed with visitors it was extremely difficult for them to get any clear picture of what had happened. The head office of the Board in Maidstone was also undermanned as the Chief Engineer was ill, and his work devolved on his deputy, Mr. Taylor.

On Sunday evening Brigadier Browning held a conference and brought the S.M.E. on to a "war" footing; he also sent Major Crooks to Mr. Taylor as a liaison officer. Some demands for working parties had been received, and these were arranged for the next day. On Monday, 2nd February, Major Crooks accompanied Mr. Taylor on a reconnaissance of the area, but the latter was so frequently waylaid by authorities, from the Minister of Agriculture downwards, that very little was accomplished. In addition much of the damage was inaccessible except by walking for miles along sea walls. The next day Mr. Taylor and Major Crooks made an attempt to look at the area from the air, but this was not very successful as a suitable aircraft was not available, and they had to go round separately in a Harvard and a Meteor.

By now the routine had been established of an evening "O" group, at which the regiments of the S.M.E. were ordered to find working parties and stores for the Kent River Board; requests for other troops being passed to Home Counties District. There was still no clear picture of the damage, nor any real plan to deal with it as a whole, and it was becoming apparent that some working parties were engaged on what seemed to be work of little importance.

On Thursday, 5th February, the writer was installed as Staff Officer Floods to the Commandant. It was clear that our first task was to give all help we could to the Kent River Board, to determine the extent of the damage and the relative importance of the various breaches. The next two days were spent in reconnaissance in co-operation with the Board and with the help of a Naval helicopter. This, coupled with the efforts of the River Board engineers on the spot, enabled the relative priorities to be decided and the troops to be taken away from less vital work.

The Second Week

By the 7th February the extent of the damage to the defences was fairly well defined and a lot of work was in hand. The River Board were keen to get all the damage made good as soon as possible, but the Services were naturally anxious to get back to their proper job of training for war. In order to get an absolutely clear picture of the help needed by the Civil authorities, Major-General Herbert, G.O.C. Home Counties District, held a meeting on 10th February at the S.M.E. which was attended by Service representatives, the Police and the River Board. He obtained a definite priority for important work, and got agreement to set up a combined H.Q. to cover the danger period of next spring tides.

This order of priority was as follows :—

(*a*)	Erith to Gravesend	Protection of factories, hospitals and the Littlebrook Power Station.
(*b*)	Kingsferry	Keeping open the Sheerness road.
(*c*)	Sheerness (Bartons Point and West Minster)	Avoiding isolation of the town.
(*d*)	Isle of Grain	Protection of oil refinery.
(*e*)	Motley Hill	Protection of Medway Towns sewage works.

On the River Darenth, troops from London District were working, assisted by Sappers from Chatham. Farther east the Navy were repairing gaps at Stone Marshes and near the Littlebrook power station. They were also responsible for the Kingsferry area, and were operating a ferry from Chatham to Sheerness in conjunction with the R.A.S.C. Water Transport Company there. On the Isle of Grain, McAlpines and Wimpeys had large numbers of workmen engaged on the refinery whom they were able to turn to repairing the sea walls. This sector was run entirely by them, except for some assistance with equipment and craft. Sheerness garrison, under Lieut.-Colonel Keane, was coping with the damage near the town with the aid of plant and stores supplied by the S.M.E. and ferried in by the Navy. Motley Hill and Chetney Marshes were under 10 Trades Training Regiment, who were assisted by the Buffs from Canterbury. Along the south bank of the Swale there were parties of Navy at Kemsley Mills, then Sappers, Marines, Buffs, Royal West Kents and R.A.F. from West Malling and Sandwich as far as Seasalter. A sandbag wall was being built on the road across Graveney Marshes as the wall there was too badly damaged to be repaired before next high tides. East of Herne Bay the railway embankment was being turned into a temporary sea wall by a contractor.

Most of the work consisted of repairing the walls with sandbags. At first Service bags were used and filled near the site, but after a few days, the Kent County Surveyor, Mr. Vallis, organized filling centres and filled bags of all shapes and sizes were delivered to convenient points by lorry. The main difficulty was getting them to the gaps with the sea on one side of the wall and floods on the other. DUKWs, folding boats, L.C.As. and barges were used where possible, but the bulk of the work consisted of carrying bags by hand along the slippery tops of the sea walls in biting cold weather.

In places where the walls were only damaged, repairs were not too difficult, but elsewhere, where they were completely broken down, the water flowed in and out with every tide, and deep scour occurred. On the River Darenth, in London District's area, a scoured hole was stopped with 600 tons of cement in bags, and a sandbag wall built on top. At Motley Hill a wall had to be built on firm ground behind the gap to stop the flow, and then the scour hole filled to close the breach. These were very long and laborious operations. Where water was being retained on the land by the sea walls it was necessary to make controlled breaches. A gap some twelve to sixteen feet wide was dug in the wall, and the spoil put into sandbags. A small retaining wall about one yard thick was left at the inshore end and was finally taken out by detonating four 1 lb.-charges. The breach was left to drain until the approach of spring tides made it necessary to close it with sandbags.

Kent Flood Control H.Q.

The spring tide danger period was from 13th to 19th February. So far there had been no further danger of damage, and Service assistance had been controlled and co-ordinated by Colonel de Brett, the Deputy Commandant of the S.M.E., assisted by the writer and Major Kenwrick-Cox, the B.M., with his two G.S.O.s3. This organization had proved adequate, but it made a long day (and sometimes night as well) for all concerned and there was no margin to cope with fresh trouble. As a result of General Herbert's meeting this organization was strengthened in order that it might be able to operate continuously throughout the danger period. The H.Q. was to be manned by a Controller to allocate Service aid according to the requirements of the Kent River Board. An intelligence section was provided to record information from the police and other sources, whilst the operation room was manned by a G.S.O.2, a G.S.O.3, a subaltern and a Naval liaison officer. In the S.M.E. theatre an information room was set up for the benefit of visitors and Press. Liaison officers, with wireless, clerks, orderlies and provost (to lend tone to the proceedings) were added and the whole organized into three shifts. The North Sea could do its worst.

General Herbert's plan was to complete urgent work and then draw troops into reserve so that they would be able to deal with fresh damage if it occurred. Soldiers were moved into Maidstone from Canterbury and Lingfield and a squadron of 32 Assault Regiment R.E. was brought in as a reserve of trained Sappers, 12 Regiment (the S.M.E. reserve) having been moved north of the river earlier. Extra transport was provided and the troops in barracks were kept half at thirty minutes' notices and half at four hours' notice by day and night. Sheerness was reinforced and a wireless link provided in case the G.P.O. lines failed. Danger times during the spring tides period were taken to to be three hours either side of high water at Sheerness, which allowed for the coastal variation. During these times the police sent their wirelss cars to the most important area and the Services provided patrols with portable wireless sets to pass information to the police cars from places where the weak spots on the walls could be observed. R.E. officers who knew the area were stationed with each police car ready to take over working parties as officers-in-charge of work. In the event, the organization was not set up entirely as planned, as the Kent River Board was directed by the Ministry of Agriculture and Fisheries to establish a H.Q. at their Gillingham office, so they were unable to find a representative to be at our H.Q. A direct line was laid between the two offices, which enabled us to maintain contact, although the Gillingham office, with it's limited facilities, was liable to become overloaded and overcrowded. Fortunately the weather remained calm and no further damage occurred, so that apart from the dispatch of a party to Motley Hill, where a wall was weeping badly, the organization was not tested.

By 19th February all troops were withdrawn and returned to their normal duties, except the Navy who were still operating a few landing craft delivering stores to breaches. This withdrawal was not accomplished without some firmness, as the River Board were understandably loath to give up a hardworking source of labour. A table showing the number of men employed each day is given in Appendix " A."

Lessons

The ability of the Services to set up an organization for reconnaissance in conjunction with the Police at short notice is of the utmost value to the Civil authorities. The latter are not organized to switch with such ease and ability, and so are not in a position to build up a new organization in a short space of time. It needs to be more generally recognized that the Services are not only suppliers of labour.

Prearranged plans for Service aid in emergencies normally take the form of arrangements to dispatch a body of men with tools, rations and equipment to certain areas. These plans tend to be detailed and rigid and often cause delay because the emergency when it occurs is usually somewhat different from the one that was foreseen. The problem at the beginning of these emergencies is nearly always to find out what has happened, and it would seem better to have plans to put existing H.Q. on to a war footing with facilities for collecting and collating intelligence, an organization to deal with stores, and an operations room with an adequate staff. A few troops would, of course, have to be ready to move at short notice, but the bulk could be organized later and then employed to full effect in the best way. If the emergency proved to be a small one, the H.Q. could quickly be stood down with little dislocation; a better arrangement than trying to increase and organize it when already working at full pressure.

The organization of the work followed well-tried principles which were again vindicated. An officer in charge of work, who was usually a Sapper, gave tasks to the officer in charge of the working party in accordance with the instructions of the River Board's engineers. He also arranged for stores and reported progress nightly to H.Q., S.M.E. Stores were organized centrally by O.C. S.M.E. Stores who controlled all issues.

All three Service ministries gave instructions that all possible aid was to be given to the Civil power. No further operational direction was given, nor was it necessary, as co-operation between the Services was quite outstanding, but representatives of the Services ministries met daily at the Cabinet Official Committee on Emergencies. The Navy ran the ferry to Sheerness and the Army co-ordinated the work on land, whilst the R.A.F. accommodated the Naval Aircraft and provided their own. The Army provided stores for the other Services and transport and tools for the R.A.F. It all worked extremely well and was most heartening.

Tailpiece

It all ended as it should. On the 19th February I said to Major Reed, O.C. S.M.E. Stores, "Well, we are closing down now." "Yes," he replied, "and I am closing in."

APPENDIX "A"

Working Party Strength 1st to 19th February

Date	*Navy (including Marines)*	*Army*	*R.A.F.*	*Total*	*Reserves (All Services)*
1	—	80	—	80	At ½ or 4 hours' notice to move during danger periods 13th–19th Feb.
2	—	300	—	300	
3	—	480	—	480	
4	200	600	—	800	
5	200	575	—	775	
6	850	610	—	1,460	
7	1,120	625	100	1,845	
8	1,420	550	100	2,070	
9	1,450	715	200	2,365	
10	1,450	940	160	2,450	
11	1,450	1,195	160	2,805	
12	1,500	1,020	200	2,720	
13	840	672	100	1,612	2,158
14	400	720	100	1,220	2,250
15	400	742	—	1,142	2,628
16	400	582	—	982	3,032
17	125	422	—	547	3,467
18	—	—	—	—	1,524
19	—	—	—	—	300

THE CONSTRUCTION OF FORWARD AIRFIELDS

By Captain T. C. White, R.E.

Introduction

THERE is a tendency amongst many officers, particularly Sappers, to think in terms of a "few days" for the time required to produce a "forward airfield." When one points out that some forward airfields may take as long as five regiment-months to complete, the same old argument is nearly always produced—"but, my dear chap, at so-and-so in Normandy they had the fighters on the ground in three days, and the ground there was simply frightful."

The aim of this paper is to attempt to make clear what is involved in the design and construction of forward airfields, and to illustrate how the modern trend in the design of military aircraft has made the problem a far bigger one to-day than it was in the last war.

The Factors

There are three basic factors which need to be considered. These are the standard of the forward airfield; the applied load; and the bearing capacity of the ground.

The Standard of the Airfield

Airfields are classified in two distinct ways. Firstly with reference to the type of aircraft flying from the field, e.g., fighter, transport, medium bomber, etc. Secondly, by the length of time that they are expected to operate. The standards in this second classification are: one month, six months and five years. Forward airfields are those built in the active zone of operations and will normally be confined to those required to last for one month or six months. A one-month airfield (U.S.A. term: Emergency Airfield) covers such as a transport field for a specific operation, and refuelling and rearming fields, whilst a six-month airfield (U.S.A. term: Minimum Operational Airfield) might have to completely accommodate a wing of aircraft, requiring anything up to eighty individual hard-standings, a bulk aviation fuel installation and some form of rocket and ammunition storage. A five-year airfield (U.S.A. term: Full Operational Airfield) will seldom start its life as such within the active zone of operations and need not be considered here. This general classification represents no change from the situation as in the last war. There has, however, been a change in the standards required by the R.A.F. with regard to dimensions and gradients, etc. This has largely been brought about by the advent of jet engines. In general, jet aircraft require an 8,000-ft. runway, as against 6,000 ft. for most piston-engined planes. Whereas a longitudinal grade of 1 per cent is about the maximum for jets, a grade of 1.25 per cent is acceptable for piston types. These are, of course, ideal criteria and in many cases standards far below these will have to be accepted. The actual standards that are allowable will no doubt be laid down by the Air Command of the theatre in question, and much will depend on the type of aircraft, and whether the fields are emergency or minimum operational in classification. The effect of these increased standards for jet aircraft will increase the amount of earthwork and materials, for most projects.

The Applied Load

The applied load, or the weight of the aircraft in so far as this affects runway design, is always expressed in terms of E.S.W.L. (equivalent single wheel load). This is expressed in pounds and refers to the heaviest load liable to be imparted through one of the main landing wheels, or through a group of wheels where dual or twin tandem assemblies are used. The other important aspect of the applied load is the tyre pressure and consequently the contact area with the ground. For a given E.S.W.L., the higher the tyre pressure (and consequently the smaller the contact) the higher is the intensity of stress at the surface of the runway. These two items have obviously a direct bearing on the construction of airfields in terms of materials, labour, and time. The higher the E.S.W.L., the thicker the pavement, and the higher the tyre pressure the stronger must be the *surface* of the pavement. It is interesting to make a comparison of different types of aircraft in respect of these weights and pressures as in 1942 and 1952 :—

Aircraft	1942		1952	
	E.S.W.L. lb.	T.P. p.s.i.	E.S.W.L. lb.	T.P. p.s.i.
Fighter	3,500	57	8,000	150
Light Bomber	9,950	57	29,000	165
Medium or Heavy Transport	12,600	42	36,200	72

This shows only too clearly the general trend towards bigger and heavier aircraft. Bigger loads to be carried longer distances, more fuel to make this possible, heavier armaments, more comprehensive radio and radar installations, and so on, makes this a logical state of affairs. The greatest increases in tyre pressures are in the main confined to the smaller and high speed aircraft. One of the reasons for this is that high speed craft must have aerofoils of a high fineness ratio. A thin aerofoil section means a thin wheel and tyre to retract inside the wing. Blisters on the under side of the wings, placed so as to allow a bigger wheel to be housed, set up sufficient parasite drag to detract considerably from the performance of high-speed aircraft, and are not, therefore, acceptable. There is reason to suppose that tyre pressures of up to 300 p.s.i. will not be uncommon in the near future.

A point worth mentioning here is that the worst load caused by an aircraft is that of the machine when it is stationary or taxi-ing very slowly, and not, as is commonly supposed, on touchdown. When an aircraft touches down, and whilst it travels on the runway at a speed approaching its flying speed, most of the weight of the machine is taken up by the lifting action of the wings. For this reason it is a common teaching in America that the centre third of a runway may be of a lower specification than other parts of the airfield.

The combination of high E.S.W.Ls., high tyre pressures, more efficient and violent braking (made possible by the stabilizing effect of nose wheels), high landing speeds, and the effect of jet fuels on certain types of surfaces makes some of the present-day "applied loads" pretty awkward factors for airfield designers.

Bearing Capacity of the Ground

Although, of course, there has been no change in the bearing capacity of different types of ground during the past ten years, our knowledge of the actual values which can be applied to them and how to get the best out of them in the most economical way has increased considerably. An immense amount of research has been done on this subject, both in this country and in the U.S.A., and, at last, we in the Army are benefiting from the results.

The importance of the moisture content of a soil; the achievement and control of the soil density; and the important relation these factors have with one another, have been reduced to terms of C.B.R. (California bearing ratio) values. C.B.R. values have in turn been reduced to terms of inches of thickness and strength of pavement required for a given E.S.W.L. and tyre pressure. This sounds like the answer to the engineer's prayer, but there are still many snags. The biggest of these is the determination of the C.B.R. value itself. This can be done with a machine on a sample of soil in the laboratory. There is a mobile machine which can be taken into the field and used to determine the value of a soil *in situ*, but at the moment it requires the weight of a 3-ton vehicle to operate it. These, then, are not methods which can easily be used for forward airfield work, where speed is nearly always such an important factor. In order then to make use of this invaluable design method, some small and quickly operated machine must be available. A small

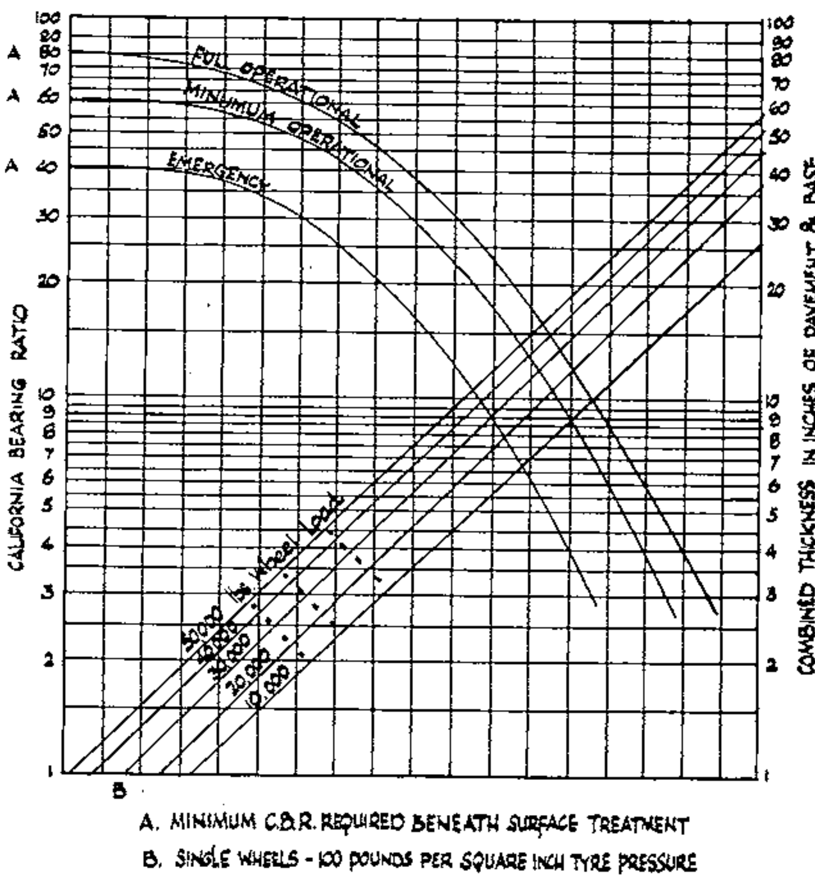


FIG. 1. FLEXIBLE PAVEMENT DESIGN GRAPH FOR AIRFIELDS.

"walking stick" type of penetrometer is under development and this may well prove an ideal machine with which to assess C.B.R. values in forward areas. In addition we *must* learn to assess the C.B.R. value of a soil with reasonable accuracy without artificial aids. This latter method is not too difficult a task, and it should never be regarded as an affair for the specialist only. Sapper officers must be able to make an intelligent guess at C.B.R. values without the aid of any machinery at all, if only for the reason that this method of design is also applicable to road construction.

Fig. 1 shows a C.B.R. design graph (U.S.A. origin) for airfields catering for aircraft with tyre pressures up to 100 p.s.i. Other graphs of the same type are available for 200 p.s.i. tyre pressures; aircraft with dual wheels, and aircraft with twin tandem assemblies. The method of using these graphs is as follows:—Enter the graph on the left hand side at the C.B.R. value of the sub grade, and follow this value horizontally until it intersects whichever "time-curve" is required. From this point move vertically upwards, or downwards as the case may be, until intersection is made with the line representing the E.S.W.L. in question. From this intersection move horizontally to the right hand side of the graph where the thickness, in inches of pavement and base, may be read off. The graph may, of course, be read in the reverse direction starting with pavement thickness and ending with a C.B.R. value. The time curves on the graph terminate on the left hand axis at C.B.R. values of 40, 60 and 80 per cent respectively for one-month, six-month, and five-year airfields. These values represent the minimum strength of the top course of construction, compatible with tyre pressures of up to 100 p.s.i. The required thickness of this course (within the total thickness already determined) can be determined by entering the graph with the C.B.R. value of the base material to be used beneath the surface. Where a bituminous type of surface course is used these are considered to have C.B.R. values of 80 per cent or more, depending upon the type. In the case of forward fields, however, a surface course such as this will seldom be used, in which case the base material itself must conform to the minimum C.B.R. requirement, unless a prefabricated surface such as P.S.P. (see page 176) is used.

For tyre pressures of up to 200 p.s.i. these surface values are in-increased to 50, 80 and 100 per cent respectively, and are thus indicated on the appropriate graph. All the graphs are based on a daily average and a daily maximum number of landing and take-off cycles for the life of the airfield. The number of cycles varies according to the weight of the aircraft.

With information such as this at our disposal the problem of design with regard to flexible pavements has been very greatly eased.

Methods of Construction

There has been little change in the methods of construction of forward airfields, with the notable exception of soil stabilization. A good deal more is now known about the value of P.S.P. as a construction material than was known during the last war. The most common methods are as follows :—

Natural or Compacted Soil.—Uncompacted soil in its natural state will seldom have a high bearing value. In some cases efficient compaction may raise the C.B.R. value sufficiently to use the soil without the addition of further construction material. Our increased knowledge of compaction and compaction equipment should enable us to make better use of this method in the future. In general this method is limited to dry-weather fields.

Mechanical Stabilization.—Mechanically stable soils can produce extremely high C.B.R. values. The process may be quite quick to complete, but on the other hand may involve huge quantities of soil being hauled to the site, depending upon the natural grading of the soil *in situ*. The moisture content is important if the best is to be got out of this method. Mechanically stable soils even when completely compacted will require some kind of waterproofing for wet weather operation.

Bituminous Stabilization.—In general this method is limited to dry sandy soils. High C.B.R. values are seldom obtained, but a waterproof course of construction can be made fairly quickly. Considerable machinery is, of course, required.

Cement Stabilization.—Much has been said about cement stabilized runways over the past few years and many people still think this method is the acme of all methods of rapid construction. One must be careful not to credit cement stabilization with advantages which it does not possess. Correct moisture content ; the presence of organic matter ; and the clay content of the soil, are some of the major snags at the present time. As development proceeds these, and other difficulties, will no doubt be overcome. The most common type of stabilizing machine can stabilize at a rate of about one mile a day of a 7 ft. wide strip. Apart from the mixing machine itself, other equipment is also required, such as tipper trucks, water tankers, motor graders, rollers, etc., which together make up a stabilizing team. A six-month fighter airfield of the most modest dimensions is the equivalent of some fifty miles of 7 ft. wide road. Bear in mind also that the soil cement mixture must be cured in the same way as concrete, and the method does not appear to be a particularly quick one, when compared, for instance, with a layer of P.S.P. A direct comparison of soil cement and P.S.P. is not easy, as the proportion of plant and labour is quite different in both cases. However, a 6-in. course of cement stabilized soil has in many cases, a very similar construction value as a layer of P.S.P., and the weights of cement and P.S.P. required, are almost exactly the same per unit area. Soil cement has one tremendous advantage over P.S.P., in that it provides a water-proof course of construction. Where tyre pressures of more than 100 p.s.i. are encountered, some kind of wearing course will be required on top of the soil-cement for long-term use.

Pierced Steel Plank.—Several new types of P.S.P. are under development by the U.S.A. The P.S.P. at present in use is very similar to that which was commonly in use during the last war, and is designated M.6. The only major difference has been the introduction of end connectors which help to distribute the applied load in a longitudinal direction from one plank to another. A later type of P.S.P., known as M.8 has also been developed in the U.S.A., which is considerably stronger than M.6, but it weighs 7.3 lb. per sq. ft. as against 5.4.

Development along these lines seems to indicate some kind of light plastic or fibre glass mat, and prototypes of this kind have already been produced in the U.S.A.

TABLE I

Values of P.S.P. (M.6 and M.8) as a construction material

Tyre Pressure p.s.i.	Value in inches of equivalent pavement construction	
	M.6	M.8
up to 40	12	16
40–100	8	11
100–200	6	8
200–300	4	6

Values given are applicable to sub-grades having C.B.R. values of not more than 10 per cent.

The value of P.S.P. as a construction material can be expressed in inches of equivalent pavement construction, and varies with the tyre pressure of the applied load and the strength of the sub-grade. The maximum value is obtained on sub-grades of C.B.R. 10 per cent and less. Tentative values are given in Table I, and pavement thicknesses as given by design curves may be reduced by these amounts where P.S.P. is used. On sub-grades having higher C.B.R. values than 10 per cent the equivalent value of the P.S.P. will gradually reduce, and on very low C.B.R. sub-grades where the soil tends to pump up through the P.S.P. its value becomes very limited. No precise figures are yet available on the rate at which reduction takes place, but it is probably safe to assume that P.S.P. laid on sub-grades having a higher strength than C.B.R. 50 per cent has little value other than that of a wearing course, and of protection against the effect of high tyre pressure.

A runway 8,000 × 150 ft., complete with a return taxiway, operational readiness platforms and hardstandings for two squadrons of fighter aircraft might require some 5,000 tons of P.S.P. (M.6).

Prefabricated Bituminous Surfacing.—This must still be the quickest method of waterproofing an airfield surface and it must not be looked upon as being out of date. It has little or no strength in itself and is normally used in conjunction with P.S.P. Unless laid in a triple thickness the bayonets on the under side of M.6 P.S.P. will quickly penetrate the P.B.S. M.8 P.S.P., having no projections on its under side, does not have this objectionable habit, which says much in its favour. The effect of kerosine fuel is, of course, disastrous to P.B.S. in its old form, but experiments are in hand with a view to producing this material in a form which will not be affected by jet-fuels.

The Present Position

The present position is then, that we are faced with stronger and longer airfields to build. The standard of construction demanded of the engineer is higher than ever before. In order to deal with this problem efficiently our airfield potential must be high and in itself of a high standard. It is not the actual construction of an airfield that is difficult ; the engineer tasks involved are perfectly ordinary ones requiring no specialist knowledge or training. It is in the planning and logistics of this job that some special knowledge is of immense value. The need to appreciate quickly the requirements of the R.A.F. ; the ability to distinguish their needs from their wants ; a knowledge of aircraft and their characteristics ; the ability to select quickly airfield sites which will present the least amount of earth-work and yet still have an alignment which will satisfy the R.A.F., are but a few of the more important things at which we must be extremely proficient. The officers with this sort of knowledge must be those on the staff of the D.C.E. (air) or the C.E. Airfields. There must also be the more junior officer who must know, for instance : what the minimum radius of corners on taxi-tracks are ; who can appreciate what are hazards to aircraft, both in the circuit and on the ground ; and who can advise the R.A.F. as to which aircraft can safely use a particular runway, and so on. These officers must be those who are actually on the job. In addition to these personnel of whom few appear to exist, there must, of course, be the units capable of building airfields quickly. The Airfield

Group which carried out this task in the last war no longer exists. Present Engineer units have insufficient plant for these projects and a variety of other tasks to perform. The U.S. Army have a good arrangement in their Engineer Aviation Battalion. These battalions, whose personnel are of the U.S. Corps of Engineers, are administered by and operate as a component of the U.S.A.F. Each battalion has some twenty-seven tractors, eighteen scrapers and nine motor graders as its major earth-moving equipment.

Finally let us consider broadly the possible increase in work required for a particular case, and compare the provision of a six-month airfield for a 1942 piston-engined fighter against the same for a 1952 jet fighter on a sub-grade having a strength of C.B.R. 10 per cent. The former (E.S.W.L. 3,500 at 57 p.s.i.) requires a pavement thickness of 4 in. with a surface value of C.B.R. 60 per cent. The latter (E.S.W.L. 8,000 at 150 p.s.i.) requires a pavement thickness of 8 in. with a surface value of C.B.R. 80 per cent.

From Table I, M.6 type of P.S.P. has a value of 8 in. on a C.B.R. 10 per cent sub-grade and under a tyre pressure of 57 p.s.i. ; but this value drops to 6 in. under a tyre pressure of 150 p.s.i. In the case of the piston fighter then P.S.P. will do the job, but in the case of the jet fighter we are under-designed by 2 in. The minimum lengths of the runways would be in the order of 3,000 and 5,000 ft. respectively and this quantity of P.S.P. would be 1,080 tons and 1,800 tons respectively. There is, of course, an increase in earthwork consequent on increased length. For the remaining 2 in. of construction we must consider the following : 2 in. of stone on this area amounts to 3,700 tons. Cement soil stabilization would require about 1,200 tons of cement, and it would be impracticable to stabilize a depth of less than 4 in. underneath the P.S.P. To stabilize mechanically the sub-grade to increase its C.B.R. value, and allowing for, say, 50 per cent of added soil for a 4 in. depth, we require to haul in 5,000 cu. yds. of soil. Thus is the conception of P.S.P. and " a few days " transformed into quite a construction project, to be thought of in terms of weeks rather than days.

Summary

We are faced with bigger and heavier aircraft which have high tyre pressures. Runways must be longer, thicker, and stronger than they were during the last war and limiting gradients are more severe. Rapid methods of construction have advanced only a little. The plant, labour, material organization and time required to build forward airfields has increased tremendously in consequence of these developments.

DE-RUSTING OF METALS BY USE OF CHEMICALS

By MAJOR R. E. PARR, R.E.

INTRODUCTION

SINCE the end of the war there has been the greatest need to exercise economy in the use of metals, due of course to global shortages and to the extensive requirements of reconstruction programmes. What might have been rejected in pre-war days has now to be given a second life and to this end many methods and means have been devised to get the fullest employment out of used materials without reducing the original efficiency. So, in B.A.O.R., to cope with the accumulation of ferrous metals that had deteriorated through exposure to the elements, a method of de-rusting, cleaning and preservation has been tried out with good results.

Before embarking, in B.A.O.R., on the construction of a large preservation plant a small pilot plant was experimented with.

On the success of the pilot plant depended the future of the large one. The experiment was a success and methods now explained are basically those used on the pilot plant.

PLAN

A plant was required for the de-rusting of metal, mainly bridging components, up to 21 ft. long and 6 ft. wide. These dimensions allow for the treatment of Bailey Bridging transoms and panels. The system adopted requires six tanks whose individual rôles are as follows :—

(*a*) Removal of grease and paint by an alkali solution.
(*b*) Washing off the alkali solution by warm water.
(*c*) Removal of rust by muriatic acid.
(*d*) Washing off the acid solution and sludge with warm water.
(*e*) Application of phosphate film to the metal by the use of a phosphoric acid.

Two tanks are needed for the actual de-rusting process, as it takes one hour, whilst the other operations each take thirty minutes.

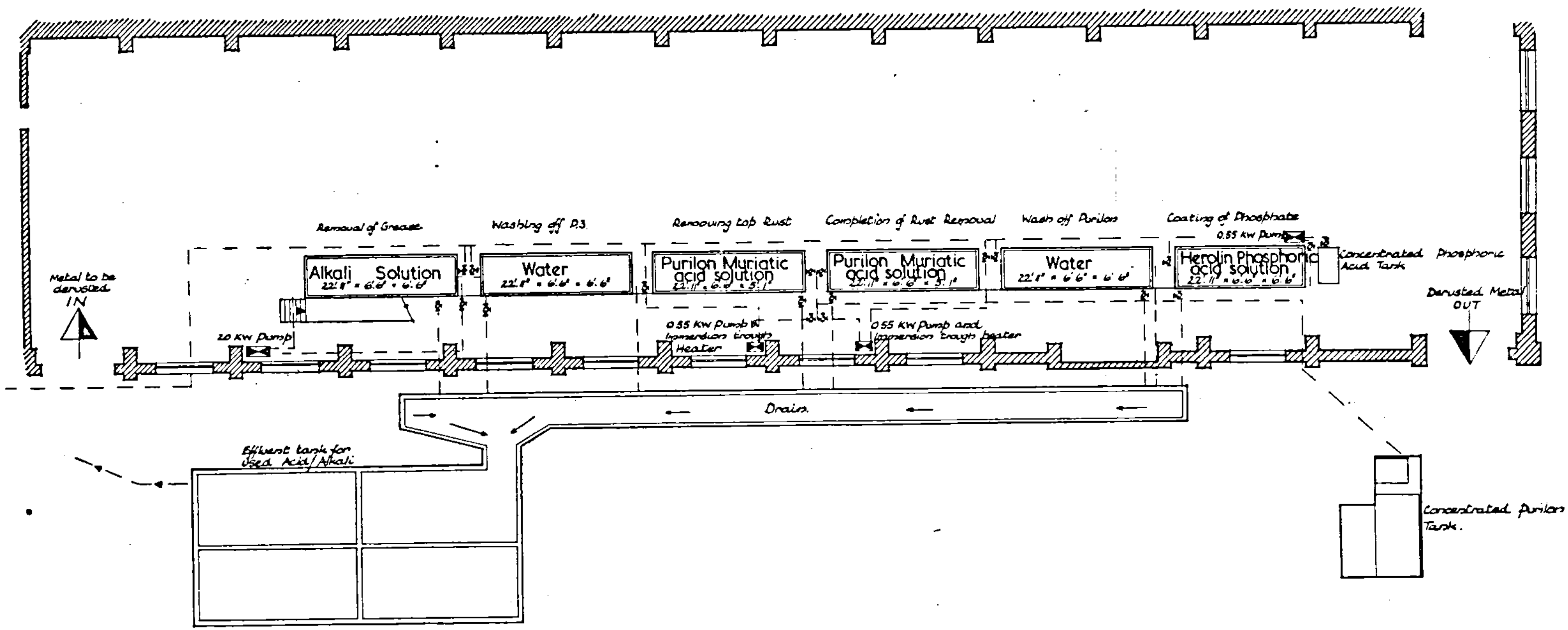
Tanks for the preservation plant were manufactured and installed by Messrs. Quack, of Berlin, and electrical work was carried out by Messrs. Siemens-Schuckert of Düsseldorf.

DESCRIPTION OF THE PLANT

A plan of the plant showing sizes of the tanks is attached at Appendix " A ". The function of each tank and the sequence of the de-rusting process is as follows :—

Tank No. 1

This is for the removal of paint and grease by using a solution of 16 % alkali with water. The tank is of mild steel and, as the alkali



CHEMICAL DERUSTING PLANT 303 E.S.D. WILLICH solution does not attack metal, is unlined. The best results are obtained when the solution is heated to 85° C. In all of the tanks, to prevent the loads damaging the heating pipes or the lining, there is a grillage of 3 × 2 in. R.S.Js., 1 in. above the bottom. Better results are obtained if the solution is agitated and this is achieved by using a 20-kW pump with a 10-in. inlet and outlet pipe. The outlet pipe leads to six 4-in. tubes which are placed in the tank just below the load-bearing R.S.Js. Each tube has twenty ½-in. jets playing on the metal which help to wash away loose paint and grease. Trouble has been experienced with the hot alkaline solution attacking the gland packing of the pump, and causing it to leak. Several types of packing have been tried, but the best has proved to be ordinary graphited asbestos. This requires slight daily adjustment to prevent leaking, and periodical replacement.

Tank No. 2

Like the first this tank is of unlined mild steel. It contains water heated to 50° C., which washes away all traces of the alkaline from the metal prior to it entering the acid tanks. The water is changed at the rate of 20 gallons per minute.

Tanks 3 and 4

The third and fourth tanks are those containing muriatic acid for the removal of rust. It has been found that the best results are obtained with a solution of 15 % muriatic acid with water.

These tanks are constructed of mild steel and are lined with a patent acid resisting plastic, which is sprayed on and is effective as long as the tanks are not heated. It has not been found necessary so far to renew the lining but this will be necessary at a later date. The life of the plastic lining is estimated at eighteen months.

Tank No. 5

This has the same function as tank No. 2 ; sludge and the muriatic solution is removed by warm water. The water again has a change rate of 20 gallons per minute, and is heated to 50° C. Unlike the other wash tank, this one is lined to prevent the acid contained in the sludge attacking the mild steel outer case of the tank. A plastic lining similar to that used in tanks Nos. 3 and 4 is the most suitable for this purpose, a slight variation in the composition of the lining allows it to withstand heat.

Tank No. 6

The phosphoric acid contained in this tank provides the de-rusted metal with a protective phosphoric film. For this purpose the acid is used at a strength of 14 % with water, at a temperature of 40° C. This tank is lined with 3 mm. sheet lead. It has been found necessary to insert a small outlet pipe in the outer case to give warning if the lead lining is damaged. Before this pipe was fitted, damage was caused to the electrical heating elements by liquid that had leaked through the lead lining, and not being able to get away, had risen until it was up to the level of the elements.

The tank is partially lined with timber to prevent the metal loads damaging the lead lining.

Heating

All tanks are fitted so that they can be heated by electricity and, except for the two muriatic acid tanks, each tank has twenty 9-kW. elements. These are placed midway between the bottom of the tanks and the load-bearing R.S.Js. Due to faulty design, the automatic switches for each tank were placed actually on the side of the tanks. This caused the automatic switches to be affected by the heat and made them unreliable.

The two muriatic acid tanks each have a 40-kW. heater fitted into a circulating system and detached from the tanks. These heaters are required to maintain the solution at a minimum temperature of 15° C., but so far the heat from the other tanks has made the use of these heaters unnecessary.

The total connected load in the whole plant is 850-kW. The total power is, however, not required at any one time as normally the load is 550-kW. and for initial heating only 700-kW.

To provide this power, a 1,000 kVA. transformer was installed in a sub-station specially built for the purpose. This work was carried out by the unit with its own labour, based on a design prepared by its Clerk of Works (E) in conjunction with the civil authority.

Tank Filling

The method of filling the tanks with the various chemicals is interesting, and worthy of study. No special arrangements are made for the alkaline tank and the two washing tanks, as they are supplied direct from the water main. The alkaline is poured into its tank by hand direct from the containers in which it arrives. A normal charge of the tank is 4 tons. It has been found more economical to empty this tank after 120 hours' use and clean it out and refill, than to top up with alkaline to maintain it at its correct strength because the solution becomes greasy and ineffective unless changed completely. The topping-up method is also liable to cause the circulating system to become clogged. The two muriatic acid tanks are filled from an outside reservoir tank which is connected by a pipeline to the two tanks. Unlike the alkaline tank, these tanks can be economically topped up and last for 480 hours without charging.

The reservoir tank is sited beside a railway siding so that the special wagons can be unloaded into it direct by gravity feed. An electric pump is provided for pumping the acid from the reservoir

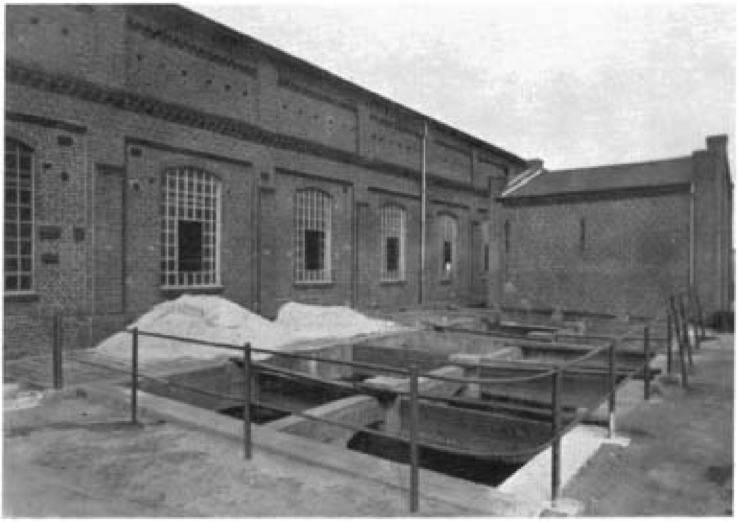


Photo 1.—Sedimentation Tank.

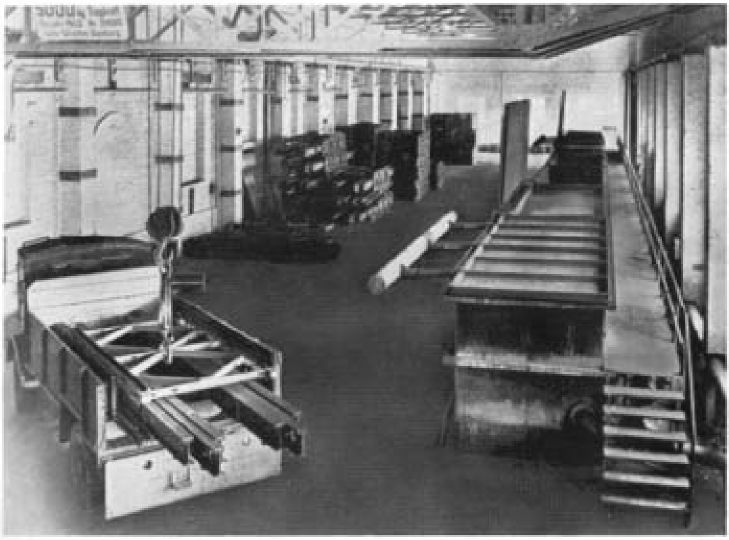


Photo. 2—Shed with 5 ton Overhead Gantry.

De-Rusting Of Metals By Use Of Chemicals 1,2

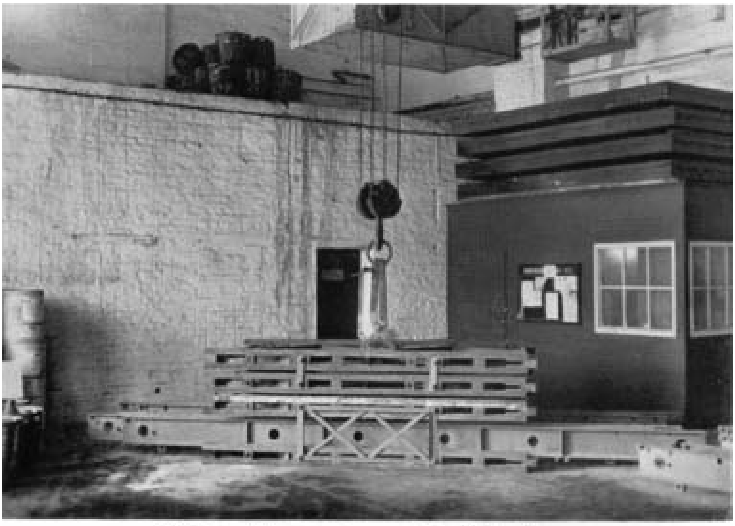


Photo 3.—Components arranged in Package form.

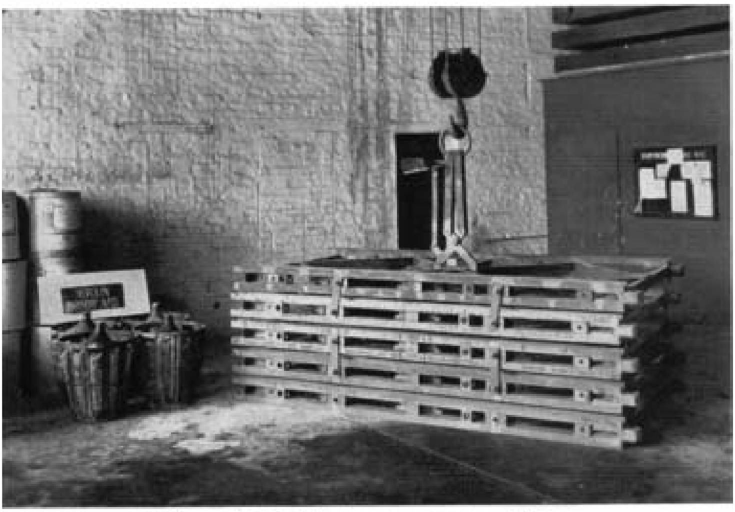


Photo 4.—Bailey Bridge panels arranged as a Package.

tank to the two de-rusting tanks. The reservoir tank has the same sort of patent plastic lining as the muriatic acid tanks, but it has been found that the lining does not withstand the effect of the undiluted acid for more than five months.

Trouble was experienced at first because of the absence of a one-way valve in the pipe-line connecting the reservoir to the two de-rusting tanks. When pumping ceased, the ordinary stop-cock was not completely closed, and damage to the electric motor resulted from the acid flowing back down the pipe-line and leaking from the pump.

It is necessary when designing a plant of this type to ensure that the reservoir tank is large enough to hold sufficient acid to fill both the de-rusting tanks, in this case 16 tons, or to take the whole contents of the railway wagons used for the acid, whichever is the greater.

The phosphoric acid is poured into its tank from the carboys in which it arrives. A special carboy barrow is provided, which with a ramp built against the side of the tank allows the acid to be poured direct from the carboys into the tank.

Drainage

The last operation to be dealt with is the disposal of the used chemicals and the water that is continuously flowing from the plant. This is accomplished by pipes leading from all tanks to a sedimentation tank. (Photo 1.) Here the effluent is cleaned by filters and by the use of lime-stone before disposal into the main sewage system. Frequent tests of the liquid entering the sewers are made to ensure it has been adequately neutralized. Any concrete, as in the drainaway, must be completely free from limestone as the acid attacks limestone and would cause the concrete to disrupt and crumble.

Operation

The plant is installed in an old steel rolling shed which is equipped with 5-ton electric overhead gantry crane (Photo 2). This crane has proved invaluable, and although it was originally thought it would not be able to cope by itself, has managed quite successfully. The steam and vapour rising from the tanks has had no serious ill effects upon the crane, although the brakedrum has to receive special care and maintenance to counteract a tendency to slip caused by the steamy atmosphere.

The loads are all pre-packed and the aim is to fill each tank in either one or two lifts. It has been found quite simple to produce suitable packages, and illustrations of some of these are shown in Photos 3 and 4.

Because of the considerable amount of time required to heat the tanks, it is necessary to work the plant twenty-four hours a day. This has been done in the basis of a five-day week, with Saturday mornings as a tank cleaning and maintenance period. As all equipment is inspected, gauged and, in the case of Bailey bridge panels, load-tested in the Rowan test rig, prior to de-rusting, and later given three coats of paint, the maintenance of a steady flow of metal through the plant is difficult. By careful timing of supply and removal a steady flow has been maintained and the various ancillary tasks such as the testing, packaging and painting have kept abreast of the actual de-rusting. In this connexion, it should be pointed out that after leaving the last tank, the metal must be left for twenty-four hours to allow the phosphoric film to dry, after which it must be painted immediately or it rusts badly.

So as not to overload the overhead travelling crane in the preservation shed, each package of metal does not exceed 2½ tons weight and as a package is in each tank for thirty minutes, by working eight -hour shifts a day for five days a week, the theoretical output should be between 500 and 600 tons per week. In fact, even when no major interruptions occur, 326 tons per week is the maximum that has been produced to date. The difference is largely accounted for by the innumerable small delays that occur, mainly on night shifts, by losses of time caused by lifting, lowering, and off-loading packages of metal into and out of tanks.

Four men including the plant foreman and one crane operator work the plant each shift.

General

The system described above, is a modification of that outlined in C.I.E.M.E. Specification RE/PROV/4787 which requires the use of eleven tanks or ovens. Although the latter method is the correct one, circumstances did not allow its adoption, but results from the system in use are satisfactory.

A slight modification was introduced as a result of a visit to the plant by Dr. E. Longhurst, of the Operation Research Section of the Ministry of Supply, who recommended that the metal should be washed after treatment in the phosphoric acid tank (No. 6) before drying and painting. This can be done in Tank No. 5, using Tank No. 2 for washing metal from the muriatic acid tanks (Nos. 3 and 4) as well as from the alkali tank (No. 1). As Tank No. 2 is unlined, frequent tests are required to ensure that the alkali neutralizes this acid solution so as not to damage the tank.

Although the de-rusting operation is similar to that used in the original small plant, the design of the plants themselves is entirely different. While the new plant is quite sound, and contains many good details, there have been a number of teething troubles that could have been avoided. As in all projects, the requirement for sound and thorough planning cannot be too greatly stressed.

MOTI RAM

By LIEUT.-COLONEL J. J. D. GROVES, M.C., R.E.

I BELIEVE he was there to meet me with the Adjutant when the Dakota came to rest on Pegu Airfield in December, 1945. Anyway, somebody did well to unravel my baggage there, for I could not stay to see to it myself.

The Movement Control Officer in Bangkok had been rather unco-operative that morning about the pile of belongings that was to accompany me. He had stuck unimaginatively to his "personal-baggage-plus-56 lb." principle, whereas I had argued that there was no virtue in sending Dakotas back to Burma empty, for the sake of a theory. He certainly had the satisfaction of enforcing the regulations —but as soon as we were parted, a vast and benign R.A.F. quartermaster sort of fellow drew me aside and assured me that if I did not mind my baggage being loaded in a different aircraft to myself he could arrange for it to follow me in the next flight—only an hour later!

So that was how it worked out. I stepped out at Pegu with my orthodox 56-lb. allowance. But in hot pursuit another Dakota staggered in with the rest of my gear, which included a teak chest as big as a coffin. So everyone was satisfied. And Moti Ram, who was placed in charge of it all, accepted the situation with his usual air of serene amazement.

Here let me try to describe this Indian who was to be such a stout companion to me for the next year. He was a stocky, bullet-headed little Hindu, perhaps 25 years old, who came from a peasant village somewhere near Almora. His expression was friendly and sincere; his eyes brown—and brim-full of that naive combination of fun and affection which in children so warms the heart of a parent. There was something very elf-like in his appearance; he always bore himself intensely seriously in one's presence, but was ever ready to burst into delighted conversation on the least pretext. Life to him was a continual excitement, and British officers were certainly incredible beings who obviously thrilled him to the marrow. This attitude becomes comprehensible when one realizes that Moti Ram's criterion of life was only that of a very poor farming district in the Himalayan foothills where customs had varied not at all for 2,000 years or so. In short—he had no previous civilized experience when he joined King George V's Own Bengal Sappers and Miners in 1943.

It was not a question of my winning the confidence or respect of my new orderly. He had already dedicated his whole loyalty to me before I arrived, and to him it was purely a question of studying my peculiarities as intently as he could in order that he might the better be able to do his job. Above all Moti Ram was perhaps the most genuine, childlike and delightful native soul that I have ever encountered.

Now if I had been an Indian Army officer of long standing, or in fact had any pre-war service in India at all, I am sure I would have counted Moti Ram as nothing out of the ordinary—and certainly not worth writing about. But, since all my pre-war service had been divided between U.K. and Malaya, this vintage of Indian orderly was a complete revelation to me.

Before my arrival he had been a simple *Jawan* in 75 Field Company, Bengal Sappers and Miners—of which Kedda Dut was the Subedar. I fancy that he had been given a very thorough briefing by his illustrious sponsor, who perhaps by coincidence hailed also from the Almora district. So possibly I rather over-rated the initial zeal of Moti! Anyway his ministrations to myself were entirely untutored and primitive in application.

When he called me each morning he would tip-toe ostentatiously round the room, chiding himself severely when he dropped one of my boots with a crash, or scalded his finger as he tested my shaving water. When the stage was all set to rouse the *Sahib*, he would finally stalk my mosquito net and peer through to see if I was awake. If I was he beamed delightedly; if not he would grasp the side of the bed and very gently shake it, and with deeply puckered brow would gradually increase the tempo until I showed signs of life. He was obviously immensely relieved when I did wake up each morning, for he took this calling procedure very seriously.

Moti had never seen a shotgun used before I arrived in Burma, and it was perhaps his greatest delight to accompany me when I walked-up jungle fowl and grey partridge in the evenings after work. When I shot badly he looked miserable the whole time and became almost desperate in his anxiety lest we should return to the mess empty handed. But with every bird I brought down his face beamed with delight as he marked them, and he would plunge gaily into the most appalling thorn and scrub to retrieve a bird.

My headquarters was at the village of Myitnge, nine miles south of Mandalay, and I had taken over the best of the remaining bomb-shattered bungalows, which had before the war been occupied by a senior British official of Burma Railways. One corner of this building had been blown away during a R.A.F. raid before the Japanese had been chased out, but it served as a most comfortable mess. Graceful great rain-trees shaded the lawn, bougainvillaea covered the porch, and at one side of the compound was a small white pagoda flanked by ornately carven *Chinthes* and before which a large temple-tree ladened the evening air with the exotic scent of its lovely waxen flowers.

Myitnge Manor, as I named our requisitioned property, also had some highly diverting sporting amenities close at hand. Jungle fowl and grey partridge were to be found within a few hundred yards, but these I carefully preserved for the entertainment of visiting friends. There was also a small *jheel* within the confines of the estate and apart from the snipe which abounded in the marsh at one end of it, there were times when flighting teal kept both barrels hot.

Moti Ram did not really approve of shooting near the *jheel*, for although there was not a thornbush too thick to stop him, he was no water spaniel. It was not that he failed in eagerness—for he would wade in till his nostrils were awash—but, alas, he could not swim !

* * * * *

The project which had been allotted to the Royal Engineers in North Burma after the war was the reopening of the severely damaged system of Burma Railways. In short—this meant the repair of some very large bridges in the vicinity of Mandalay and also the replacement of over fifty smaller ones which had been destroyed on the line between Katha and Myitkyina some 300 miles north.

I should stress too, that the repairs required to these bridges were of no minor nature. The tide of battle had travelled full bore northwards with the Japs on our heels in 1942. Then back again in 1944, when the flood of Japs receded. But apart from the continual attention which the bridges received from the R.A.F. during the intervening years, some of them had been specially earmarked by the Airborne Forces of General Wingate as well. So by the time we arrived on the scene many of the sites required new concrete abutments and piers—and new steel girders to span them.

It was during my tours of inspection of the northern part of the railways that Moti Ram became particularly inflated with self-importance. Yet he was always so easily amused, simple and loyal that a trip without him was never so comfortable or enjoyable for me. Besides his zeal in attending to my personal needs on these excursions, Moti became vested with a new cloak of dignity. As the most travelled *Jawan* of the whole formation, he was not only an up-to-date news agent and purveyor of scandal from one camp to the next, but his opinions carried almost editorial influence. Far into the night could Moti be heard regaling his hearers with red-hot information regarding the coming partition of India, or the crisis arising in the Bombay Sapper and Miners lines when the Sunday meat ration of goat (on the hoof) had given birth to twins—and the C.R.E. Sahib had ordered an indefinite stay of its consumption by the unit.

The restoration of the northern sector of railway for 160 miles above Katha took eight months to complete. Four companies of Royal Indian Engineers, a Railway Construction Company and some 700-odd Japanese Surrendered Personnel (J.S.Ps.) had been deployed on the task.

* * * * *

My final inspection of the line was a truly festive affair. I had managed to get a Beachcraft aeroplane to fly me from Meiktila to Myitkyina. That in itself was the most delightful trip, at an altitude of perhaps 2,000 feet with the great Irrawaddy River always somewhere in view below. When we passed over Myitnge Bridge, Moti Ram was beside himself with excitement as he recognized the tented camps of the units below, and nearly pressed his nose through the perspex when he sighted the mess itself.

A few minutes later we were flying over the shambles that was Mandalay. Here was the great square, moated keep which enclosed the remains of the palace of the last King of Burma ; there was Pagoda Hill where the Japanese had fought and died—not much more than a year ago.

On up the winding yellow Irrawaddy. Tiny figures were moving on the white steps of the lovely Kyaukmyaung Pagoda that stands on the western bank, with Shwebo beyond ; some were naked children, some were pi-dogs scratching themselves in the morning sun. Then came the narrows, with the landing stage at Thabeikkyin and dusty white road winding into the Chin Hills to Mogok—that amazing cleft in the mountains where the only stones found are precious—sapphires, rubies or zircons.

In another half-hour we were down at Bhamo to deliver mail, then airborne again for Myitkyina. The whole trip had taken less than two hours, though to do it by road meant 550 miles via Lashio and Namhkam on the China border, and spending four nights *en route*.

The commanding officer of a Madrassi Engineer Battalion met me on the airfield, and within a few minutes I had started on my last journey down Burma Railways. Before we set off there was a kind of tape-cutting ceremony at the railway station when the Madrassi V.C.Os. produced some magnificent garlands of flowers which were duly hung round the necks of myself and every other officer in the party ! Thus flower decked, from the knees upwards, we must have presented a comic, as well as colourful, spectacle as we climbed aboard the convoy of rail-jeeps that was to take us south.

Here let me explain that a rail-jeep is a perfectly ordinary Jeep but the normal road-wheels are replaced by light railway wheels whose interior rims fitted the metre-gauge railway line. I can only say that driving one is the greatest fun imaginable. To begin with, it always gave me the rather guilty feeling that a father gets when the children catch him playing with their toys. There is all the thrill of pretending to be an engine driver, plus the most magnificent clatter and clanking of wheels, and the excitement of wondering if the next set of points have been correctly set by the signal box. Yet really the whole affair is bogus—because it is exactly the same as driving a Jeep on the road, with the added simplicity that it is hardly necessary to steer it at all.

To Moti Ram, who sat on my bedroll in the last Jeep, this was the absolute seventh heaven of delight, and I noticed that he had even acquired a garland for his own adornment.

All the main repairs to the various bridges had by now been completed, but naturally there was a 100 per cent turnout of the men of all units who had achieved the task. Some of them were still putting the finishing touches to their work, or fixing concrete moulds of unit signs to bridge abutments, but most of them had simply been waiting to watch the triumphal procession.

Even the J.S.P.s showed a curious pride in the project that they had helped to complete. Every Jap stood motionless with his eyes riveted to his front as the rail-jeep ground to a halt, and their officer stood with bowed head as the interpreter hissed and spluttered his explanation of the work they had done.

That night I spent at Mogaung, the first town to have been liberated in the Burma theatre. Next morning we were away early—the first stop Loilaw, where a completely new bridge had been constructed. Then as we entered the sector for which the Faridkot Company had been responsible, fresh garlands of flowers were festooned about the party before the procession could get under way again.

Another night was spent at Hopin—and so it went on. Each unit headquarters also required me to sit down to a *bara khana* and beer before going on to the next. So by the time I reached Indaw I had seen a lot, said a lot, and eaten a lot—and it was nearing dusk on the third day.

But it was only about twelve more miles on to Katha where I had arranged to meet my Chief Engineer, and also the Northern District Representative of Burma Railways to whom I was handing over the line for operation. So, driving the leading Jeep with Moti Ram sitting beside me, I now pressed on at a good thirty-five miles an hour with headlights full on, and my thoughts drifting ahead towards Home Leave—and the cry of hounds below Saxonbury Hill.

Yes—driving a rail-jeep at night was even more fun than in daytime! With the windscreen folded flat down on the bonnet, and the cool night air whipping one's cheeks, racing along that last sector of jungle railway which was now officially "open"—I hadn't a care in the world—yet!

* * * * *

The huge beast suddenly heaved itself out of the darkness—thirty yards ahead of us—straight on to the railway track—just like that!

It looked twice the size of the Jeep and its great hulking body was glistening in the light with wet shiny mud. I now know what is meant by "panic gripping one by the throat"—for from the first second it was plain that I was going to collide with a wild elephant, and nothing that I or my Jeep could do in time would avert disaster.

It was a wonderful chance for Dick Barton—but not me!

In another two seconds—when the gap had narrowed to perhaps ten yards—I realized that it was not an elephant but a water buffalo which had lurched out of its mud-wallow beside the track. Its emotional response was obviously the same as mine, for in an instant the buffalo altered course, and with the most astonishing burst of speed, it hared down the railway track ahead of us. With its tail hoisted vertical in fright, and hooves pounding a desperate tattoo upon the sleepers, I shall never forget the sight of that mighty posterior, so vividly illuminated by the headlights.

At *le moment critique* it made a last convulsive jink to the side, but its near quarter took the full impact.

The first thing that happened was that a dense shower of stinking buffalo mud and what-not came straight back over the lowered windscreen, with complete Walt Disney effectiveness.

The buffalo itself did a sort of cart-wheel along the edge of the embankment, and in doing so one of its huge horns grazed the side of the Jeep and nearly tore off Moti Ram's trousers, as he was in the act of abandoning ship. Somehow the Jeep itself remained on the rails, and I managed to stop it in another fifty yards.

By that time I could hear the buffalo going like a lamp-lighter in the opposite direction, its speed certainly unimpaired. Moti himself was no worse off than I—in fact his mud pack had been partially scraped off when he rolled down the bank.

* * * * *

Within half an hour I was pausing over my second strong whisky and soda as I tried to explain to my Chief Engineer why I looked and smelt as though I had crawled out of a sewer.

It was a spectacular finish of a highly enjoyable and almost historical trip. But within a year Burma was to be riven by independence and revolution, and so the reopened railway has apparently benefited nobody.

A week later, when I sailed from Rangoon, Moti Ram stood alone on the dockside to bid me good-bye. He was my last personal link with the Indian Army that had grown into my heart so very completely in such a short time.

A small, solitary and dignified figure that I shall not forget. To me he is a symbol of something that Britain took four centuries to win—and about four cabinet sessions to lose forever.

MAJOR-GENERAL H. B. W. HUGHES, C.B., D.S.O., O.B.E.

HENRY BERNARD WYLDE HUGHES, the son of C. W. Hughes Esq., of Headley, Hants, was born on 8th May, 1887. He passed into the R.M.A. from Cheltenham and was commissioned in December, 1906.

After the Young Officers' Course at Chatham he was posted in 1909 to the 23rd Field Company at Aldershot, thus beginning his service at the station where he was destined to spend so many happy years. In 1912 he went to India, becoming Garrison Engineer at Bannu near the N.W. Frontier, where during the first year of World War I he saw active service against the Mohmands. March, 1916, saw him in command of the newly formed 88th Field Company, arriving at Basra to join the 13th (British) Division, just moved from Egypt to reinforce the army in Mesopotamia. The division was soon involved in the final and desperate attempts to relieve Kut, and later took part in General Maude's advance up the Tigris. During this campaign Hughes was present at many of the famous bridging operations, including the Diyala crossing, where, in 1917, he won a well-earned D.S.O. He ended the war a brevet-major.

He returned to the Frontier, and before long was appointed C.R.E. of the Dera Column during the Waziristan Operations of 1920, when he was awarded the O.B.E. In 1921 he married Nora Beatrice, daughter of H. W. E. Hickson, Esq.

By 1922 he was back at Aldershot as District Officer, Wellington Lines, but the following year was appointed Adjutant of the 1st Division. In 1924 he took over command of his original company, the 23rd, and in 1926 became O.C. Mounted Depot. After three years in command of the 42nd Field Company in Egypt, he again found himself at Aldershot, as D.C.R.E. North, in 1931 and as C.R.E. 2nd Division in 1932. After a year as an Instructor at the Senior Officers' School, he became A.G.7 at the War Office, but on the outbreak of World War II was appointed Chief Engineer, Western Command.

On the formation of Headquarters Middle East Forces in 1940, he was chosen to be Engineer-in-Chief, a post that he filled with great distinction for three very busy years. For his services he was created a C.B. in 1941. When General Eisenhower assumed command of the Allied Forces in North Africa, Hughes was appointed his Deputy Chief Engineer, and the following year was again picked to serve General Eisenhower as Chief Engineer to the Allied Expeditionary Force during the liberation of N.W. Europe. He received the French Croix de Guerre and was appointed an Officer of the Legion of Honour and of the United States Legion of Merit.

On the surrender of Germany, he became Engineer-in-Chief at the War Office, retiring at the end of 1945 to take up a very senior post under the Ministry of Works. Failing health eventually compelled him to give this up and he settled at Aldeburgh, where he died peacefully on 22nd February at the age of 65, leaving a widow and two sons.

Hughes was pre-eminently an Aldershot Sapper, with great experience of field units, especially during the days when they depended so much upon the horse. He was a keen rider, hunting regularly with the local packs and encouraging all his officers to do so. As a unit commander he was admired and beloved by all ranks.

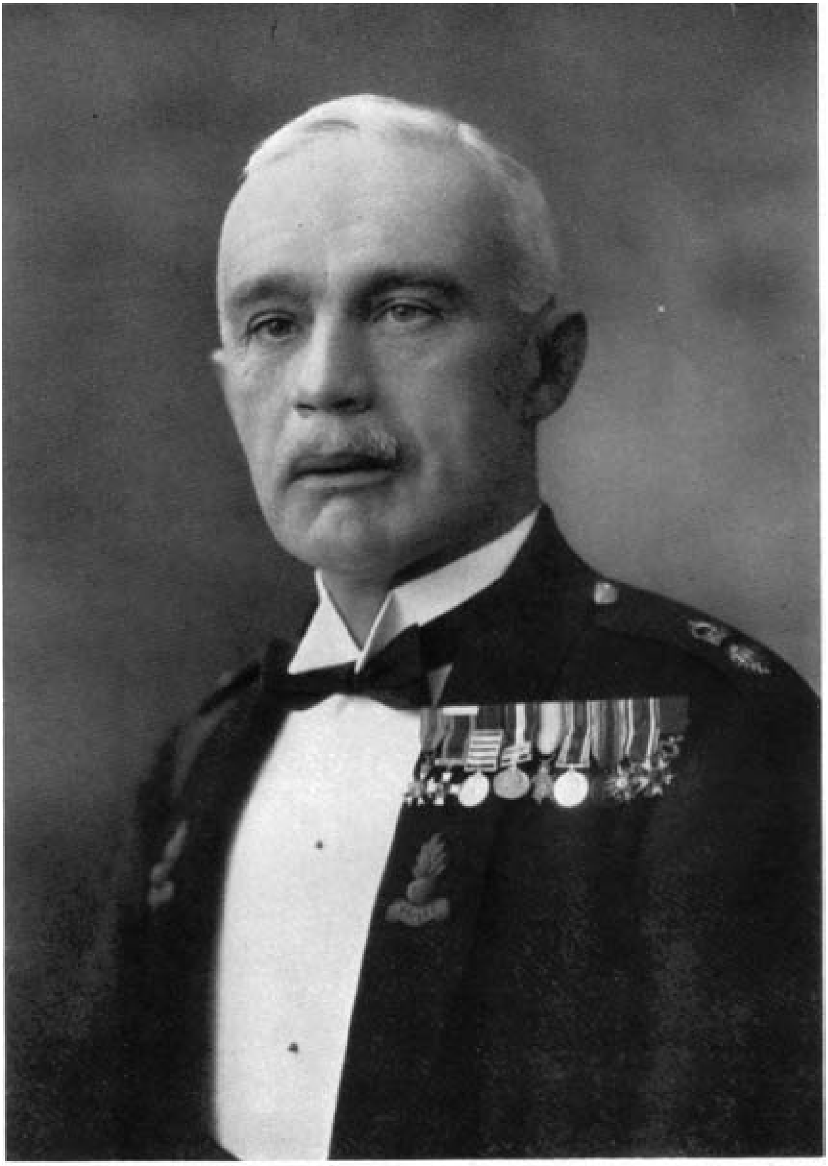
He had the rare quality of leadership without a trace of the bully or martinet, and was particularly successful in getting the very best out of the least efficient of his officers and men. As A.G.7, he was unusually approachable and understanding, and the knowledge he then gained of so many R.E. officers was to serve him well later on. During World War II his career was quite phenomenal, and it is unlikely that any British Sapper will ever again be called upon to carry the engineering responsibilities that were his before and after D-day, involving as they did the activities of both British and American engineers (including ports and railways) from the front line to the base, in what was *par excellence* an engineering campaign.

He never pretended to be a highly qualified technical engineer, but his quite unusual degree of hard common sense always enabled him to see at once whether a technical proposal was sound or otherwise. He chose his subordinates well, and having done so left them to do their jobs, knowing full well that no one would ever let him down willingly. Although an unusually bad traveller, especially by air, he toured the vast areas of the Middle East unstintingly, and of all the officers at G.H.Q. he became perhaps the most intimately acquainted with the Command. He had under him at that time engineers from almost every corner of the British Commonwealth and he endeared himself to them all. With the combined British and American forces in North Africa, and later in N.W. Europe, there were, of course, many occasions when serious difficulties might have arisen between the allied engineers, and it was largely due to the personality of "Daddy" Hughes that the war ended with those strong feelings of cordiality and respect that still exist between the two Corps. To the officers of the British Sappers he was, of course, extremely well known, and the name "Daddy" Hughes quite truly indicates the feelings of trust, love and respect that they all felt for him.

The Corps has lost one of its greatest engineer leaders, a very human, kind-hearted, unselfish and modest man, eminently practical and always sound, a man whose services to his country and to his Corps have never perhaps been adequately recognized.

E.F.T.

Major-General HBW Hughes CB DSO OBE



Brigadier CR Johnson CMG DSO

BRIGADIER C. R. JOHNSON, C.M.G., D.S.O.

CHARLES REGINALD JOHNSON was born on 23rd December, 1876, the son of Lieut.-Colonel C. H. Johnson, J.P., of Thorngumbald Hall in Yorkshire. Educated at Clifton he was commissioned into the Corps from the "Shop" in 1896. On completion of the usual course at the S.M.E. he was posted to the 7th Field Company at the Curragh in 1898, and went with this company to South Africa the following year, just before the outbreak of the Boer War.

One section of the company was in Kimberley throughout the siege and the rest of the company distinguished itself at the battle of Paardeburg when Cronje surrendered. After the relief of Kimberley the company was employed largely on the repair of railways and bridges and the construction of blockhouses.

A diary kept by a lance-corporal in the company throughout the war, contains the following entry under Xmas Day, 1900: "Lieutenant C. R. Johnson, commanding the section, presented us with £5 and also a pint of whiskey between every six men." This was typical of Johnson's thought for others.

For his services in South Africa he was awarded the D.S.O., the Queen's Medal with five clasps and King's Medal with two clasps.

After the war he returned to the U.K. and was posted, first as D.O. Birmingham and then, in 1903, he was appointed as an Instructor in Fortifications at the "Shop." Two years later he was made Assistant Adjutant and shortly afterwards was appointed to command one of the cadet companies, which last appointment he held for four years, serving six years in all at the "Shop."

In 1904 he married Ida, the daughter of Mr. F. A. Hutchinson of Preston.

On completion of his tour at the "Shop" in 1909, he was posted as O.C. 2nd Field Troop in South Africa and returned with this unit to Chatham in 1913, when the British Troops were withdrawn. On the outbreak of World War I in 1914, the 2nd Field Troop became part of the 1st Field Squadron, with the 1st Cavalry Division, and went to France with the original Expeditionary Force. He was promoted Major on 30th October, 1914, and in 1915 he was appointed to command the 2nd Field Squadron attached to the 2nd Cavalry Division. At that time there was only one Field Squadron with a Cavalry Division and the O.C. of the squadron was also the R.E. adviser to the divisional commander and so had the same position and responsibilities as a C.R.E. with an infantry division.

In 1916 he was invalided home and was then posted to the Training Depot at Aldershot, but returned to France in 1917 as C.R.E. 4th Division. He was promoted brevet Lieut.-Colonel on 1st January, 1918, and was appointed a C.M.G. in 1919. He also received the order of St. Stanislas, 3rd Class, was made a Chevalier of the Legion of Honour and was Mentioned in Despatches five times.

In 1919 he was employed as President of the Peace Commission in Kiel and in 1921 he held a special appointment at Chatham under the D.F.W., for the revision of Training Manuals.

On substantive promotion to Lieut.-Colonel in 1922 he was appointed to the R.E. Board, where he served for four years, when he was placed on half pay, but was appointed Chief Engineer of the British Army of the Rhine in 1927 and the following year he was appointed Chief Engineer Eastern Command, with the rank of Brigadier, on completion of which he was placed on retired pay in December, 1932.

On retirement he went as Bursar to Kelly College, at Tavistock, which he held till 1940. During the second World War he worked with the Civil Defence organization at Tavistock and after the war he was Treasurer of the local Conservative Association.

Reggie Johnson had three main hobbies—bridge, racing and fishing. He and his wife were both very good and ardent bridge players and wherever they were they were able to devote a great deal of their time together to this pleasure. They also both enjoyed attending race meetings when possible to do so.

Possessed of a most charming nature and a great sense of humour he was loved by all who knew him and especially by those who worked under him. He was most methodical in all his work and especially with accounts, which stood him in good stead as a bursar after he retired.

H.W.H. writes: "I was one of Reggie Johnson's subalterns in the 2nd Field Troop, South Africa, from 1908 to 1910 and afterwards at Chatham. I have the happiest memories of him as a first-class C.O., one of those who always got the work carried out cheerfully—exactly as he wanted it and with the minimum of fuss and bother.

"He and his wife were a devoted and very charming couple, the sort of people who leave behind them the feeling that those who have been privileged to know them are the better for having done so."

Of recent years he had become rather deaf and this, combined with the fact of living so far from London, prevented him from attending Corps functions and so his many friends in the Corps had not seen much of him since he retired.

A great gentleman and a very loyal and true friend passed away after a short illness on 11th March, 1953. He is survived by his widow, who was his most constant and devoted companion, and by two sons, both lieut-colonels in the Army.

C.C.P.

BOOK REVIEWS

SAPPERS IN THE PERSIAN GULF

By COLONEL W. A. ADCOCK

(Published by Thacker & Co., Bombay, India. Price Rs. 10/8/- or from Gale & Polden, Aldershot. Price 18s.)

This is a very difficult book to review, for it is a mixture of memories and technical advice, coupled with a "Who was who in Paiforce." Naturally each section suffers from the mixture, but the picture of the fantastic complication of the engineering requirements of modern war emerges clearly. Colonel Adcock tried to join up in India in 1939, only to be told he was not required. He was not to be put off and joined in 1940 and in May, 1941, sailed for Iraq in command of an E. & M. Company.

From then on either as O.C. Company, A.D.W., E. & M., or C.R.E. he tackled every job that falls to the lot of the E. & M. experts. Pumping and filtration plants, pipe lines, generating stations, overhead power lines, air conditioning and refrigeration, barrel and jerrican factories, all these and every possible variation of each one of them was part and parcel of E. & M. experience in Paiforce. From them all Colonel Adock learnt much and the technical tips that are scattered through the book are well worth finding. In particular the tips on air conditioning in Chapters 6 and 7 should be noted by anyone facing a job in the less pleasant parts of the world.

In the Pacific the proportion of engineers to the total force rose to 15 per cent. What the level was in Paiforce I do not know, but the requirements certainly must have been very high and we were lucky to find the technicians in India to draw on. In the future the demands will be even more severe and of course there will not be enough Sappers. Books like this point a warning to those who would take a chance on cutting the engineer compliment of any force. Not an easy book to read, but plenty of valuable material both for historian and technician.

L.D.G.

BRITISH ARMY SIGNALS IN THE SECOND WORLD WAR

By Major-General R. F. H. NALDER, C.B., O.B.E.

(Published by Messrs. Gale & Polden. Price 17s. 6d.)

The object of this history is to give a general survey of development in the Royal Signals before and during World War II so as to provide a general background to which Signal histories of the various campaigns can be related. The first four chapters form a chronological narrative : the remaining thirteen deal with development by subjects.

The "maintenance of the object" is evidently one of the author's favourite principles, for he has held to it most relentlessly throughout the book. Scarcely a name is to be found : no clash of views disturbs the story. The Royal Signals appear in their time-honoured rôle as the selfless handmaiden of the Army.

Although thus lacking somewhat in human warmth, the history is a most valuable general and technical record of obstacles overcome and progress achieved.

The lack of a settled strategy for the Middle East prevented the allotment of sufficient funds for the provision of the necessary signal equipments, which had a serious effect on the communications through the Mediterranean.

The war apparently brought forth surprisingly few innovations but perfected the use of equipment invented after World War I. Line communications continued to bear the chief load of Signal traffic. The technique of the "buried cable," curious to relate, had to be learnt afresh. After a shaky start, which all commanders will remember, wireless and radio in the field finished the war as a reliable medium for the control of mobile forces.

All the familiar and less familiar Signal problems of the war are fully discussed, including the importance of women operators.

A chapter on the future would have been illuminating. One of the advantages of the West in any future war should be its superior signal technique and communications. They will, in any event, require to be superlatively good, in order to counteract the disadvantages of being on the defensive.

B.T.W.

THE CAMPAIGN ON NEW BRITAIN and MARINES IN THE CENTRAL SOLOMONS

(Published by the Historical Branch—H.Q. U.S. Marine Corps)

The U.S. Marine Corps tackles the writing of its official histories on the principle that if the job is worth doing at all, it is worth doing well. The two books mentioned above are, respectively, the tenth and eleventh in a series of monographs about Marine operations in the war with Japan. When sufficient monographs have been compiled, they will be condensed into a final history of the Marine Corps in World War II. It would be difficult to devise a more comprehensive plan.

In the operations on the Solomon Islands, which actually took place first, the Marine Corps, and the U.S. High Command also, were mastering the technique of the "island hopping," which led so inevitably to the downfall of Japan. By the time New Britain was attacked, the Marine Corps had acquired great skill in landing operations.

For this reason *The Campaign on New Britain* is perhaps the more instructive of the two books. The capture of the Cape Gloucester airfield by the 1st Marine Division was a model six-day operation, which is well worth careful study. Having secured it and sealed it off from the rest of the large island of New Britain, the Marine Division was relieved by an Army Division. Three hundred miles away round Rabaul, at the eastern end of the island, nearly 40,000 Japanese stagnated for a further two years. They took no more part in the war. The dominant air/sea power of the U.S.A. was deciding the issue thousands of miles away to the north-west. How it would have delighted Captain Mahan to see his countrymen making such good use of the sea.

Both monographs bear witness in detail to the tremendous advantages which air/sea power confers. Costly, perhaps to create and maintain, its economy in the expenditure of human life is astonishing. New Britain's casualty bill for the U.S. Marine Corps was 310 killed in action and 1,083 wounded. The total defeat of Japan in the Pacific cost the U.S.A. only 105,000 casualties.

The photographs provide a feast of incident. They almost tell the story by themselves. The maps are admirable, but should be inserted so that they can be opened and left open for reference as the reader reads on. At present he has to turn back or distort the maps.

B.T.W.

IMPERIAL MILITARY GEOGRAPHY

By BRIGADIER D. M. COLE, C.B.E., Litt. D.

(Published by Sifton Praed & Co., Ltd., Price 24s.)

Eleven editions of this now well-known book have been published since it first appeared in 1924 under the modest title *Elementary Imperial Military Geography.* The immediately successful first edition was reprinted within six months and an enlarged second edition issued before the end of a year. After that the successive editions seem to bear witness to the tensions which distracted the world between the wars. The publication of the "largely rewritten" seventh edition, for instance, coincided with the seizure of power by Hitler in 1933. The ninth edition, 1937, was the last to be published before the war. It had 414 pages and 28 maps. The chapter on the defence of Great Britain and her home waters was a notably accurate appreciation of the perils to come. Twelve years later a tenth edition set out the post-war geography of the Commonwealth, into which the Empire has now merged. With 318 pages and only 17 maps it was shorter and a little drier. This eleventh edition of 1953 has 323 pages and 15 maps. New items, amongst many others, include notes on a possible African army, atomic energy, the E.D.C., Israel, Korea, the Sudan, Tibet, the Japanese Peace Treaty and the Tripartite Pacific agreement. Brigadier Cole has thus battled nobly with the perpetual political changes that vex the military geographer.

Perhaps air security is now the first essential in the defence of Great Britain, otherwise the heart of the Commonwealth might quickly cease to beat. The index has references to oil resources but not to coal and shipping, both of which have their special sections. Steel hardly gets a mention anywhere. But these trifles do not mar a book, which is almost an institution in the British Army.

B.T.W.

THE MILITARY NECESSITY

By ALFRED DE VIGNY

Translated by Humphrey Hare from *Servitude et Grandeur Militaires*

(Published by The Cresset Press. Price 12s. 6d.)

Vigny, a man of stoic and deeply contemplative nature, and, in the opinion of the great Italian critic, Croce, possibly the greatest poet of France, spent twelve years in the army and writes with sympathy and understanding of a soldier's lot. In this masterpiece, with honest and penetrating thought he discusses the soldier's function, considers from many angles his condition and, though not in so many words, his ideals. The book, published in Paris in 1835, never shirks the issue and indeed was once believed to be a mere attack upon the army. With his exposition of the soldier's abnegation and enforced acceptances yet lofty aims, Vigny shows himself a great artist in the telling of three thought-provoking "case histories" which drive home his points most forcibly. He himself saw many changes of government without switching over his own true loyalties; his book, however, remains a work of genius for all time, with countless applications for the modern reader, such as the possibility of duty conflicting with conscience. (Was there no conscientious German at Oradour?) A clear portrait of dictators of our own time can be seen in Napoleon's picture here, together with a glimpse of the dangers in armies for all up-start rulers.

Vigny's three stories have an unforgettable poignancy and, with his reflections on soldiering, form a most rewarding work, laying bare the contradictions as well as the virtues of the military profession in a self-conscious age when war has lost all its glory. Under "Military Bondage" comes the tale of the kindly sea captain who obeyed sealed orders to shoot the husband of the happy young pair on his ship, only to spend the rest of his life caring for the grief-maddened widow. After an interlude on the soldier's quasi-monastic vows of poverty and obedience, follows the tale of the old quartermaster of artillery at Vincennes who was blown to pieces by an explosion. Officers who stood near-by and escaped, refrain from comment on the pitiable sight of the dismembered corpse. The last story, under "Military Grandeur," concerns Captain Renaud who, as a boy, had idolized Napoleon and was for years a prisoner, free on parole, of the devoted Admiral Collingwood. The selfless Admiral had inspired the boy with respect for the pledged word and with a desire to serve his country as he did. As a young man fighting for Napoleon against the Russians, this captain "of upright and austere temperament" had led a surprise night attack, killing a boy officer together with his father. Appalled by his act, he had vowed never to carry a sword again, but instead the malacca cane which fell from the dying lad's hand. Thence came his nickname "Malacca Cane." Years later, after street fighting in the revolution of 1830, a Parisian guttersnipe, playing with a pistol, fired a marble at the officer and mortally wounded him. Thus ironically, thought the dying Malacca Cane, the wheel had come full circle.

The book is, with a couple of insignificant and perfectly justifiable exceptions, most faithfully and ably translated by Humphrey Hare who prefaces it with a masterly introduction. This new Cresset Press version, edited by John Hayward, has made available again a work to be valued by all thinking readers. L.R.W.

STRENGTH OF MATERIALS

By Arthur Morley

(Tenth Edition, published by Longmans, Green & Co. Price 25s.)

This book was originally written, in 1908, for engineering students, but when the ninth edition was published in 1940, the need for resetting type gave an opportunity for a more complete revision than had been possible for previous editions. In those parts of the subject in which research or development had made much change desirable, chapters or articles were rewritten. Notable instances were the work on fatigue, criterion of elastic strength, creep, metallurgical developments of ferrous metals and methods of testing. More use too was made of elastic strain energy and the theorems related to it for the determinations of elastic deformations.

The tenth and latest edition has had many small changes and additions made to it, particularly in relation to helical springs, strain gauges and strain analysis.

It is difficult to judge a technical book such as this until one has used it for some time. However, after a first inspection it appears to be a well-laid-out book adequately covering the subject for students who are following courses of study leading to engineering degrees, Higher National Certificates or the examinations of the professional engineering institutions. It would also be a very useful reference book, and it contains a large number of diagrams and test questions with answers and worked out numerical examples. G.H.

EXAMPLES OF THE DESIGN OF REINFORCED CONCRETE BUILDINGS

By Chas. E. Reynolds

(Published by Concrete Publications Ltd. Price. 10s.)

The principal, and in some cases the only, resort of the schoolboy who finds his sums getting a little out of hand, is to a " formula " or to the " worked examples " section of his textbook. By substituting one set of figures for another, and by a certain amount of luck, he will often arrive at the right solution. Unfortunately, this opens the gate to a primrose path, which many people are apt to prefer to the straight and narrow way leading over the pinnacles known as " first principles," which are therefore often ignored. The schoolboy is father to the Sapper Officer, and it is small wonder that supplementary courses call incessantly for "formulae" and " worked examples," and in higher places, can it be that a similar cry is heard for " type designs " ?

The cry is hard to resist if it is possible to provide worked examples to cover all likely problems. This is the case with Mr. Reynolds's book, where each aspect and instance in the design of a reinforced concrete building has been explored and tabulated : examples are given of the design of all the principal members, with comments to explain the work and details of the generally accepted formulae which may be used.

It is not a " readable " book, nor is it a course of instruction, but as a work of reference it will be of great value to the unpractised designer, while the amount of labour which may be saved by the informed use of Mr. Reynold's tables will be tremendous. It must be mentioned that the work is based on the British Standard Codes of Practice, although many of the tables and remarks are of general application.

D.A.S.

THE " CEMENTONE " HANDBOOK FOR ARCHITECTS AND CONTRACTORS

(Published by Messrs. Joseph Freeman Sons & Co. Ltd.)

Messrs. Joseph Freeman, Sons & Co. Ltd., the manufacturers of " Cementone," have produced the third edition of their handbook. In this they have increased the number of pages to include more complete information on the Cementone products and have also included data on certain products outside the Cementone range. These include such materials as washable water paint, enamel-gloss finish paints, varnish, wood stain and wax polish.

The Cementone products themselves are ten in number and include colours for cement and plaster, waterproofing liquids and powders, concrete floor binders and surface primers.

The handbook is well laid out, each product being treated under a separate heading, where general details are given together with recommendations for use, prices and, in a lot of cases, specifications for different types of work. This should prove a very useful handbook for those engaged in building or contracting.

G.H.

TECHNICAL NOTES

THE MILITARY ENGINEER

(*Journal of the Society of American Military Engineers,*)
November–December, 1952

" Airport Pavement Performance," by Charles F. Horne.

The author, Administrator of Civil Aeronautics since May, 1951, examines the performance, and causes of failure, of both rigid and flexible runways under ever-increasing aircraft loads.

After listing the fundamentals of basic design and considering examples of heavy maintenance required on initially under-designed runways, he concludes that although runway design based on performance is purely rule-of-thumb, this method has been accepted as the most reliable that is available at the present time. More satisfactory methods are under investigation for determining runway thickness on the basis of stress analysis within the runway and the supporting subgrade.

"Linear Prestressed Concrete Construction," by Charles C. Zollman.

An interesting and well illustrated article showing how European prestressed concrete techniques have been applied and modified to meet American conditions and are now emerging as what could be called American prestressing techniques. Briefly, the high cost of site work and the existing nation-wide, highly developed and fully mechanized concrete block industry, which produces high quality blocks under ideal conditions for control of mixing, placing and curing, is leading to simplification of tensioning techniques and factory mass production of simple, economical, pre-fabricated, standard units. The main American task is to replace thousands of secondary bridges, with spans varying from twenty to sixty feet, and to provide millions of square feet of one-storey industrial plants with standard girders, beams, and roof panels to span typical 20 × 60 ft, 40 × 60 ft. and 60 × 80 ft. bays.

This should be of value and guidance in the correct application of this technique to military bridging and war accommodation problems.

" Soil Stabilization Methods," by Commander Fred F. Kravath, Civil Engineer Corps, U.S. Navy.

A valuable article summarizing thirty-five papers on Soil Stabilization presented at a recent symposium on the subject organized by the Massachusetts Institute of Technology, and sponsored by the Navy Department, the Corps of Engineers, and other government, educational and private agencies.

The author deals with the conventional cement and bitumen methods, the more limited lime, calcium chloride, and sodium silicate processes, and the recently developed resinous techniques such as aniline-furfural, calcium-acrylate, chrome-lignin, and plasmofalt. In addition he adds brief notes on electrical stabilization, consolidation of clay soil by atmospheric pressure, altering soil water relationships with chemicals, and stabilization by compaction and resonant frequency vibration. In attempting to cover so wide a field, many essential details, such as cost and weight of stabilizing agents per cubic yard of soil, have unfortunately had to be omitted, but these will doubtless be available when Proceedings of the Soil Stabilization Conference are published by the Massachusetts Institute of Technology. Meanwhile the military engineer is still in pursuit of the ideal ; a cheap stabilizing agent of which about 5 per cent by weight of the soil to be stabilized will be adequate, and which will be of universal application to all types of soil.

THE ECONOMIC AND INDUSTRIAL EFFECT OF NEW HIGHWAY CONSTRUCTION

(*Civil Engineering*, March, 1953)

In this article the author evaluates the national economic waste in motor transport and time, brought about by the outdated and inefficient road traffic facilities of the United Kingdom.

By comparing traffic movement on old and new roads, where new construction has made it possible, the author shows that the travelling time saved over the new roads is in excess of 20 per cent. To this saving in time can be added the incalculable, but obviously enormous saving in costs of operating and maintenance of transport brought about by the steady flow of vehicles on well aligned and surfaced roads of adequate capacity.

In dealing with the obvious solution to this national problem, the author points to the fact that of the £338 million revenue from motor taxation in 1952, only £33 million was allotted to roads. Over the last five years the total annual expenditure on roads in the country was in the region of £70 million, of which only £1 million was for new construction.

The author goes into some detail in his proposal for a ten-year programme, spending an additional £15 million per year on new construction.

The type of construction envisaged is two carriageways, each 24 ft. wide, with a central reservation. The estimated cost is £150,000 per mile. The author produces his estimates to show that the necessary plant and materials can now be provided by British industry, given the demand to stimulate expansion.

The plan envisages continuity of work on contract lengths, each of 10 miles, by ten main contractors to produce 100 miles per year and 1,000 miles of new road under the ten-year programme. With mechanized construction the labour force is estimated at 10,000 only.

The subject has been treated on broad lines, but the article shows that the author has gone into considerable detail and investigation, to show that such a plan is now within the capacity of the engineering profession and industry. All that is needed is the requisite money.

THE MACKENZIE KING BRIDGE, OTTAWA

(*The Engineering Journal of Canada*, December, 1952)

The construction of the Mackenzie King Bridge, in Ottawa, was started in April, 1950, and it was opened for traffic late in 1951. The bridge is designed to carry six lanes of traffic and passes over two major roadways, the Rideau Canal, and twenty-three railway tracks.

The over-all length of the structure is some 1,030 ft., divided into three main portions, as under :—

(*a*) The Canal Crossing, a skewed three-span continuous concrete structure crossing the driveway, the canal and four railway tracks.

(*b*) The Railway Yard Crossing, of twelve spans of continuous steel deck girders, over nineteen railways tracks and a freight shed.

(*c*) The Nicholas Street Crossing, a three-span continuous concrete frame.

The design and methods of construction show some unusual features, notably the virtual absence of normal bracing in the steel portion of the structure. The placing of concrete and splicing of welded steel girders also present interesting ideas.

MODERN PIONEERS

(*The Engineering Journal of Canada*, December, 1952)

In an interesting paper which outlines the part already played by engineers in the rapidly accelerating development of Canada, and points to some of the problems yet to be solved, the author aptly describes engineering as depending upon men, machines, materials, methods and money. He stresses the predominance of the human factor and the importance of understanding not only men associated with engineering, but also the " consumer " and the investor. Many will find his exposition of the virtues of free enterprise both acceptable and instructive.

SEATTLE HIGHWAY VIADUCT AND VEHICULAR SUBWAY

(*The Engineering Journal of Canada*, January, 1953.)

Seattle's traffic problem is exceptional since the city is confined, to east and west, by Lake Washington and Puget Sound, and through traffic on the north–south routes accounts for about half the vehicles passing through the congested central business district.

Limitation of space has led to an interesting solution of the problem. Some 2½ miles of new roadway involves two main reinforced concrete structures, a double-deck viaduct and a vehicular subway, joined by a transition section in which the two decks are brought together into a single viaduct forming the subway approach. The double-deck structure, 4,502 ft. long, carries three lanes of traffic in one direction on each deck. The subway, 2,134 ft. in length, will accommodate four traffic lanes.

The article describing this project does not give a very clear impression of the general layout, but contains interesting information about a number of uncommon features.

The use of a double-deck structure creates unusual design problems, complicated by the need for railway clearance under the lower deck and for the provision of ramp-connexions to street level. The subway employs a most unconventional and economical ventilating system, automatically controlled by carbon-monoxide testing equipment, and this, together with a comprehensive set of safety devices, is clearly described. Subway lighting receives particular attention, notably at the transition from sunlight to relative gloom.

DETERMINING SOIL MOISTURE AND DENSITY BY NUCLEAR RADIATIONS

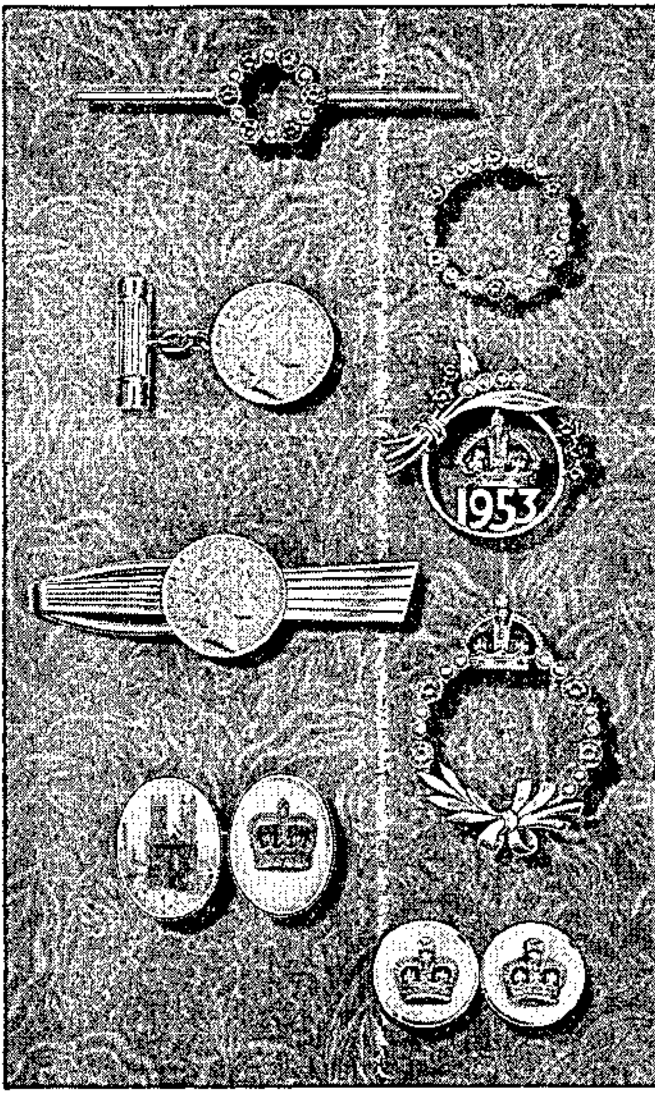
(*The Engineering Journal of Canada*, January, 1953.)

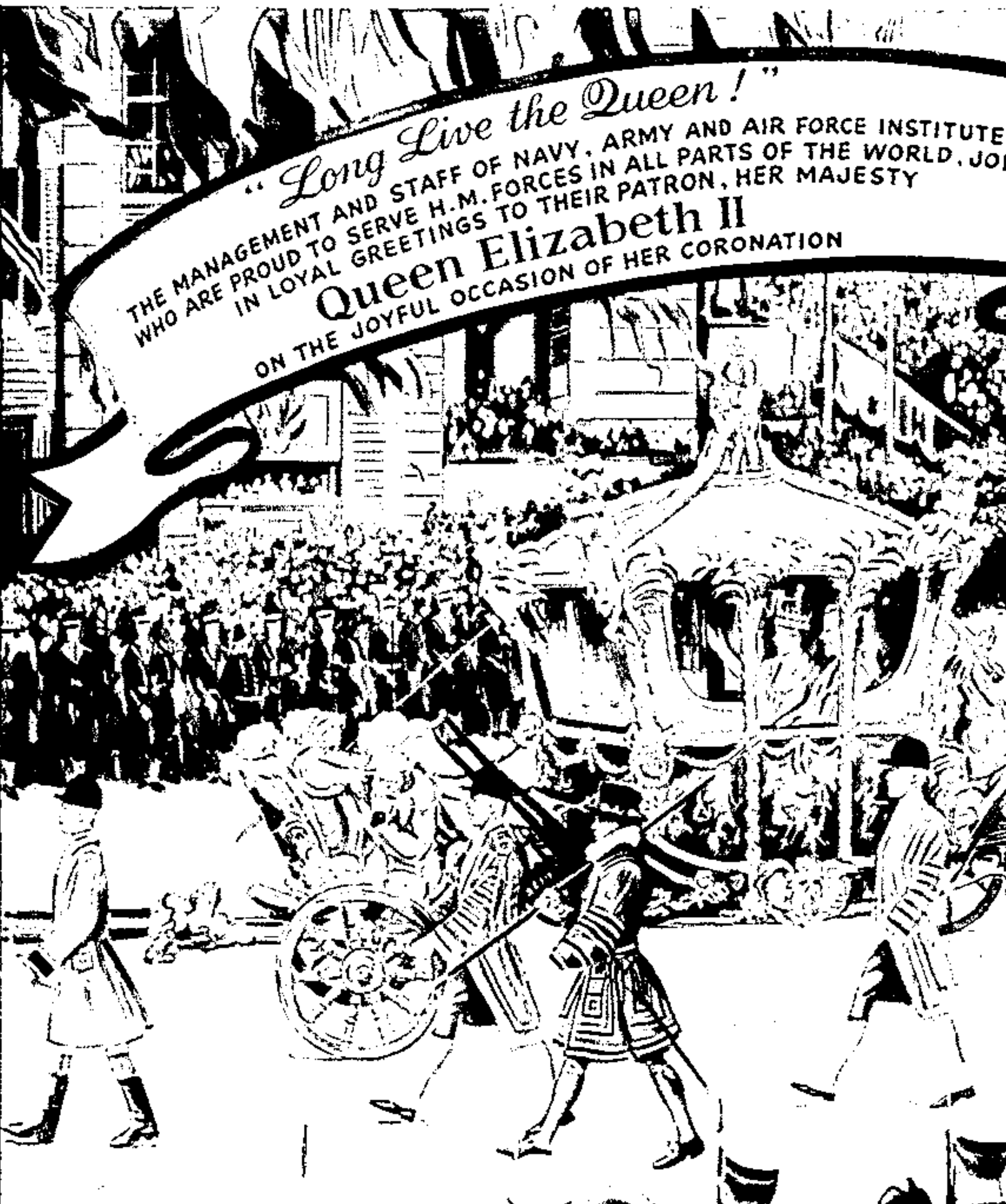
In the construction of roads and airfields a rapid and accurate means of determining the moisture content and density of soil would be invaluable, for present oven-drying methods are somewhat slow and laborious. This paper describes meters which have been devised for this purpose and which, though not yet fully developed, show considerable promise under practical test. The main interest of the paper, perhaps, is that it gives a concrete example of the application of nuclear chemistry to engineering problems.

The moisture meter is based on fast neutron bombardment of the soil causing the reflection of slow neutrons which activate a detector foil.

The density meter is based on the gamma ray absorption of the soil.

At the end of the article is a short glossary for the benefit of those unfamiliar with nuclear physics terminology.


1953


"Long Live the Queen!"
THE MANAGEMENT AND STAFF OF NAVY, ARMY AND AIR FORCE INSTITUTE
WHO ARE PROUD TO SERVE H.M. FORCES IN ALL PARTS OF THE WORLD,
IN LOYAL GREETINGS TO THEIR PATRON, HER MAJESTY
Queen Elizabeth II
ON THE JOYFUL OCCASION OF HER CORONATION


ARTHUR
FERRIER