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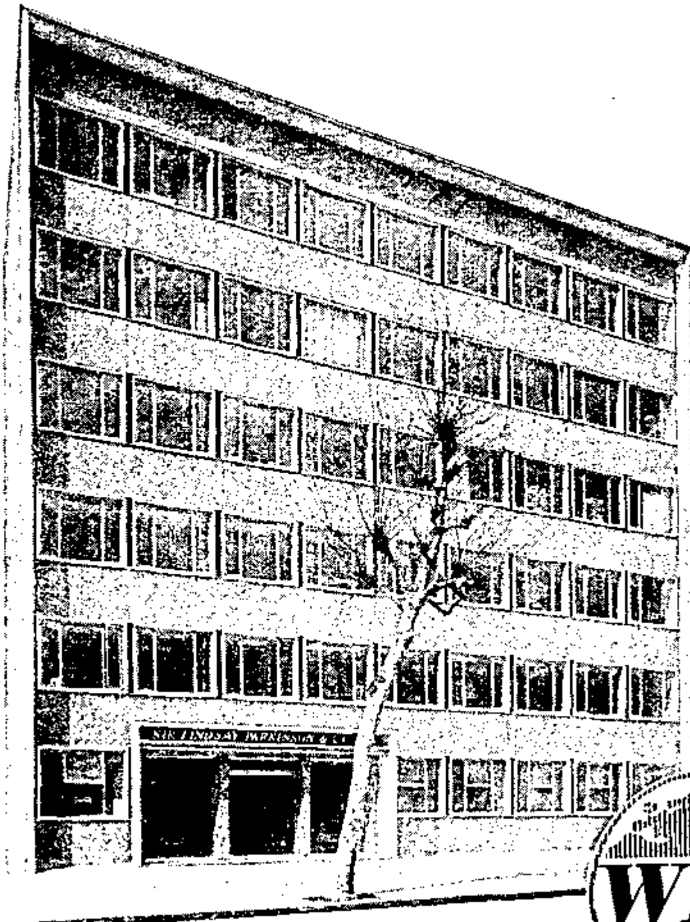

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THE ROYAL ENGINEERS JOURNAL

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SEPTEMBER, 1957

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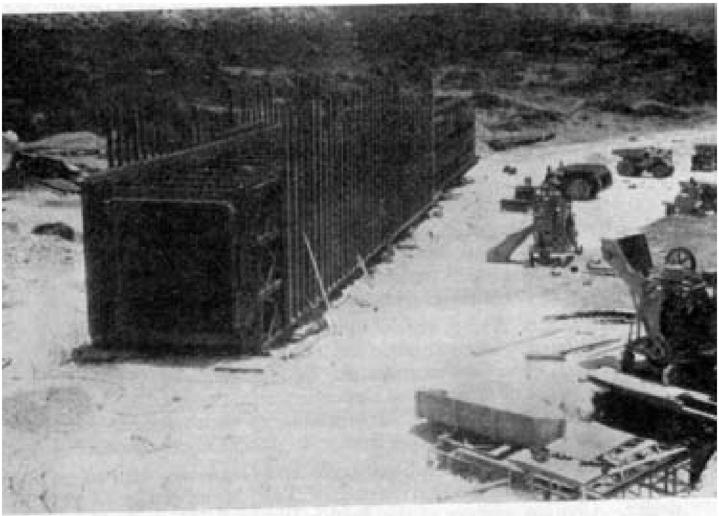


Photo 1.—South Adit structure during erection, showing shuttering in position.

Photo 2.—The completed Adit.

Episkopi Tunnel, Cyprus 1 , 2

Three months in the Life of a Field Engineer Regiment in M.E.L.F., 1956

By "Gordon, MacRose & Co."

Prologue

"At last," said the C.O., addressing his squadron commanders in Cyprus early in August, 1956, "it looks as if we are going to be able to do some proper training.

"You, Chota, will take your squadron to Tripoli for six weeks desert training in accordance with the plans we have already made. The Chief Engineer is going to set a War Fitness test for you in your last week there.

"You, Eric, will send one troop of your squadron to Tripoli too. Another troop is to carry out the water supply scheme you have been working on. It will be excellent training. The third troop must do some dry bridging.

'Your squadron, Cyril, must finish off the work on the Episkopi Tunnel, and then do training in demolitions and mine warfare. You will also have to take over camp guards and duties for a while. Any Internal Security commitments that arise will come your way.

"The Field Park Squadron must sort out its stores and plant after all the works we have been doing. You, Sandy, (addressing the Second-in-Command) are to get R.H.Q. on to a harbour and wireless exercise, as soon as possible. Make it tough. I, personally, shall go on leave."

Unfortunately, the C.O. had reckoned without the Suez crisis. Some of the tasks which the Regiment actually carried out in the next three months are described in this article.

Building Temporary Camps

General Description

Hardly had the conference ended when the call came for a squadron to go immediately to Nicosia to build camps for units due to arrive in Cyprus very shortly in connexion with the Suez crisis. The field squadron, which was working up for Tripoli, could most easily be detached, although one troop was in the hills on an exercise and another was guarding Government House in Nicosia. The squadron arrived in Nicosia twenty-four hours later, and prospects of training in Tripoli faded. They found the following tasks waiting for them:—

(*a*) A camp for a British battalion.

(*b*) Camps for three minor units.

(*c*) Extension of existing camps to accommodate three minor units.

(*d*) Two thousand yards of unclimbable fence to extend an ammunition depot.

(*e*) Two and a half miles of 4-in. victaulic and screwed pipe for water supply to these camps.

On paper, this is a formidable list, but in fact emergency camps in Cyprus in summer consist only of camp structures to Scale "A", which is pretty basic. For example, Scale "A" for a 120-man camp comprises shelters for cookhouses, ablutions and latrines only. One tap, sullage drainage, including grease traps, an incinerator and swill cages are provided. There is no concreting, but soak pits and deep trench latrines (D.T.L.) have to be dug. Erection of tents, perimeter fence and surface drainage are the responsibility of the occupying unit.

If the camp is to be occupied during winter, and in any case if time, stores and labour permit, it is extended to Scale "B". This includes a number of huts, concrete floors in structures and slabs for tents, water on a more generous scale, and electricity. When building to Scale "A", provision has to be made for subsequent extension to Scale "B": for example, cookhouse shelters are built facing each other exactly 10 ft. apart, so that the gap between them can be roofed over.

Execution

Detailed siting and layout were the responsibility of the local D.C.R.E.; but such was the rush that in some cases plans could only be produced after the work was finished. Structures for a Scale "A" camp are largely prefabricated. Purlins, rafters and ledgers are cut to size, bundled and numbered. When building it is most important that the structures are put together correctly, otherwise a timber shortage will occur before the task is completed.

Apart from badly warped timber, the R.E. Workshops produced good quality materials cut to the correct size, although they sometimes made "in lieu" issues, such as two 9-ft. lengths of corrugated iron instead of three 6-ft. lengths. Much of the material from contractors was short in length, width or gauge; one load of "C.G.I." was found to be 36-gauge corrugated—tinplate; the squadron commander was literally able to "tear off a strip" to give a sample to each of those interested or concerned! It was, however, replaced by the contractor with the usual abject apologies and promises.

Before any work started, an officer of the squadron was made responsible for stores control; he had a small staff of two N.C.O.s and two sappers, and all stores and equipment were drawn through this organization, which was kept quite separate from that of the S.Q.M.S.; it proved invaluable, as it enabled the Troop commanders to keep on their own tasks without eternally having to leave it to chase up stores, and left the S.Q.M.S. free to deal with rations, accommodation stores, A.F.G. 1098 stores and the squadron canteen. We had already learnt that on any works job, this question of stores control is all important.

The sites for the minor unit camps were on a solid rock plateau. Nowhere was the earth cover more than 9 in. deep, and every excavation, however small, required a compressor, and blasting was extensively used. A hole had to be dug for each upright in each structure, grease traps had to be dug in, and D.T.Ls. and soak pits were expected to be 16 ft. deep. After working with heavy picks for fourteen hours on each of three days, one D.T.L. was only 4 ft. deep, and an appeal to authority brought a concession wrung out of A.D.A.H. that in this camp bucket latrines would be permitted.

Tents and perimeter fences were put up by occupying units, and of course they had to borrow compressors to put in pickets and tent pegs; for a minor unit some 2,000 holes had to be drilled. It was very quickly found out that such people knew little about the machines and their use; how to prevent a drill getting stuck in the ground, the use of air lubricators and even refuelling the machine were regarded as engineer ju-ju (as indeed was making two lines of tents parallel) and much of the work expected of them was in fact done by the squadron, due to the rocky ground.

Thus compressors were on the go all the time. The truck-mounted type was the most useful, as it could move quickly along the line of a perimeter fence or down a row of tents, though it overheated frequently; the rubber-wheeled Holmans needed a truck in constant attendance, which was wasteful, but were most reliable; and what were soon scornfully known as the "tin wheel jobs" were a menace, and only used for tasks where they could be kept stationary for a day or so.

At another site, where the camp for the infantry battalion was to be built, it was found that a 19 RB, rigged as a back actor, was of great value. The bucket width and length of arm, are ideal for digging D.T.Ls. and a twenty-seater could be dug in two hours, as against four days with eight men. The correct setting of the bucket on the arm and getting the tracks level are important, and it cannot dig a trench less than about 18 ft. long if it is to achieve the right depth. The unclimbable fence involved some 500 post holes to be dug 4 ft. into hard ground, and we were fortunate to obtain on contract a 9-in. powered augur mounted on the back of an agricultural tractor, and this saved a great deal of time.

Engineer troops in Cyrpus have recently had considerable experience in pipelines of all kinds, and in almost every case the problem of stores supply is the limiting factor in speed of erection. There are many different diameters and types of piping, and the fittings never seem available at the right time. It is quite impossible to devise a set of fittings, as all projects are different—one may require 2 miles of straight victaulic, in another the line may have to follow ditches and culverts and require large numbers of easy bends. A shortage of cutting and grooving machines was also severely felt, particularly in spare cutting tools. A 10-ton truck is the most suitable for "stringing" pipelines, due to the length of its body as well as its capacity, and it was found that a troop could lay a mile of 4-in. victaulic or half a mile of 4-in. screwed, in a day provided there was not too much digging through banks, etc., and not too many bends. Incidentally the piping was far too hot to touch except in the early morning, and the ordinary sandbag was found to be invaluable as a glove.

The unclimbable fence consisted of 13-ft. posts let into the ground, with a 2-ft. length of timber nailed to the top projecting upwards and outwards at forty-five degrees. The posts are at 4 yd. centres, every tenth post is braced, and barbed wire strained along the fence at 6-in. intervals. We were fortunate in having an infantry working party who soon got the hang of it, and one troop with sixty infantry finished the 2,000 yds. of fence in a week. The top 9 in. of the post-holes were filled with concrete; the quickest way was found to be from a tipper loaded with cement, mixed aggregate and water for about 2 tons of concrete; this was mixed by hand on the tipper in small batches, and shovelled straight into the holes after the wiring was complete, so that there was no movement of the poles while the concrete was setting.

The Squadron was in Nicosia for the hottest part of the hottest summer for eight years. The published temperature reached 116° F., and this meant that no metal could be touched by hand. This was exceptionally trying when dealing with piping and C.G.I. cladding for camp structures; petrol vapourization affected several trucks, and the supply of cold drinks to men on site was vital to maintain speed of work. The Squadron was working at full pressure; its preparation for Desert Training as an independent unit was of great value, and the administration ran smoothly throughout the four weeks that the Squadron was detached. A sky-wave wireless link was opened three times a day to R.H.Q., 50 miles away over 4,000-ft. hills, and was always loud and clear.

Comment

The Squadron had no previous training in the type of work it was required to undertake; the traditional versatility of Sappers appears to continue unimpaired, and apart from minor defects, the equipment on A.F.G. 1098 was adequate. Works tasks in a hot climate in double time are very fatiguing; a little attention to welfare in an unusual form can pay high dividend in efficiency. So too can an intelligent use of plant. A good stores organization for a task of this kind is a necessity, and should be kept separate from the S.Q.M.S. and his set-up. More time is lost through poor stores organization than by poor supervision of work, and the H.Q. Subaltern is the right man to take it on. His staff will be dependent on personalities, but a representative of each troop working is the ideal.

The Episkopi Tunnel

Background

Work on the Episkopi Tunnel had been going on intermittently for eighteen months, and was by now entering its last phase. The tunnel forms part of the cantonment for the new Joint Middle East Headquarters now being built at Episkopi.

The cantonment stands on cliffs 250 ft. high overlooking the sea. Below it the shore is divided by headlands into a number of quite separate beaches of up to a mile in length. The largest, best and nearest beach was completely inaccessible, except by precipitous goat tracks suitable for agile foot traffic only. Longing eyes were cast on this beach, not only as an ideal recreational area, but because of the large quantity of good quality sand and aggregate regularly washed up on the foreshore. It was considered that the cost of the tunnel would be more than offset by the savings made if this material were available for the many concrete buildings to be built in the cantonment. It was an overriding consideration that the cost of the tunnel should be as low as possible, and this, of course, meant using troop labour.

The tunnel was aligned to run from the beach northwards through the headland towards a point where the main East–West road through the cantonment dips steeply through a valley known as Happy Valley. About a quarter of a mile of new road was to be constructed connecting the north end of the tunnel with the main road. The length of tunnel to be excavated was just over a quarter of a mile, at an average gradient of 1 in 40 up from the beach.

At the beach end, an unstable cliff 250 ft. high overhangs the tunnel portal, and falls from it are frequent. Ages of scabbing of the face have produced a 90-ft. high bank of scree, mixed with large boulders, at the foot of the precipice, and stretching 150 ft. out towards the sea. To give safe access from the tunnel portal to the beach, this scree had to be cleared away, and it was planned to build an adit in the form of a concrete box 150 ft. long, strong enough to withstand any future rock falls from the cliffs.

During 1955, the tunnelling troop of the Fortress Regiment from Gibraltar, assisted by our predecessors, had expertly driven the tunnel, working from north to south. This tunnel had been designed to take single-way vehicles, up to 3-ton size, and averaged 16 ft. in width and 12 ft. clear height on the centre line. It had been provided with a temporary roof lining consisting of frames made from Decauville track, to which had been fixed longitudinally unserviceable Bailey Bridge ribands. Our predecessors had also cleared away the scree for the adit, using excavators brought into the beach by Z-craft, and had built, clear of the scree on the beach, 150 ft. of triple storey double truss Bailey Bridge, which was to be encased in concrete 2 ft. thick to form the adit. During the excavation work, one RB 19 had been damaged by a fall of rock. Fortunately the operator escaped, but the need for the adit was proved.

At this stage (October, 1955) our predecessors had been ordered abruptly to stop work, and to get on with dealing with E.O.K.A. It was not until the summer of 1956 that troops could be made available for work again.

Work in 1956

The major items of work still to be done consisted of:—

(*a*) A concrete road throughout the tunnel length.

(*b*) Completion of the adit at the beach end.

(*c*) Permanent lining of the first 30 ft. of each end of the tunnel with a reinforced concrete arch (the temporary lining was considered adequate for the remainder).

(*d*) The construction of approach roads, and miscellaneous small tasks.

During the winter months, there had been fresh falls of rock from the cliff face, virtually blocking the entrance at that end of the tunnel.

The Concrete Road

The construction of a quarter of a mile of 6-in. unreinforced concrete road, 9 ft. between curbs, was a comparatively straightforward, if somewhat monotonous task. The operations to be carried out were:—

(*a*) Mucking out the tunnel floor to the required level.

(*b*) Laying 6 in. of gravel base (in which was inserted an agricultural pipe along the centre line).

(*c*) Shuttering and concreting the curbs.

(*d*) Pouring the concrete road surface.

It had originally been intended to do this task working from both ends of the tunnel, in order to reduce the length of haul of materials. But as the south entrance was blocked, it all had to be done from the north. The Decauville track, which had been laid during the tunnelling operations, was rehabilitated, and all material was handled in skips pulled by small locos. The number of men who could be employed on the one working face in the tunnel was limited by space, and it was found that the best way of working was to do all the mucking out and laying of gravel base by night shift. Concreting of the curbs proceeded at least twenty-four hours ahead of the road slab. The whole task was carried out by a troop who received some outside assistance in running the concrete mixing plant just outside the north end of the tunnel.

Starting at the south end of the tunnel, and working uphill, the daily output increased as the length of haul was reduced, and as the drill got firmly established, until about 70 ft. of road could be completed in each twenty-four hours. In all about 300 cu. yds. of concrete was poured.

The Adit

Meanwhile the remainder of the Squadron was getting ready to build the

Adit, and the necessary plant and stores were being moved to the beach by sea in Z-craft. The face shovels did excellent work clearing the rock face without a mishap, while the Bailey structure was being prepared for moving into position at the end of the tunnel. It was decided to fix reinforcement and shuttering to the first 100 ft. of the structure before it was winched in, so that there would be no danger from falling rock to the men doing this task. The launching weight therefore amounted to 130 ton, but the structure was moved up the 1 in 40 slope without difficulty using the winches of size 1 dozers.

A concrete pump had been ordered from England, as it was the only means of placing concrete in the tunnel lining. It also provided the safest way of placing concrete in the walls and roof of the Adit, since it would require fewer men in the danger area than any other method. The pump supplied was a PC4 Pumcret model, feeding a 4½-in. pipe and powered by a Ruston diesel engine.

Apart from the C.O., nobody had ever worked a concrete pump before, and it was some time before its likes and dislikes were properly understood. We were to learn the hard way the golden rules about pumping concrete. First, the mix must be right, of suitable grading and with the right amount of water, otherwise blockages occur. As our sand and aggregate had to come from the beach, the correct proportioning took a good deal of trial and error. Second, the pump is a voracious animal, which must never be starved. A continuous-type mixer is the proper answer, but this type is seldom available through military channels. Batch mixers grouped round the pump hopper must be of sufficient capacity, not only to satisfy the pump, but also to continue to do so should one mixer break down. Third, the flow of materials to the mixer must be assured, and the necessary teams of men, barrows, excavators and dozers must be drilled. Fourth, stoppages in the pipe are always liable to occur, and the correct drill for clearing them, and for cleaning out the pipe at the end of the day's work must be learnt and rehearsed. Failure in this respect leads to unnecessary labour in removing hardened concrete from the system. Finally, the pump itself and its engine must be carefully cleaned and maintained after each day's pumping, to remove all traces of grout which quickly gums them up.

The pipe is heavy to handle, and we soon learnt to arrange the concreting programme so that there was as little stopping and relaying of pipe as possible. When we started pumping, we were lucky to get an output of 5 cu. yds. hour, but towards the end of the job we achieved 9 cu. yds. hour (at which the pump was rated) and a total of 50 cu. yds. in a shift.

After the first 100 ft. of the Adit had been concreted, we could breathe a sigh of relief; the rest of the work was out of the danger area. At this stage the Squadron who had been nearly four months on the tunnel were relieved. It was now August, and the Suez crisis was looming up. There was a feeling in the air that work on the tunnel might have to be called off for more serious affairs. The tempo of work was increased, as we were determined to finish the adit at all costs, for this, with the completed road, would enable traffic to use the tunnel. It was now the hottest month of the year, and the high cliffs acted as a sun trap, reflecting the heat on to the men working below, stripped to the waist. Rests were taken in the cool of the tunnel, through which cooler air usually circulated. Our premonitions were fulfilled, and just as the last hours of concreting on the Adit were being worked, we received orders to stop work, and start a new job of an entirely different nature, and of the highest priority. There was just time to strike the last of the shuttering, and doze a burster course of scree on to the top of the Adit. The troops with their equipment were withdrawn through the now usable tunnel, and went straight to work on the new job. The remaining tasks on the tunnel had to be deferred until the spring of 1957, when they were duly completed by the Regiment.

Comment

Though much of this project was pure concrete-bashing, there were a number of field-engineering features in it, and many men had a chance to work at their trade, which is always popular. Much hidden talent was unearthed, the key to success was good organization and control and there was ample opportunity for officers and N.C.Os. to prove their worth as organizers and to widen their engineering knowledge.

Akrotiri Petroleum Project

Background

This project, at the Royal Air Force Base at Akrotiri in the south of Cyprus, was intended to fulfil two requirements. First, to provide as a matter of great urgency, storage for 700 tons of reserve aviation fuel, to be brought in and taken away by road bowser. Secondly to develop this as soon as possible into a proper tank farm of 1,750 ton capacity for fuel brought in by tanker through a ship to shore line. Very tight completion dates were set for both parts of the project, and it was decided to deploy two field squadrons on to the work. One squadron was to erect the tanks, five of the latest 3,000-barrel capacity, bolted, steel tanks being rushed out from England for the purpose. The second squadron was to be responsible for all pipe runs conecting the tanks, the ship to shore line, bowser filling points, and ancillary work, such as fire precautions, electric lighting, storm water drainage and security fences.

Building the Tanks

Site layout was agreed on 28th August, and plant of the Field Park Squadron at once started excavating the pits in which the tanks were to be erected. One field squadron, straight from the tunnel, established themselves in a camp near the site, and were ready for work on 3rd September.

The first two tanks were flown out from the U.K. Two plane-loads of stores, with Major E. W. Kenworthy, R.E., an expert in this task, arrived on 3rd September, and a third aircraft arrived the next day. These contained two tanks, although certain vital parts of the second tank, and some erection tools did not arrive till a week later. Nevertheless, work on erecting the first tank started at once, rather slowly at first, while we were learning the technique. It is essential to get the base absolutely level on a sand mat. Apart from this, the main difficulties are the proper application of the sealing material at the many joints between plates, and the correct tightening of the 12,000 bolts which go into each tank. The latter task is not suitable for pneumatic nut runners, but must be done by hand operated ratchet torque wrenches set to the correct torque. Thanks to Major Kenworthy's expert knowledge, the technique was soon learnt, and work proceeded by shifts, both day and night, a project lighting set being rigged to permit night work. Both tanks were ready for testing on 18th September.

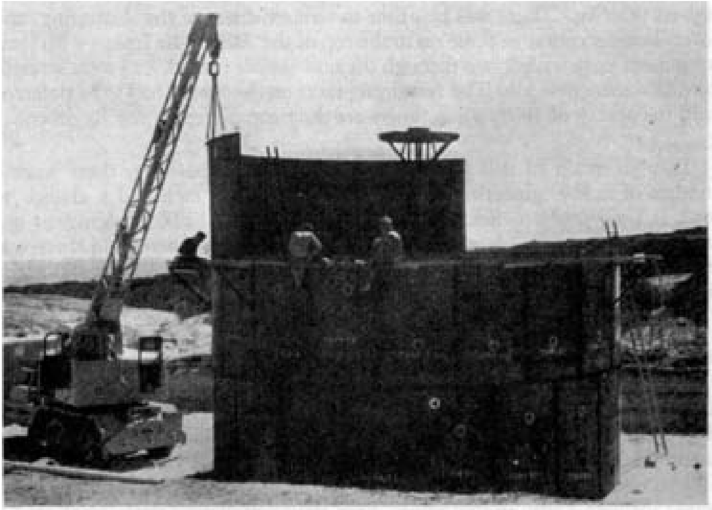


Photo 3.—A tank being erected.

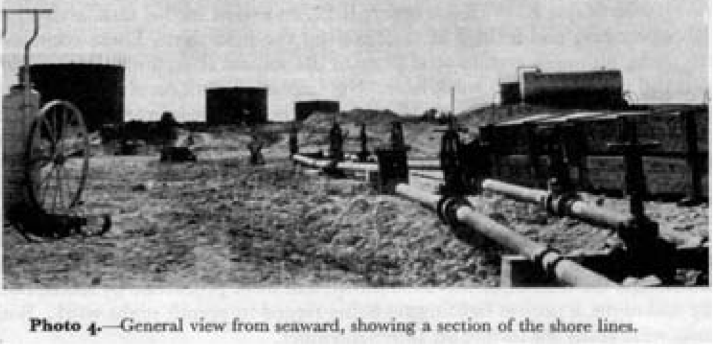


Photo 4.—General view from seaward, showing a section of the shore lines.

Episkopi Tunnel, Cyprus 3 , 4

The tanks were tested by filling with sea water, using fire pumps. A number of leaks due to faulty tightening of bolts and bad placing of the jointing material were located and rectified. One of the plates started to leak at its centre, due to faulty manufacture, which only became apparent under pressure. In the absence of any spare plates, this had to be taken out and electrically welded. As it was in the centre strake, this meant stripping part of the upper strake and the roof, and the whole job, including re-testing took two and a half days. Even so the tanks were ready for filling with aviation fuel only twenty-four hours behind the target date.

Meanwhile excavation for the next three tanks and their associated pipe runs had been going on steadily. The tanks themselves arrived by sea between 19th and 24th September, and work on erecting them started as soon as sufficient stores were available. It had been found that the best working party was twenty-two O.Rs. under a sergeant; so these three tanks were given as task work, one to each troop of the squadron. Rivalry was intense, not only as to who could build fastest, but also as to which tank, when tested would have the fewest leaks. In addition, a production line method had been evolved, whereby pairs of plates were bolted together on the ground, and swung into position by crane. The Coles Bridging crane, with its power lowering, was ideal, but an RB 19 and an NCK were also used successfully. The first tank had taken 3,000 man hours. The last three, under the task system, averaged 1,850 man hours. Working nine hours a day the troops had the tanks ready for testing on 6th October, and for fuel two days later.

Shore pipe lines

About 3,000 ft. of 6 in. victualic pipe, and 1,000 ft. of 4-in. screwed pipe had to be laid to connect the tanks to the ship to shore line and to the Bowser filling point. The shore lines included over forty rising-gate valves, and were laid in open trenches up to 8 ft. deep. Planning of the project had necessarily been very rushed, and the site layout led to an unnecessarily complicated pipe layout. The Workshop troop of the Field Park Squadron were fully occupied, both in their workshop and on the site, in making and fitting specials. Once laid, each section of pipe had to be isolated from its neighbours by concrete walls in the trenches, so as to reduce the fire risk from leaking fuel. Each tank pit and trench required storm water drainage. The whole of this work was carried out by one troop of the second Field Squadron, who were able to keep pace with the general progress of the work. This troop also installed a surface ring main, 2,500 ft. long, with hydrants, in 6-in. victaulic pipe, through which sea water could be pumped for fire fighting purposes.

The Ship to Shore Line

The construction of the ship to shore line, 1,250 ft. long, was given to another troop of the second Field Squadron. A convenient sandy beach, gently shelving and with no appreciable tide, was chosen about a mile from the tank farm site. No one had any experience of this work, and no written instructions were available. But a M.E.X.E. trials report on a similar kind of pipe proved most valuable.

The pipe, made by Mosely Rubber Company, came in 25-ft. lengths; internal diameter is 8 in., and each end is fitted with a steel flange, 15 in. in diameter, with twelve 1-in. holes. The flanges are male and female, the male end rising about $\frac{1}{16}$ in. more than the female recess; when the jointing material is inserted, the flanges are about $\frac{1}{8}$-in. apart. Each length weighs nearly half a ton, and they came two to a wooden box; the end of the box had to be broken open before stacking to make sure all male ends faced the same way. The pipe just floats when filled with air, but of course sinks to the bottom when full of liquid, be it sea water or petrol, and bends easily to a radius of about 6 ft.

The boxes of pipe were stacked perpendicular to the water's edge, on the beach; roller runway was laid parallel to the boxes, with timber sledges on the runway. Two pipes were then taken from their boxes (a task for ten men) and connected, then pushed on the sledges down the runway into the sea, after a blank flange had been fitted to the seaward end.

A further pair were then taken out and joined together, this pair then being connected to the standing part of the pipe—thus there were two parties making joints all the time, and the pipe was "boomed out" 50 ft. at a time, being held offshore by a Mk. V tug. By this method it took a troop one and a half days to complete 1,250 ft.

Having got the pipe floating, with a blank flange fitted with a screwed stopcock at each end, it was hauled with the tug parallel with the beach, in about 2–3 ft. of water. A compressor was connected up and the pipe "blown up" to 100 lb. per sq. in., to test the joints. Each joint was pushed fully under water by hand, and inspected for leaks; two joints leaked and were duly tightened, but it was with horror that we saw that ten pipe sections were leaking where the rubber overlapped the steel spigot to which the flange was attached. These leaks were small but serious, as in time oil fuel would rot the rubber. This was entirely unexpected, and caused much delay. The pipe was brand new, straight from the factory, and stated to be able to withstand a working pressure of 150 lb. per sq. in., tested to 225 lb. per sq. in. The defective sections were scattered throughout the length of the pipeline, and clearly any new sections must be tested before being included. The problem was tackled by pulling ashore with winch trucks the offending sections, removing them and joining the two ends.

Work was then restarted on the production line, but this time a test was made after every two lengths had been connected up and boomed out; this took time as the blank flange had to be fitted and taken off again and during this process a further three defective pipes were found. The new 250-ft. length was then connected to the original length (now 1000-ft.) and a final pressure test made to test this joint and those caused by removing the ten defective pipes. An interesting factor is that under this pressure the pipe lengthens by some 5 per cent; this caused considerable snaking of those lengths that had grounded.

At last the pipe was ready for towing to its proper position; an Air Sea Rescue flight provided the towing craft and a F.B.E. bay, powered with two propulsion units, took station two-thirds of the way along the pipe. The pipe was hauled up under the decking by means of a small derrick, thus securing it to the bay, which was used as a rudder. As the tow came inshore it was handed over to the tug, which took it ashore, where a winch truck took it over, and hauled the end up to its final position.

The offshore blank flange was removed, and the offshore end then sank in some 35 ft. of water; the inshore stopcock was then opened, letting the air out and more water in; the whole pipe then lay on the bottom. Anchorages had already been prepared, and some laid; they consisted of half-ton cast iron sinkers and concrete blocks. These were then connected to the pipe with chain from the F.B.E. bay in shallow water, and by an officer with an aqua lung in deeper water. The seaward end of the pipe was connected to a buoy, so that a tanker can lift the end and connect to its own discharge manifold.

The work was completed on 29th September, having taken just a week.

Other Works

Other tasks in this project, carried out by the remaining troop of the second Field Squadron, included the construction of an overhead bowser-filling point, fed by gravity from a dispense tank sited on a 6 in. reinforced concrete slab on top of a convenient sand dune. This tank was filled by an electric pump, and an electrical system to supply the pump and for lighting of the whole farm was installed. A security fence was built around the whole installation. The whole project was finished up to schedule on 10th October, and handed over next day to the R.A.S.C., whose task it was to operate it. The first tanker came in to discharge very soon afterwards.

Comment

This was an interesting, unusual and satisfying project, demanding initiative and common sense. The technical skill required was within the capacity of a Field Engineer Regiment, although it would have been impossible to make a good job of the tanks without expert advice.

As usual in a rush job, the bottleneck was the provision of stores. A special organization to deal with this is essential. Where the correct stores could not be provided in time, there was ample scope for improvisation; here the resources of the Field Park Squadron proved most valuable, especially the workshop troop. Nearly every engineering job requires plant of some sort, and an efficient plant troop proved of great value.

The planning of the project had been very rushed and modifications to the plan as the work proceeded caused some delay. If pressure to get work started could have been resisted a few days longer, the completion date of the whole project might well have been advanced.

A Field Engineer Regiment is at its most efficient when its normal chain of command and organization is maintained, with specific tasks allotted to each squadron, troop and section. Task work produces the quickest results, but is only possible if the job has been properly planned and the supply of stores and materials is assured.

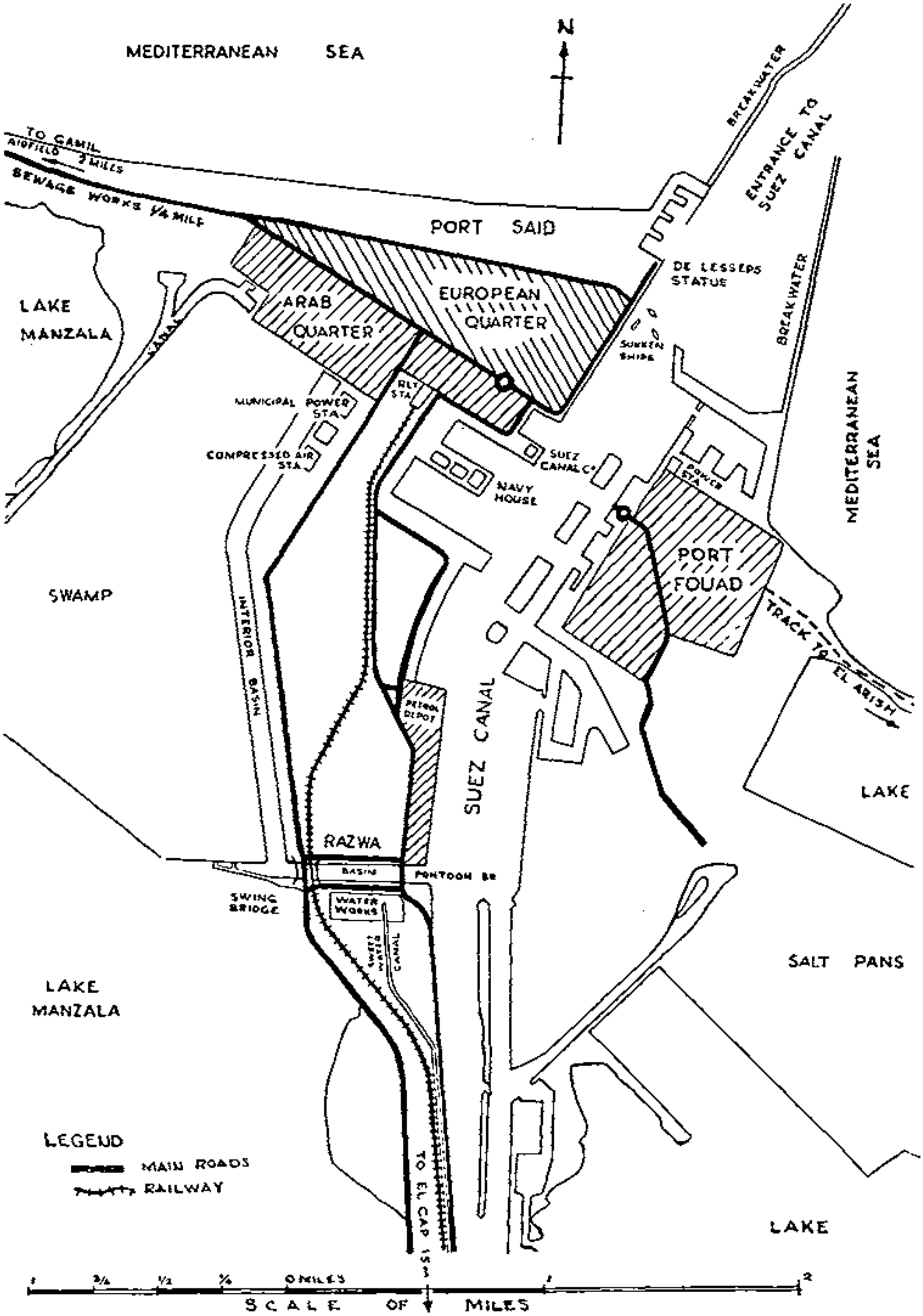
Operation "Musketeer"

Introduction

While work at Akrotiri was being pressed forward, it was evident that matters were coming to a head in the Suez crisis. The Regiment had not been warned for any operation, but being stationed in the nearest British garrison to Port Said, it was clear our services might suddenly be required.

Official word that we were to prepare for operations was not received until 28th October, and the Regiment was put at twenty-four hours notice to embark. Five days later, after a hectic period of "mobilization" including the reception of men, vehicles, and equipment to bring us from L.E. to H.E., Regimental Headquarters, one field squadron and a troop of a second field squadron, embarked for Port Said. The rest of the regiment stood by at Limassol at twenty-four hours' notice.

MAP OF PORT SAID



The Order of Battle

The first engineer troops to arrive at Port Said, other than transportation units, were something of a mixed bag, and comprised the following:—

An Airborne Field Squadron.

Regimental H.Q., one Field Squadron and one troop from "X" Field Engineer Regiment.

One Field Squadron from another Regiment.

One E.M. Squadron.

One Stores Recognition troop

Detachment of an Airfield Construction Squadron.

All these, with the exception of the Airborne Field Squadron, came under the command of "X" Field Engineer Regiment on landing, the C.O. assuming the duties of C.R.E. Port Said. It was intended that the remainder of "X" Field Engineer Regiment should follow from Cyprus in the second lift three or four days later. But in the event they were all turned back after embarking, with the exception of the Stores Troop of the Field Park Squadron, which duly arrived in Port Said.

Tasks Allotted

The following were the tasks envisaged for the Regiment before the operation started, in order of priority:—

(*a*) The construction of a class 60 E.W.B.P.B. across the interior basin, should the Razwa swing bridge be demolished.

(*b*) The setting up of water points.

(*c*) The repair and operation of public utilities.

(*d*) Repairs to El Gamil airfield.

(*e*) Unloading of engineer stores and the setting up of an engineer stores dump.

The Arrival

The engineer troops referred to above arrived off Port Said in various ships on the afternnon of 6th November and started disembarking on that day in various unorthodox ways. In the Key Plan the Railway Station area had been allotted to the Engineers. At the time of landing, this area had not yet been cleared of snipers, so temporary billets were found in the N.E. corner of the town.

Vehicles, with G.1098 equipment, were in various L.S.Ts. and M.T. ships, and because of congestion at the few available berths, they could not be got ashore for several days. Sufficient vehicles for essential needs were requisitioned. But lack of equipment was a severe handicap, and the need to discover "engineer resources" in the town soon impressed itself upon all ranks.

Engineer stores for the allotted tasks had been loaded in Cyprus into cargo ships. They too arrived off Port Said on 6th November, but again lack of berths prevented these being unloaded for several days. Fortunately the bulk of the engineer stores were not required at once, but there was an acute shortage of defence stores.

Reconnaissance

The first problem was to get information about the engineer situation in the town with special reference to the tasks forecast. General information with regard to these tasks had been issued before the operation, but no one could foretell the damage caused by our own forces or by Egyptian sabotage, neglect or mismanagement.

As a result of reports from various reconnaissance parties, it was known by midday 7th November that:—

(*a*) Razwa swing bridge had been captured intact by the French, and was undamaged, except that the wooden decking was not standing up well to the passage of tanks.

(*b*) The Cl. 9 pontoon bridge at Razwa had been damaged and was unusable.

(*c*) Gamil airfield was virtually undamaged.

(*d*) The water works had been captured intact by the French paratroops, and could soon be got going. But the distribution system had suffered a good deal of damage, and many roads were flooded.

(*e*) Both the Port Fouad and Port Said power stations were undamaged, but the electrical distribution system in Port Said town had suffered considerable damage, especially to overhead lines and transformer stations. Sufficient staff remained at the Port Fouad power station to get it running without military assistance.

(*f*) Direct hits by bombs and rockets had reduced the sewage pumping plant to a shambles.

It was therefore evident that the main engineer effort would have to go into the repair and operation of the public utilities. To understand the work carried out by the engineers, a brief description of the public utilities is necessary.

Water

All fresh water for the 200,000 inhabitants of Port Said (including Port Fouad) comes from the Nile, flowing by gravity in the Sweet Water Canal. This canal crosses the desert from the Nile valley to Kantara, where it turns and runs alongside the Suez Canal. It terminates at the water works at Razwa, where the water is purified and pumped under pressure through ring mains to all parts of the town. Power for the water works is supplied from the power station in Port Fouad, though standby generators exist at Razwa.

The whole of the water supply installation had been operated by the Suez Canal Company until the time of its nationalization by Nasser. After nationalization, an Egyptian official had been placed in charge. Under his charge, the installations had been kept going, sufficient of the old Suez Canal Company's employees remaining to achieve this. But maintenance work had suffered, particularly the routine clearance of weeds from the Sweet Water Canal.

The distribution system had suffered two or three major breaks in the ring main as a result of the battle, and there were a great number of broken feeder pipes, especially those leading into buildings which had been damaged by fire, shelling and bombing.

Electricity

Port Said is served by two power stations, one in Port Said itself, and one in Port Fouad. The Port Fouad installation is a modern power station, built and operated by the Suez Canal Co., to supply the whole of Port Fouad, the dock installations on both sides of the canal, and the water works. The Port Said installation, a much older one, is run by the Port Said Municipality and serves Port Said town. To a limited extent, the two systems can be interconnected, to enable the east end of Port Said town to be supplied from the Port Fouad station.

Neither of these power stations suffered any damage in the battle. At Port Fouad a skeleton staff composed mostly of French and Greeks, had remained at their posts.

The distribution system from the Port Fouad station was virtually undamaged. In Port Said itself, however, a great deal of damage had been caused. The power from the station is distributed at high voltage to street transformers, situated at various points in the town. Many of the high-tension lines had been damaged by bombing, and the Egyptians had done their best to sabotage the transformers.

Sewage

Port Said has an extensive water-borne sewage system, ending in an up-to-date sewage farm near Gamil airfield. Lack of any natural fall necessitates pumping, and in most cases this pumping is done by compressed air generated at the municipal compressed air station. This station had received direct hits from bombs and rockets. The sewers themselves were undamaged, except for a few minor breaks. The sewage farm itself was intact. The whole of the sewage system was under the control of the municipality.

Initial Allotment of Tasks

From the information obtained as a result of reconnaissance, the C.R.E. allotted tasks as follows on 7th November:—

(*a*) E.M. Squadron (i) One troop to take over the water works and get them running. (ii) One troop to take over the municipal power station and start repairing the distribution system.

(*b*) "Y" Field Squadron (i) Clearance of mines, U.X.B. and booby traps from the beaches and Gamil airfield. (ii) Debris clearance at the compressed air pumping station. (iii) Maintenance of Razwa swing bridge. (iv) Patrols to detect breaks in the water distribution system, and to isolate them.

(*c*) "Z" Field Squadron (i) Clearance of obstructions on the quays so as to speed up disembarkation and off-loading of stores. (ii) to supply guards required on certain vital points (e.g. the telephone exchange).

The Airborne Field Squadron in addition to supporting their own brigade assisted by repairing the road to the airfield, which had been cratered, and by frequently reporting on the condition of the Sweet Water Canal.

Considerable difficulty was encountered in tracing the Egyptian authorities responsible for public utilities. Former French and Greek officials and employees of the Suez Canal Company came forward at once, and offered their services at the Port Fouad power station and the water works. It was at once clear that these officials, having been deprived of authority as a result of nationalization, did not command the support of their Egyptian subordinates. If things were to be got going quickly, and Egyptian technicians and labourers obtained, we should have to work through Nasser's men. Accordingly their co-operation was sought by the C.R.E., and gradually they responded to firm but kind treatment. The officials of the Suez Canal Company obligingly stepped down.

Tasks 9th–16th November

By 9th November sufficent civilian staff had been assembled at the Water Works to keep them running. But they needed support and protection. One troop of "Z" Field Squadron was put into the water works, so relieving the troop of the E.M. Squadron, who became responsible for getting the sewage working. The civilian staff at Port Fouad power station likewise required support and protection and the Field Squadron took over this commitment as well.

On 9th November the Railway Station was reported secure, and the Regiment moved in that day, occupying the station itself and three school buildings adjacent to it as barrack blocks. "Z" Field Squadron were given the task of getting a train running, and in the event this proved a very wise measure.

On 11th November the ships containing engineer stores were berthed and "Z" Field Squadron provided unloading parties each day thereafter. A further task was the clearance of debris from streets, and the pulling down of unsafe buildings in the town, and this work was carried out by "Y" Field Squadron over the next few days.

This distribution of work continued for a week. Other tasks which had to be carried out during this period were:

(*a*) Construction of water points for units who had not access to the mains.

(*b*) Clearance of debris from the Sweet Water Canal.

(*c*) Shoring up of unsafe buildings used as billets by the allies.

(*d*) Running ambulance trains to and from El Cap.

(*e*) Site preparation and wiring of an ammunition depot and P.O.W. cage.

(*f*) Setting up an engineer stores dump in the Railway goods yard.

By 16th November there had arrived in Port Said:—

One Corps Engineer Regiment.

C.R.E. of an Infantry Division.

C.R.E. Works and Staff.

It had been decided that troops of "X" Field Engineer Regiment proper should return to Cyprus on 17th November. The C.O. accordingly handed over his duties to the C.R.E. Works on 16th November and units remaining behind were redeployed under the two Cs.R.E.

Lessons from the Operation

The Engineer troops under C.R.E. were just sufficient for the tasks which had to be done. If we had had to build a Cl. 60 E.W.B.P.B. over the interior basin, or if the water works or power station had suffered serious damage, the troops immediately available would have been quite inadequate, and there would have been great delay in getting the public utilities going, possibly with serious results.

The E.M. Squadron composed entirely of reservists, and without their tools or equipment, did magnificent work in restoring the public utilities, and appeared to be the ideal type of unit for this type of task. Field Squadrons once more showed their adaptability.

The importance of good reconnaissance in this type of operation, as in any other, cannot be too highly stressed.

If the C.R.E. is to exercise proper control, good communications are essential. Engineers must be ready to provide their own in the early stages.

Conclusion

It may well be that, in any future war, a Field Engineer Regiment will have to undertake projects of a general engineering nature as frequently as conventional field engineering tasks. The Field Engineer Regiment of today, with its own elements of plant, workshops and stores in the Field Park Squadron, is a powerful organization, well able to do so. Unusual tasks, such as these described above, unearth a good deal of hidden talent, especially among National Servicemen, many of whom have useful knowledge and experience in the building trades.

To carry out a works project to a set date can, therefore, be good training for war, particularly if task work can be adopted, since time is usually an overriding factor in war. Full training value is only obtained if the normal regimental organization and chain of command are maintained, and if the work is properly planned. Proper reconnaissance and planning are as important in this type of work as in any other military operation. It is a mistake to think that to deploy troops on to a job in a rush will necessarily advance the completion date. A little extra time spent on planning and preparation will usually be repaid by quicker completion.

Lack of stores is the biggest single cause of lack of progress in any engineering task carried out by troop labour. At every level there must be an officer or senior N.C.O. detailed specifically to get stores to the site at the right time.

In peacetime, works tasks are popular with the troops, who derive from them a sense of real achievement. But such tasks do demand the whole efforts of the officers and men employed on them to the detriment of their military skill. No squadron should be employed on them for more than three or four months at a time, to be followed by an equal period of training in military and field engineering subjects.

The wide diversity of tasks described in this article, and carried out by one Field Engineer Regiment in the period of a few months, shows that the traditional versatility of the Royal Engineers can still be relied upon.

Prestressed Strain Gauges for Quick Determination of Safe Loads on Bridges

By Brigadier R. A. G. Binny, O.B.E., B.A., M.I.C.E. and
Major J. P. Fitzgerald-Smith, B.Eng., A.M.I.C.E., R.E.

Introduction

The problem posed was to devise a quick and simple method of assessing the military load classification of a bridge, working to any desired factor of safety, with a view to:—

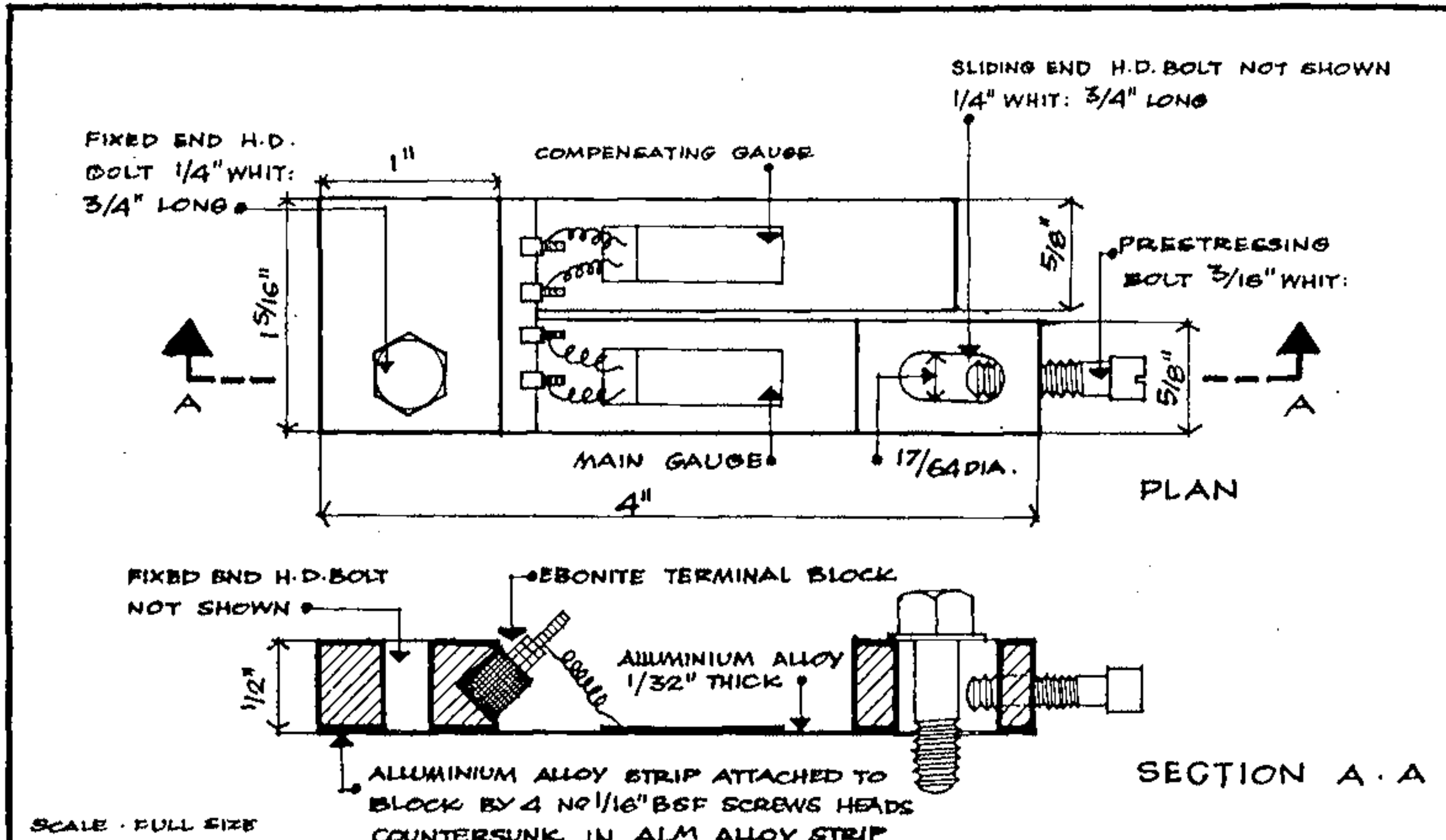
(*a*) classifying bridges for military loads in normal circumstances

(*b*) upgrading the classification of a bridge with a reduced factor of safety as an operational necessity in war.

A strain gauge analysis appeared an attractive method, in that, provided the gauges were placed at critical points, then the actual stresses set up by different classes of vehicle could be assessed. It would then be possible, in war, to increase the bridge classification up to such a figure as would impose the maximum stress considered desirable at the weakest point.

For any such system to have a practical application in the field it must be simple, quick and independent of the weather. Furthermore, the tests must be capable of being carried out by comparatively unskilled personnel.

Strain gauges are extremely difficult to stick on, unless the operator is experienced at the task. Furthermore, the drying out and subsequent waterproofing require fine weather and drying equipment.



PRESTRESSED STRAIN GAUGE ADAPTOR

FIG. 1.

It was, therefore, decided to employ gauges previously stuck on to an adaptor in the laboratory, the complete strain gauge adaptor being issued to the user. The problem here was to devise an adaptor which could be screwed on to the bridge under service conditions, and yet have no play in the screwed connexions etc. which would nullify the small movements which require to be recorded in order to read strain measurements. Such an adaptor was devised by the authors. The design is shown in Figure 1.

This problem was solved by sticking the strain gauges on to an aluminium alloy strip, which was pre-stressed in tension between holding-down bolts. Photographs showing the gauges in use are shown in this paper.

A compensating gauge was located on an unstressed strip lying alongside the pre-stressed main gauge. The idea behind the pre-stressing being to take up all play in the holding-down bolts, etc. If a compression member is under test, it is of course essential to give the gauge sufficient tensile pre-stress initially for it to retain some tensile pre-stress on the application of the test load. Conversely, if a tension member is under test, care must be taken to avoid stressing the aluminium strip beyond the elastic limit. The choice of aluminium alloy with a low value of Youngs Modulus is thus an advantage.

Before discussing the general method employed, a word on military bridge classification.

All military vehicles are classified by a number e.g. "Class 70". This denotes that that particular vehicle imposes a certain maximum bending moment and shear on any particular simply supported span, due allowance being made for impact. Normally Bending is the deciding factor. For example a Class 70 vehicle imposes a maximum bending moment of 847 ft.-tons on a 50-ft. simply supported span. Fairly obviously a "Class 70" bridge will take vehicles up to and including Class 70.

Since these tests were carried out the classification of bridges has been revised. The nomogram shown in Fig. 2 would accordingly have to be altered to agree with the new EUDDL tables when published. The method described in the following pages refers to the determination of maximum bending moments; but by selecting the position of the gauges the effect of maximum shear could equally well be determined. The calculations of these stresses, however, by normal methods presents little difficulty.

The general principles of the method adopted for classifying bridges, using pre-stressed strain gauge adaptors is given below.

A track vehicle such as a tank, or crawler tractor, is passed over the span in question in bounds of its own track length, the strain being recorded on the strain gauges at critical points for each successive bound. The critical points chosen can be either critical points for bending or for shear. The sum of the strains so recorded at each critical point gives the total strain, and hence the stress, imposed at that point for a uniformly distributed load equal to:—

$$\frac{\text{Wt. of track vehicle} \times \text{span}}{\text{length of track base}}$$

If the dead-weight of the span is then calculated, or estimated, then, simple proportion will give the stress set up at the critical points by the dead-weight of the span i.e. the permanent stresses due to the dead load.

The maximum single strain reading is then recorded. This reading, together with the previously found stress due to the dead load, enables a calculation to be made for the weight of a mythical track vehicle, of the same track

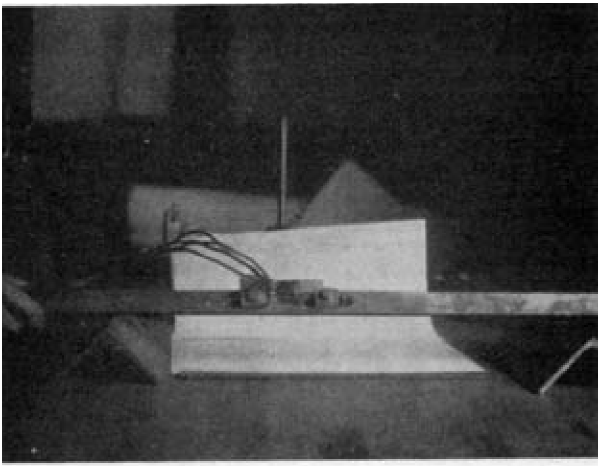


Photo 1.—Strain gauge adaptor.

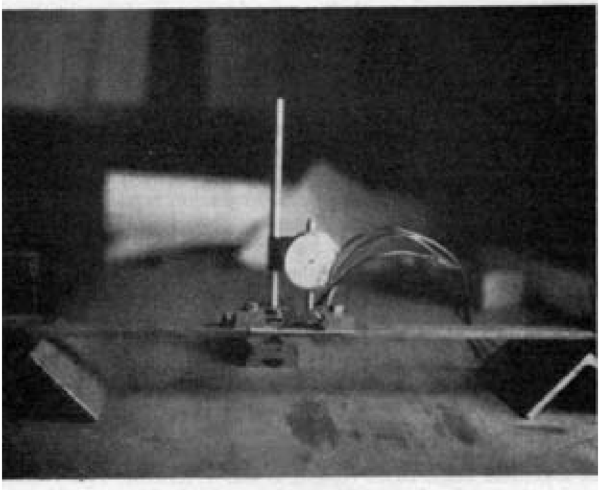


Photo 2.—The test rig.

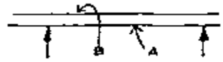
Prestressed Strain Gauges 1 , 2

Fig. 2.

BRIDGE CLASSIFICATION USING PRE-STRESSED STRAIN GAUGES

1. DESCRIPTION OF BRIDGE AND SKETCH SHOWING POSITION A B ETC OF GAUGES

Third bay of West Viaduct to Havengore Bridge 2 No 16×6 RSJ main girders, continuous over 25' spans. Trough flooring



G is placed on underside of troughing in the centre at mid-span

2 TRACK VEHICLE USED FOR TESTS MD10 without Blade

3 SYMBOLS & VALUES :—

WT OF TEST VEHICLE = W = 9·6 TONS : SPAN OF BRIDGE = L = 25 FT

TRACK LENGTH = ℓ = 6·4 FT : DEAD WT OF SPAN = Wd = 10 TONS

MAX PERMISSABLE STRESS = p = 8 TON/□": E FOR BRIDGE MATERIAL 13500 TONS/□"

N = L/ℓ TO NEAREST WHOLE NUMBER BELOW = 4

No OF TIMES TEST VEHICLE PASSED OVER = n = 2

$\overline{W}$ = n.N.W = 2×4×9·6 = 77

4 READINGS :—

DIAL READINGS	POSITIONS OF GAUGES				REMARKS
	A	B	C	D	
	·0025	·0015	0		
	·0073	·0026	·0066		
	·0073	·0040	·0066		
	·0025	·0015	0		
	·0025	·0015	0		
	·0073	·0026	·0077		
	·0073	·0040	·0070		
	·0025	·0015	0		
Σ∈	·0392				
∈ MAX	·0083	·0047	·009		
IMPACT FACTOR = f	1·5	1·5	1·5	1·	
DISTRIBUTION FACTOR = d	1·5	1·5	1·0	1·	
f.d. ∈MAX	·0187		·0135		

CONSIDER ONLY MAX. VALUE OF Σ∈ AND ∈MAX

5. $M = \frac{100W}{E f d \in_{MAX}}\left[p - \frac{E \Sigma \in Wd}{100 \overline{W}}\right]$

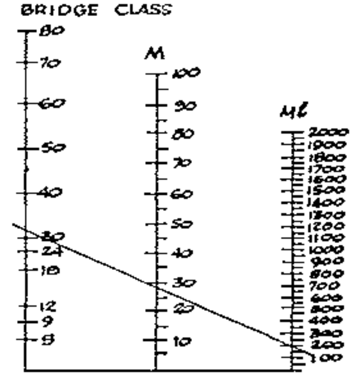
$= \frac{9{\cdot}6}{135 \times 0{\cdot}0187}\left[8 - \frac{135 \times 0{\cdot}0392 \times 10}{77}\right]$

$= 28$

$M\ell = 160$

6. ALIGN M AND Mℓ ON NOMOGRAM AND EXTEND TO CUT CLASSIFICATION

7. BRIDGE CLASSIFICATION · CLASS 30



BRIDGE CLASSIFICATION ON USING PRESTRESSED STRAIN GAUGE

1. DESCRIPTION OF BRIDGE AND SKETCH SHOWING POSITION A B etc OF GAUGES

Havengore Bridge, Bascule span of 50ft

Only one gauge placed centrally on top flange of one of main girders

2 TRACK VEHICLE USED FOR TESTS H.D.10 without blade

3 SYMBOLS + VALUES

WT OF TEST VEHICLE = W = 9·6 TONS : SPAN OF BRIDGE = L = 56 Ft

TRACK LENGTH = ℓ = 6·4 FT : DEAD WT OF SPAN = Wd = 25 TONS

MAX·PERMISSABLE STRESS = p = 8 TON/□": E. FOR BRIDGE MATERIAL = 15500 TONS/□"

N = L/ℓ TO NEAREST WHOLE NUMBER = 8

No OF TIMES TEST VEHICLE PASSED OVER = n = 1

$\overline{W}$ = n N W = 77

4 READING :—

DIAL READINGS	POSITION OF GAUGES				REMARKS
	A	B	C	D	
∈1	·0025				
∈2	·0055				
∈3	·0060				
∈4	·0087				
	·0062				
	·0060				
	·0020				
Σ∈	·0439				
∈ MAX	·0067				
IMPACT FACTOR f	1·5	1·	1·	1·	
DISTRIBUTION FACTOR = d	1·5	1·	1·	1·	
f d · ∈MAX	·0195				

CONSIDER ONLY MAX VALUE OF Σ∈ AND ∈MAX

5. $M = \frac{100W}{E f d \in_{MAX}}\left[p - \frac{E \Sigma \in Wd}{100 \overline{W}}\right]$

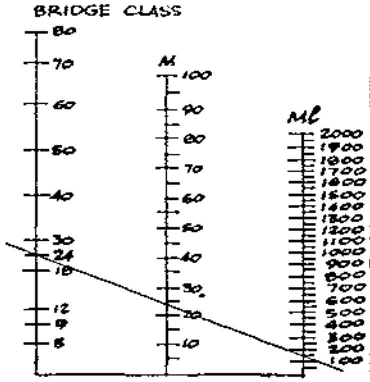
$= \frac{9{\cdot}6}{155 \times 0{\cdot}0195}\left[8 - \frac{155 \times 0{\cdot}0439 \times 25}{77}\right]$

$= 22$

$M\ell = 140$

6. ALIGN M AND Mℓ ON NOMOGRAM AND EXTEND TO CUT CLASSIFICATION

7. BRIDGE CLASSIFICATION CLASS 22



length as the test vehicle, which, when crossing the span, will impose a stress of p tons per sq. in. at the critical point. Where p tons per sq. in. is the maximum permissible stress previously decided upon, the value of p depends on:—

(*a*) The Bridge material.

(*b*) The condition of the bridge.

(*c*) The factor of safety to which it is desired to work.

It is now known that this mythical track vehicle is the heaviest vehicle, of its type, which can cross the bridge. The equivalent classification of this mythical vehicle can then be deduced from a nomogram, thus giving the classification of the bridge.

All this sounds complicated, but the whole procedure can be boiled down to recording the readings on a proforma, substituting values in a simple formula and finally using a simple nomogram in order to arrive at the bridge classification.

Before going into the details of the above outline theory it is probably better to describe the equipment used, together with the series of tests which were done on the strain gauge adaptors, in order to test their accuracy.

Details of Equipment and Tests

A strain gauge, bridge type, 4907S, was purchased from H. Tinsley & Co. Ltd., together with an Apex Unit for dealing with several gauge circuits. The Apex Unit was soon discarded. The connecting up of the gauges took a long time and would have made any bridge look more like a laboratory than a military operation. Furthermore, in order to avoid excessive voltage drop in the circuits, fairly substantial leads had to be employed. There was also the liability of errors in recording readings. It was, therefore, decided to work on the principle of one gauge at a time.

The aluminium alloy strips were sent to H. Tinsley & Co. Ltd., who fixed on and waterproofed strain gauges of 100 ohms resistance and gauge factor of 2:1.

A drawing of the strain gauge adaptor is shown at Fig. 1 and is self explanatory. See also Photo 1. The best method of applying the pre-stress to the gauge and finally tightening down the holding-down bolts was found to be as follows:—

(*a*) Screw down both holding-down bolts hand tight.

(*b*) Tighten up the pre-stressing screw slightly, in order to take up the slack in the fixed end H.D. Bolt.

(*c*) Tighten fixed end H.D. Bolt.

(*d*) Tighten sliding end H.D. Bolt.

Note: Owing to the eccentricity of the pre-stressing bolt to the line of the aluminium strip, the action of tightening the sliding end H.D. Bolt applies the bulk of the pre-stress. It is, therefore, sometimes found that the initial tightening of the pre-stressing bolt in (*b*) above has been excessive.

Several tests were done in the workshops to ascertain the accuracy of the adaptor. These are described below:—

Test I

1. Using 1 in. × ¼ in. × 4 ft. M.S. bar. Adaptor fixed centrally. Knife edge rests at varying spans (*L*), with loads (*W*) placed outside the rests, and at varying distances (*d*) from them. The test rig is shown in Photo 2.

2. Provided the curvature is small:—

Calculated % strain = ε calc = $4.\delta.\ h\ 100/L^2$

where:—

δ in. = deflection measured by dial gauge

h in. = thickness of bar

L in. = distance between knife rests

In this case h = 0.257 in.

$\therefore$ ε calc. = $102.3\delta/L^2$

3. Assessment of maximum error due to circumstances outside the control of the apparatus.

$$\varepsilon = 4\ \delta\ h\ 100/L^2$$

Logging and differentiating

$$\frac{d\,\varepsilon}{\varepsilon} = \frac{d\,\delta}{\delta} + \frac{d\,h}{h} - \frac{2\,d\,L}{L}$$

Assuming

δ could not be measured to better $\pm$ 0.005

L ,, ,, ,, ,, ,, ,, $\pm$ 1/16 in.

h ,, ,, ,, ,, ,, ,, $\pm$ 0.001 in.

It is then possible to calculate the maximum error due to circumstances outside the control of the instrument. These errors are shown in the tables of results given below.

Test No.	L	d	δ in 1/1000 in.	$\varepsilon_{calc.}$	ε dial		% error		Max % error not due to Instrument	Remarks
					gauge on top	gauge on bottom	top	bottom		
1	12	3	12	.0086	.0082	.0082	− 4.6	− 4.6	5.2	Gauge loosened and given a new pre-stress on change of position
2		6	20	.014	.0135	.1138	− 3.6	− 1.45	3.5	
3	18	3	26	.0082	.0078	.0082	− 4.9	± 0	2.6	
4		6	44	.014	.0135	.0135	− 3.6	− 3.6	1.8	
5	24	3	41	.0073	.0073	.0073	± 0	± 0	1.7	
6		6	80	.014	.014	.013	± 0	− 7	1.1	
7	30	3	68	.0078	.0078	.008	± 0	+ 2.5	1.2	
8	36	3	96	.0076	.0075	.0075	− 1.3	− 1.3	0.9	

4. Conclusions.

(*a*) The results, with the exception of test No. 6, gauge on bottom, are well within the order of accuracy required.

Test II

These tests were carried out on R.S.Js. resting on knife edge rests. The adaptor was placed centrally on the bottom flange. A load (W) was placed centrally and the % strain (ε) recorded.

The pre-stress was released after each reading, and re-applied.

$$\text{Calculated } BM = WL/4$$

$$\text{Recorded } BM = fZ = \frac{\varepsilon}{100} E\ Z$$

Serial No	L in.	Z	W ton	BM calc.	ε	BM Recorded	% Error
1	120	5.47	0.155	4.65	.0063	4.65	± 0%
2	96	5.47	0.155	3.72	.0051	3.76	1.08%
3	72	5.47	0.155	2.78	.0038	2.81	1.08%
4	120	22.42	.0695	20.8	.0069	20.8	± 0%

Note: The strains imposed on the beams in Serials 2 and 3 were very small.

Test III

In this test a 5 in. × 3 in. × 11 lb. R.S.J., over a 10-ft. span was used. The adaptor was placed centrally on the bottom flange. The load, of weight 0.155 ton, was rectangular in shape, and was moved across the beam in bounds of its own length, emulating the movements of a tank or other tracked vehicle as explained earlier.

w = weight of block in tons
L = span in feet
l = length of block in feet
$\varepsilon_1\ \varepsilon_2$ etc. = dial readings of % strain at each bound
$\Sigma\, \varepsilon$ = sum of individual dial readings

Total distributed load $= wL/l$ tons.

A stress $E\, \Sigma\, \varepsilon/100$ is caused by a EUDDL of wL/l tons

∴ a stress p tons/sq. in. is caused by a EUDDL of $\dfrac{w\, L\, p\, 100}{l.\ E.\ \Sigma.\ \varepsilon}$

Readings $\varepsilon_1 = 0.0009$ $\quad w = 0.155$ tons
$\varepsilon_2 = 0.0022$ $\quad L = 10$ ft.
etc. 0.0040 $\quad l = 1.25$ ft.
0.0055
0.006
0.004
0.0021
0.0009

$\Sigma\, \varepsilon = 0.0256$

∴ at a max. permissible fibre stress of 8 tons/sq. in.

$$\text{EUDDL} = \frac{0.155 \times 10 \times 8 \times 100}{1.25 \times 13500 \times 0.0256}$$
$$= 2.88 \text{ tons}$$

EUDDL ex. steel handbook for R.S.J. in question
= 2.9 tons
% error = 0.07 %

It was found necessary in all tests to apply the load several times in order to bed the adaptor down. Two or three applications only were necessary before the galvanometer zeroed satisfactorily.

Conclusions on the Preliminary Tests

In view of the fact that the adaptor was removed between each test and then reset, it would appear that it is satisfactory and that its accuracy is well within the requirements.

Calculations and Procedure

Symbols:—

W	=	Weight of test vehicle—tons
L	=	Span under consideration—feet
l	=	Track length—feet
W_d	=	Total dead-weight of span—tons
n	=	Number of runs made by test vehicle
N	=	Number of positions of test vehicle—single run
$\overline{W}$	=	$n.N\ W$
$\Sigma\varepsilon$	=	Sum of % strain readings
$\varepsilon_{max.}$	=	Maximum % strain readings
p	=	Maximum permissible stress on bridge—tons/sq. in.
fd	=	Stress caused by dead load of bridge
E	=	Youngs Modulus for bridge material—tons/sq. in.
f	=	Impact factor
d	=	Distribution factor

1. Owing to the fact that it is only rarely that the span is a direct multiple of the track length, take:—

$N = L/l$ to the nearest whole number,

e.g. if $L = 27$ ft. and $l = 6$ ft., take $N = 4$, and disregard the 1.5 ft. at each end of the span. Similarly if L/l were to equal 3.9 take $N = 4$ and give a small overlap to the vehicle in its bounds across the bridge.

2. Test track vehicles likely to be available are not always symmetrically loaded. If a high order of accuracy is required, the test vehicle should be passed over the bridge once in each direction, i.e. $n = 2$.

Thus, total EUDDL set up by test vehicle $= nNW = \overline{W}$.

3. To find the stresses due to the dead weight of the bridge, at any critical point at which a strain gauge has been fixed.

A distributed load of $\overline{W}$ causes a stress $\Sigma\varepsilon.\ E/100$

$\therefore$ " " " W_d " " " $\dfrac{\Sigma\varepsilon.\ E.\ W_d}{100\ \overline{W}}$

i.e. stress caused by dead load $= \Sigma\varepsilon.\ E.\ W_d/100\overline{W} = f_d$ (1)

4. To find the weight, M tons, of a mythical track vehicle of track length l ft., which causes a total stress of p tons/sq. in. at the critical point in question.

Consider W at position where ε max. is obtained

$\varepsilon_{max.}\ E/100$ is stress caused by W

$\therefore p - f_d$ " " " " $100\ W\ (p - f_d)/\varepsilon_{max.}\ E.$

$\therefore M = 100\ W\ (p - f_d)/\varepsilon_{max.}\ E.$ (2)

Substituting in (2) for value of f_d from (1)

$$M = \frac{100\ W}{\varepsilon_{max.}\ E}\left[p - \frac{E.\ \Sigma\epsilon\ W_d}{100\ \overline{W}}\right] \qquad (3)$$

This mythical tank of weight M and track length l is the heaviest tank of that track length that can cross the span without stressing the critical point in question beyond p ton/sq. in.

This formula is applied to the weakest critical point, i.e. the point which gives the minimum value of M. All that remains to be done is to classify a tank weighing M tons and track length l, in order to arrive at the classification of the bridge.

Two further points have however to be taken into consideration:

(*a*) Impact factor. This necessitates multiplying the value of $\varepsilon_{max.}$ by the impact factor in the form of, say, 1.25, for a 25 per cent impact factor.

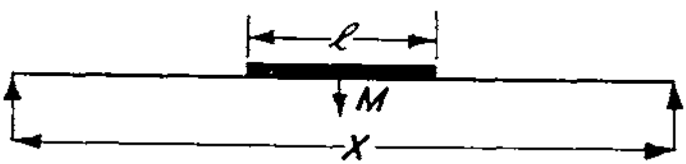
(*b*) Distribution factor. i.e. The factor which must be applied in order to take up for the extra stresses set up by a vehicle crossing the span off the centre line. This can either be done by multiplying $\varepsilon_{max.}$ by a distribution factor (*d*), or by automatic inclusion by crossing the test vehicle the desired amount off the centre line.

The final equation for *M* now reads:—

$$M = \frac{100\ W}{E f d\, \varepsilon_{max.}} \left[\frac{p - E\ \Sigma\varepsilon\ W_d}{100\ \overline{W}}\right]$$

5. To classify the mythical track vehicle of weight *M* and track length *l*, which then gives the classification of the bridge.

As stated earlier, the militiary load classification of a vehicle depends on the maximum bending moment the vehicle imposes on a simply supported span, thus:—



Classification No. — $BM._{max.} = \frac{Mx}{4} - \frac{Ml}{8}$

A simple nomogram gives the $B.M._{max.}$, and hence the classification.

6. Fig. 2 shows the *pro forma*, which includes the nomogram. The procedure for classifying a span of a bridge is then as follows:—

(*a*) Select the critical points, and fix the strain gauge adaptors at these points.

(*b*) Fill in the relevant detail at the beginning of the *pro forma.*

(*c*) Pass the test vehicle over the bridge the requisite number of times for each gauge, recording values of ε and $\varepsilon_{max.}$

(*d*) Calculate the maximum value of "*M*", and derive the classification from the nomogram.

7. This procedure was carried out on the steel bascule bridge joining Foulness Island to the mainland. This bridge is in a poor state of repair, and its correct classification had been open to doubt for a considerable period. An attempt to classify the bridge by analytical methods was lengthy and involved a host of assumptions, which left the result open to question. It is of interest to note that the result obtained within an hour or so by the methods described in this paper compared favourably with the analytical solution mentioned above, which was only arrived at after days of labour. It was in fact the desire to ascertain the strength of this bridge which led in the first place to the development of the methods described in this paper. Photo 3 shows the equipment in use.

Photo 3.—Equipment in use on bridge.

Photo 3.—Equipment in use on bridge.

Classification of Havengore Bridge

General Description

A steel bascule bridge of clear span 56 ft., approached on either side by viaducts consisting of 25 ft. span bays of continuous R.S.J. construction.

The bridge is in a bad state of repair and vibration is considerable.

The Bascule Span

Main girders, 2 No. plate girders, 44 in. deep, span 56 ft. Transoms and decking. Very much stronger than the approach decking.

The Approach Spans

East approach span, 24 bays of 25 ft.

West approach span, 10 bays of 25 ft.

The main girders of each bay consist of 2 No. 25 ft. × 16 in. × 6 in. × 62 lb. R.S.Js. at 12 ft. 6 in. centres, bolted with fish plates on the webs, to the neighbouring span joists. The R.S.Js. are supported at span points by piles, which deflect under load, recovering their original position after the load has passed.

The degree of continuity is uncertain. The roadway is supported by steel troughing $\frac{5}{16}$ in. thick and 6 in. deep, resting directly on the R.S.Js. There is 8 in. of tar macadam on top. The *proformae* for the tests on one approach span and the main span are attached, see Fig. 2.

The holes for the H.D. bolts were drilled and tapped before the tests were carried out. This was for convenience, and took thirty-five minutes. The actual tests were carried out, during a windy, cold day, with occasional showers of rain, in half an hour. The bridge was opened for traffic during the changing of positions of the adaptors. The only snag struck was that there was such vibration on the main span from the engine of the H.D.10, that the engine had to be stopped during readings, this resulted in the battery "dying" after the last reading had been taken. The readings show that the critical span is the main one, and the bridge is classified as Class 22. However, heavier loads could cross the bridge under engineer supervision, provided that the vehicle was kept to the centre line of the bridge. Using a distribution factor of 1.1, the classification of the main span is upgraded to Class 30.

Prior to these tests, the bridge was classified as Class 20. Since reclassification, a Class 25 load has successfully crossed the bridge, and pressure is being brought to bear on the C.R.E. to permit the passage of a Class 30 vehicle. This he is quite prepared to do, but the vehicle in question has not yet put in an appearance.

Conclusions

It is admitted that this paper has dealt mostly with steel bridges, it is however applicable to all types of construction, in that the methods classify the heaviest vehicle that can cross the bridge, and are not concerned with the degree of fixation in any particular member. Provided therefore that it is found possible to fix the adaptors to any type of material, it is then possible to produce an answer. This is by no means an unsurmountable problem, and designs are already in hand for concrete and timber.

A criticism which has been levelled at the methods described in this paper, is that it necessitates drilling ¼-in. diameter holes in the steel work, or some similar fixing hole in concrete. These at critical points.

It is admitted that from aesthetic considerations these holes will cause a blemish in the structure. There is no reason, however, that they should cause a permanent weakening in strength of the bridge.

The test load is by no means the maximum load that the bridge will carry. Should the holes be considered to weaken the bridge sufficiently to warrant repairing the damage, the following action can be taken:—

Steel bridges

(i) Members subjected to either direct compression, or compression due to bending. Plug the hole.

(ii) Tension members. Either do not drill in line with rivets, or weld on a flat M.S. strip after completion of tests.

(iii) Use stud bolts.

R.C.C. bridges

Grout up the hole, this being only for aesthetic reasons on the tension side.

Strength of Connexions

It is well known that the strength of bridges is very often determined by the strength of riveted, bolted, or welded connexions. This method does not take into account such weaknesses as may be present; but on the other hand, if the strength of such connexions has to be assessed, this may be done in most cases quite simply by normal methods.

Armoured Engineers

By LIEUT.-COLONEL R. L. FRANCE, M.C., R.E.

INTRODUCTION

THIS title refers to "Armoured Engineers" instead of to the official title of "Assault Engineers". It is felt that the latter title is now largely outdated by the ability of the tactical atomic weapon to destroy a "fortress" such as the "west wall", for the assault of which "Assault Engineers" were formed. In conditions of limited nuclear war they will be used in a different way and their ability to work under small arms fire is perhaps best described by the title "Armoured Engineers".

In conditions of limited nuclear war the army demands greater mobility, particularly of its armour. It is likely that this armour will be disposed in two basically different ways. The first, in armoured formations, with arms organized on a basis of armoured regiments, with a smaller proportion of infantry carried in A.P.C. and supported by armoured artillery and engineers carried both in A.Vs.R.E. and A.P.Cs. The second, in infantry formations, organized on a basis of infantry battalions, with a smaller proportion of armour with supporting artillery and engineers. When fighting, the infantry formation armour moves in bounds and the distance covered must be that of its infantry, and demands on engineers to keep it mobile will be correspondingly small. Armoured formations, however, must exploit their mobility and armoured fire power to the full, whether in attack or defence. In attack, this may mean making rapid and deep thrusts through enemy defences weakened by tactical atomic strikes; in defence, the rapid erection of obstacles, such as minefields and the rapid counter attack to contain the enemy on such artificial or natural obstacles, so forcing him to concentrate and provide an atomic target. The need of armoured engineers to maintain the necessary mobility, to provide the machine power required in these roles, and to carry out other sapper tasks such as rafting, bridging, mine warfare and demolitions in nuclear warfare conditions will now be described or discussed.

MOBILITY

Some idea of the scale of armoured engineers needed to maintain the mobility of an armoured formation can be obtained by considering the problem which would face a C.R.E. who must provide the means to pave the way for them as quickly as present military thinking requires.

Armour may be required to penetrate very deeply and quickly on routes widely dispersed and through country occupied by an enemy weakened by tactical atomic strikes. If the movement of an armoured brigade, supported by a lorried infantry brigade, is considered in such a situation it will be seen that movement on three routes would be important in order effectively to deal with enemy opposition, as well as affording better control, dispersion and quicker concentration on the objective. It would therefore be necessary to make all three routes fit to take Centurions and, if possible, Conquerors early on, together with other "F" and "A" echelon vehicles. It might also be important to develop one route early to take the 280 mm. gun, which requires high classification bridges (according to span) with strong decking, improving this route later to class 100 for loaded tank transporters.

Considering this problem of mobility in relation to a typical piece of ground it might be found that for the depth of penetration envisaged three such routes contain some forty ditches and small river crossings with water gaps of ten to one hundred feet, the majority probably less than fifty feet. Some of the bridges would be very easy to demolish and some need strengthening. The use of conventional bridging would be quite out of the question initially. If the C.R.E. were to allow for the enemy demolishing the majority of the stronger bridges he might find it necessary to ask Corps to make available two troops of four Churchill bridgelayers and three pairs of Churchill arks, besides four troops of three A.V.R.E. dozers, carrying prefabricated culverting on their backs for use in the smaller wet ditches. (Fascines are considered too clumsy for this type of operation where speed would be essential). It should then be possible, with improvisation, to deal with all the crossings by giving three A.V.R.E. dozers to the armoured regimental groups moving on each of the routes and dividing the arks and bridgelayers out to suit each route, leaving a small reserve of equipments with the reserve fourth armoured regimental group on the centre route. Some saving of bridgelayers might be possible by having spare bridges carried on ten-tonners suitably modified to carry them. Other economies could be made by using single width arks on large crossings to enable half-tracks, A.P.Cs. and lorries etc. of "F" and "A" echelons to cross after the tanks had forded. A.V.R.E. dozers might also be passed over the ark crossings, so that they could ramp down the far bank, to assist fording Centurions and Conquerors to climb it. There would probably be a need to plan the use of A.V.R.E. dozers for the possible clearing of routes blocked by rubble and demolished large trees, resulting from the blast effects of tactical atomic missiles or conventional explosives.

If the condition of the ground was not good it might be necessary for A.V.R.E. dozers to carry small fascines to lay as tank stepping stones on either side of marshy ditches. The ability of the field sappers allotted to each regimental group to provide suitable diversion approaches for "F" and "A" echelons would then be fully stretched and the early improvement of the divisional route for 280 mm. gun, "B" echelon vehicles and transporters might then require more than the remainder of the divisional engineers.

Some sets of American M4A4 deck bridging would also be demanded from Corps for the rapid strengthening of small undemolished weak culverts to enable them to take both the 280 mm. cannon and our tanks. The vast saving in bridging effort offered by this type of bridging and of the American M2 trackway type of bridge over conventional bridging is apparent in certain cases where the water gap is narrow but too deep for culverting, or where the bridge decking is weak. The addition of a simple derrick attachment with hydraulic winch on an A.V.R.E. dozer would assist the placing of M2 type trackway.

It would be important to make arrangements for the early recovery of arks and bridgelayers expended in the move forward, as soon as they could be replaced by conventional bridging on the divisional class 100 route or recovered on other routes when no longer required.

The ability of armoured engineers to maintain mobility would not be complete without mention of their use to provide surprise in local counter attacks and to keep open the routes during withdrawal.

In this latter task the equipments might be used in the same sort of way as in the rapid advance described above and also in the demolition role described later. Enemy interdiction of routes in rear of a withdrawing force by atomic or conventional weapons is likely in order to bring them to battle or produce an atomic target. The ability of armoured engineers to get to the sites quickly and to bridge gaps or clear debris and trees blocking routes would be invaluable. Their large wireless net would also be of value in maintaining engineer control which is always difficult in this phase of war.

Wide River Crossings Too Deep for Use by Arks

A.Vs.R.E. may be used to assist in this type of operation if it is assumed that future initial vehicle crossings of a wide river, too deep for Arks, would probably take place on heavy ferries widely dispersed. Where these ferries are to be used by tracked vehicles it is considered that considerable engineer surprise would be gained by using A.V.R.E. dozers speedily to tow and launch heavy ferry equipment across difficult cross-country approaches and steep river banks.

A.Vs.R.E. would also be of assistance in building a Class 80 E.W.B. pontoon bridge in tactical atomic warfare conditions. Provided the tactical situation permits, the construction of this type of bridge would enable a complete formation to cross a wide river in the shortest space of time. In order to avoid bridge construction being seen by the enemy and so invite attack by atomic weapons it may be necessary to construct such a bridge on two nights, meanwhile maintaining the bridgehead by rafts. In order to do this it would be necessary for landing bays and floating bays to be assembled and camouflaged during one night, the landing bays being kept well back on the bank, and all floating bays well dispersed, mostly upstream.

The whole bridge could then be assembled and connected up at dusk the next night, used, disconnected, dispersed and camouflaged again (including tracks) before dawn. By using A.Vs.R.E. to help launch and de-launch the heavy landing bays it should be possible for the bridge to be made up in two hours and later disconnected and camouflaged in a similar time. Although this may not allow sufficient time for use by traffic during a summer night it may allow about eight hours use or more during about six months of the year.

Minelaying

Minelaying by mechanical minelayer offers a great saving in manpower over that required for handlaying and it is of great assistance in the rapid creation of artificial obstacles on which an enemy can be trapped into producing a worthwhile atomic target. A.V.R.E. dozers are particularly suitable for the rapid towing of mechanical minelayers and also for creating phoney minefield marks at speed over widely dispersed areas where the operation of conventional bulldozers would be comparatively slow.

Mineclearing

Great savings in manpower compared with hand mineclearing methods are also offered by the use of Churchill mineclearing flails and by the Giant Viper attachment which can be towed by and fired from an A.V.R.E.

Although it might be possible to clear some known minefields by atomic blast it will not usually be possible to discover the minefields in time enough to produce the atomic strike, and take all attendant precautions. Minefields will therefore still be a great obstacle to mobility if they have not been discovered in advance and have to be cleared by hand. If really mobile conditions develop, large minefields will be unlikely owing to the time taken to lay them.

Demolitions

The use of the A.V.R.E. 6.5 in. demolition gun for emergency bridge demolition and the breaking up of obstacles and emplacements should prove invaluable in conditions of mobile warfare.

In these conditions it is doubtful if there will be time to use conventional explosives for the rapid creation of obstacles. The use of the rapid demolition devices, particularly the CD 14 cutting charge, used in conjunction with bolt firing guns, offers a great saving in sapper manpower and time, and the increase in explosive used is slight. The placing and firing of rapid demolition devices from A.V.R.E., either with or without the use of trailers carrying explosive, and the use of A.V.R.E. as cover from small arms fire while so employed, might prove invaluable in an emergency. A possible use by the enemy of a small atomic explosion to clear troops from the area of a bridge and to blast away the charges and firing circuits on the bridge in an effort to achieve a "bounce" crossing may not be too far fetched. The use of A.V.R.E. dozer crews to replace and fire the demolition charges might then be invaluable in the face of leading enemy troops.

The ability of an A.V.R.E. to tow a rooter should also not be overlooked.

Manpower Considerations

Manpower consideratons are worth some mention in greater detail since it is sometimes said that armoured engineers are wasteful in sapper manpower, their equipments expensive, and that they also have a large administrative tail behind them.

An examination of manhours and working times shows that the use of arks, bridgelayers, and flails offers a saving of at least 200 to 1 in terms of sapper manhours, and of about 50 to 1 in terms of time when compared with conventional bridging or mineclearing operations. A.V.R.E. dozers offer a saving which is harder to assess. A look at the maps of Western Europe, where a limited nuclear war may be expected, indicates many places where this saving would be essential if armoured formations are to make deep and rapid thrusts and counter attacks in the way described in the section on "Mobility".

It should not be forgotten that A.V.R.E. dozer crews can be made available in emergency to assist in crewing mechanical minelayers and in hand mineclearing, rafting and bridging. These crews would receive annual training in mines and rapid demolition work, but lack of time would probably preclude training in bridging and rafting. Their basic training should, however, make them useful working numbers in these tasks.

Road maintenance is another sapper task which in the past has taken a great amount of manpower. It is felt, however, that in well-roaded areas, such as those of Western Europe, need for road maintenance will be reduced in mobile operations with widely dispersed forces. A.V.R.E. dozers would be useful in this task, their crews being available as working numbers.

The presence of A.V.R.E. dozers cuts out any requirement in divisions for Size IV tracked bulldozers and makes a smaller requirement for Size II. Ideally, divisional field park squadrons should hold medium sized wheeled dozers and no tracked dozers if A.V.R.E. dozers are available.

The withdrawal of tank dozers and bridgelayers from the R.A.C. and their centralization under R.E. control effects economies in manpower and equipments and probably makes for more efficient over-all control.

The cost of armoured engineer equipments and of the administrative tail behind armoured engineer units is offset by considerable savings in columns of bridging vehicles and equipment.

Organization

Assuming that armoured engineers will spend most of their time with armoured formations, their organization should be matched and should be able to meet the requirements of a rapid advance, as described in the section on "Mobility". Armoured formations now tend to work in closely integrated regimental battle groups consisting of an armoured regiment, one company of infantry in A.P.C., one S.P. battery and sappers to suit the task. The engineer contribution will probably consist of a selection of armoured sappers to meet the needs of the task, plus up to a troop of field sappers for a rapid advance. The latter would be carried in A.P.C. and would be responsible for improving A.V.R.E. ark and bridgelayer crossings to make them passable to A.P.C. and "A" echelon vehicles. For this the field sappers will carry on their A.P.C., pioneer tools, some explosive and mineclearing stores, and probably some tracking stores with the "A" echelon. They may also open up laterals and do preliminary work on the divisional centre line preparing for permanent bridging where necessary. The whole should ideally be commanded by a squadron commander of the field sappers, or his second in command, who will know the armoured regiment and who would travel with armoured regimental headquarters, where he should be similarly mounted in a Centurion. Mature advice and control is therefore available to the regimental group commander.

A reconnaissance officer is also required and he should preferably be found by the field squadron providing the commander and field troop. This officer should work well forward in his scout car with the leading armoured squadron, where an A.V.R.E. dozer and A.P.C. with field sappers would also probably be found. Any other A.V.R.E. dozers, bridgelayers, etc. allotted would probably be back nearer regimental headquarters with the field troop, ready to be brought forward when obstacles are expected. Further back with the regimental "A" echelon will be the fitters' half track, petrol lorry, and perhaps a supply lorry. They thus conform to the administrative pattern of the armoured formation.

It is most important to maintain sapper/armoured regimental affiliations which develop mutual confidence and make for speed of action. Regrouping during a battle is to be avoided and may not be possible.

To meet the needs of four armoured regimental groups, four armoured engineer troops would be required, each consisting ideally of three A.V.R.E. dozers. This allows for a regimental group operating with two squadrons up, each to have an A.V.R.E. dozer, and for one A.V.R.E. dozer to be left behind to complete tasks. As an economy a special command A.V.R.E. could be omitted, command being exercised where necessary from one A.V.R.E. dozer per troop fitted with two sets. To these A.V.R.E. troops could be added arks, flails or bridgelayers as required by the regimental group. These arks, etc. should themselves be organized in troops for training and administrative purposes.

If demands for armoured engineer equipments for the infantry formations are to be met simultaneously the total of armoured engineer equipments required at one time could be formidable. Even if economies were made, the total number of equipments required to be held in the Corps Armoured Engineer Squadron would amount to much more than the tank strength of a normal armoured squadron. It would not be possible to switch equipments quickly, particularly between formations well dispersed and the requirement for strong enough routes between them might entail considerable detours. Also, time is always needed for marrying up the equipments with regimental groups and the getting of commanders into the local "picture".

Apart from these snags, the holding of all equipments at Corps makes the degree of engineer/armour teamwork required in armoured regimental groups difficult to attain. Unless the armoured engineer unit lives near the armoured units and the same elements of the unit can be made available to the same armoured units it will be very difficult to attain the standard of integration required.

One Corps Armoured Engineer Squadron offers obvious economies of manpower for command, administration and training, but some splitting of armoured engineer resources appears desirable, particularly down to armoured formations. Flails and arks are not likely to be in such general use as A.V.R.E. dozers and bridgelayers, and the use of arks can usually be forecast from air photographs or intelligence data. If any split has to be made it would appear that arks and flails should be kept at Corps, together with a reserve of A.V.R.E. dozers and bridgelayers for use by all formations of the Corps, and that a permanent allotment of A.V.R.E. dozers and bridgelayers should be made to armoured formations, where there is more likely to be a continuous demand. Close engineer/armour integration and the presence of the basic numbers of armoured engineers would then be assured to the armoured formation.

A possible way of putting this into effect economically would be to replace one troop of a field squadron supporting an armoured formation by an armoured engineer increment, consisting of six A.V.R.E. dozers and three bridgelayers. While not giving the formation the full scale of support it would need for all operations this squadron could be organized to give basic and integrated armoured engineer support to three armoured regimental groups simultaneously, to which additional sappers and armoured engineer equipments from the Corps armoured engineer squadron could be added when needed for a particular operation. The Corps squadron could be correspondingly reduced and would become a more reasonable size.

The field squadron and the armoured formation it supports would then be able to develop into a really closely knit team. As the major role of this squadron is likely to be ensuring the mobility of armour, and is very different from that of engineers supporting infantry formations, there is a strong argument for tailoring the squadron to fit in the armoured formation more closely.

A possible organization for such a field squadron is set out in the tree on page 245. The basic organization of the squadron headquarters and field sections of this squadron would be similar to that of other engineer units, apart from transport, and would therefore be interchangeable if necessary. It would be important that the troop leaders should be of the rank of captain in view of their responsibility in the armoured regimental group.

The only difficulty which might arise with this organization would be basic A.V.R.E. crew training and A.V.R.E. maintenance. Basic A.V.R.E. crew training could be carried out with the Corps squadron, however, and the Corps squadron should be able to provide trained fitters.

Outline Organization of a Field Squadron Supporting an Armoured Formation

Fd. Sqn. H.Q. (normal with addition of comd. and fitters' armd. vehs. and crews, and a 3 ton veh. for F.A.M.T.O. stores)

- Fd. Tp.
  - Tp. H.Q. to incl.
    - 1 captain
    - 1 subaltern
    - 2 scout cars
    - Fd. Sec. (Normal)
    - Fd. Sec. (Normal)
    - Armd. Engr. Sec. (2 A.V.R.E. dozers 1 bridgelayer)
- Fd. Tp.
- Fd. Tp.

Notes

1. Fd. Secs. carried in armd. vehs. with cross-country performance.
2. Armd. Regts. to provide L.A.D. assistance and P.O.L. etc.

Training

No difficulty was experienced during the last war in converting field squadrons to the armoured engineer role, except perhaps in the training of officers to employ armoured engineers to the best advantage. The training of officers can be carried out by demonstrations and T.E.W.T.S. but much better results will be achieved by officers working with armoured engineers and seeing their capabilities in a variety of conditions of ground and situations. This is most important for the engineer officers in formations to which armoured engineers are made available or are permanently allotted. It is also desirable that all engineer officers controlling the movements and allocation of these equipments should have a thorough knowledge of their capabilities.

Summary

The above description shows how important the presence of armoured engineers will be in atomic warfare conditions, where the maintenance of mobility of armoured formations will often make a completely new sort of demand on engineer resources. It emphasizes their ability to take on a variety of sapper tasks without undue waste of sapper manpower, and shows their capacity to provide the necessary machine power at times when speed is vital.

It points to the desirability of making a permanent allotment of armoured engineers to the greatest user, the armoured formation, and that they should, if possible be part of it so that the all important affiliations can be established.

Finally, the training and knowledge of the capabilities of armoured engineers must be more widespread in formations which use them.

The Division in Nuclear War

By LIEUT.-COLONEL R. A. BARRON, R.E.

AUTHOR'S NOTE

The following article was an "also-ran" entry for the Bertrand Stewart Prize Essay, 1956, and is published with the permission of the Editor of the "Army Quarterly". It is being offered for publication in the "R.E. Journal" because we all ought to be pondering the problems involved in fighting any nuclear war of the future, and every oyster-bed may contain at least one pearl.

The characteristics and organization of every element in the Army—and to some extent the Royal Navy and Royal Air Force—affect the overall Sapper picture; that is the justification for an article which covers the whole military field.

Obviously, the views expressed are personal and any similarity between them and official doctrine is purely coincidental.

INTRODUCTION

As a start, it must be appreciated that there may be degrees of nuclear warfare depending on the availability of nuclear weapons. Weapons of this type may be used in the strategic role alone, or also in the major tactical role, or in the total development of nuclear war, at all levels down to the direct tactical support of ground forces. The scope of their use will depend on the availability of nuclear projectiles and of the means of delivering them to their targets, and possibly on expediency. In considering the shape of the army of the future it is, however, essential to assume the fullest use of the weapons and to plan accordingly. Furthermore, it is the availability of the weapons to either side, not necessarily to both, which will dictate the tactical techniques and organizations which must be used; it will be unsafe to plan on the assumption that the enemy cannot use his nuclear resources at all levels of strategy and tactics, even if we are unable to do so. It must also be assumed that any change from present organizations and equipments to those required for a nuclear war is bound to be a gradual process depending on the introduction of new equipment.

Every military organization, for any type of war, is—or should be—a combination of different fighting and administrative elements carefully balanced to enable its commander to carry out his task in battle with certainty but with economy of resources. Such organizations must contain an element of compromise because the conditions of war vary widely from phase to phase and even more so between theatres of operations, and it is obviously impossible to alter the organizations incessantly. But they must, at least at the start of a war, be adjusted and balanced to the conditions in which the war is likely to be fought.

This sounds platitudinous, but there are factors which may sway the balance away from that which is tactically ideal. The sometimes peculiar needs of the peace-time army may influence military thinking and thus affect organizations which are designed to expand into those required for war. Over-caution may lead to excessive insurance against every conceivable eventuality, particularly on the administrative side. Innate conservatism, amounting in its extreme form to "fighting the last war", tends to resist re-organization and may lead to attempts to forecast the conditions of a future war in terms of existing organizations and equipment.

It is particularly vital that, in the future, no such influences shall be allowed to affect the military organizations for war. These organizations must be as sound as possible from the start. There is unlikely to be time or opportunity to adjust them as the war proceeds; the shorter and more devastating the war the truer this will be. In future, the nuclear weapon will be so dominant that every organization must be tailored to the conditions which that weapon will impose, far more than to the conditions of climate, topography and so on, which have hitherto mainly controlled such organizations.

Finally, by way of introduction, there is no one with experience of war in which nuclear weapons have been used both strategically and tactically. Much has been written of the possible conditions of such a war, chiefly in its strategic implications, but at least it is agreed that it will be vastly different to any which has gone before. In considering organizations for the future, it is essential to make an assessment of the conditions under which the war is likely to be fought and, on the basis of that assessment, to approach the problem of organizations from first principles and with an open mind.

The Strategic Shape of Nuclear War

The broad characteristics of nuclear weapons are well known, but it is anything but easy to relate those characteristics to the conduct of war; for one thing, imagination boggles at the scale of destruction which one weapon can bring about. The only answer is to curb imagination and to try to reduce the problem to its simplest terms.

As a first principle, it can be assumed that the strategic aim of contestants in any unrestricted nuclear war will be the subjugation of their opponents by complete disruption of their centres of government and of their industrial potential in its widest sense. Land battles will be fought offensively in the furtherance of this aim, with the objects either of reducing the range from which the nuclear weapons have to be delivered, of capturing enemy territory from which nuclear weapons can be launched in retaliation, or of completing subjugation by physical occupation. They will, of course, be fought defensively in precise opposition to these objects.

As a second principle, it must be accepted that any individual target in a future war will be capable of being completely destroyed by the enemy without undue effort. Apart from the undoubted ability of the nuclear weapon to achieve the required degree of destruction there will also be little chance of effectively preventing the arrival of the weapon on its target. The ballistic rocket will probably be impossible to intercept, but even aircraft or guided missiles are, as far as can be foreseen, bound to evade the defence sufficiently to ensure that at least a proportion of nuclear projectiles reach their targets. No practical degree of air superiority, or even supremacy, is likely to provide an unbeatable defence.

On its face value, this might suggest the impossibility of fighting the war at all, but there are qualifications. The target must be able to be identified as such, both by those planning its destruction, and by those launching a nuclear weapon against it. Also, assuming that there are no narrow limits of availability of the projectiles, the target must nevertheless appear to be worthy of destruction by what is certain to remain a relatively expensive weapon, and one the use of which may require political as well as military consideration. It is within these qualifications to the second principle that both sides will be seeking the answer to the successful conduct of nuclear war on land.

The avoidance of the identification of targets and the concealment of their apparent worth can be achieved by a combination of dispersion, concealment and—to a lesser extent—protection. By far the most important of these three measures is dispersion from which the remaining two must, in any case, very largely spring; where dispersion is impossible the other two become the more vital.

The installations necessary for government and control, for economic survival, and for conventional fighting on land, sea and air vary considerably in the degree to which they can be protected by these means. They vary from the major industrial factory, for which very little can be done without unrealistic expenditure of resources, to the military installation on the battlefield, for which much may be able to be done. The balance will lie heavily against the civilian installation and it must therefore be assumed that civilian production will largely cease on the outbreak of nuclear war, that normal communications by land and sea will be seriously disrupted, and that civilian government and control will be gravely disturbed. Every civilian resource will, in fact, be almost wholly concentrated on the acute problems of maintaining the bare necessities of life and of preserving morale in the home country.

From this it is apparent that armies in the field are likely, for indefinable periods, to be very largely dependent on their own immediately available resources. During such periods, which may be protracted, they will receive no supplies or reinforcements other than those which can be delivered by what are, at present, more restricted methods than those on which the maintenance of armies has hitherto normally depended: supply by air or, in the case of nations operating overseas, across beaches.

It is against this background that the land battle will be fought and that, therefore, the tactical conduct of the land battle must be evolved. In the past, individual battles have been fought in the relative isolation which will in future become commonplace, but the tactical techniques used have always been based on an assumption of not too long-delayed supply and reinforcement. Examples are many, but perhaps the most obvious are to be found in the operations in Burma between 1943 and 1945, and, from the point of view of partial failure, in the Arnhem operation in 1944; as General Eisenhower recorded about Arnhem:

" . . . would have been successful except for the intervention of bad weather. This prevented the adequate reinforcement of the northern spearhead. . . ."*

In the future, too much reliance on re-supply or reinforcement will be fatal; severe restrictions will be normal and every aspect of organization and tactics must be examined to ensure that only the most vital replenishment need be demanded of the supply services.

Because of the immense power of the nuclear weapon and the increased flexibility of the means by which it will be able to be delivered, the initiative

* "Crusade in Europe."

must lie with an aggressor even more than in the past. Furthermore, his plan of attack for his ground forces will take account of equally powerful and flexible retaliation, and must, therefore, be governed by the same need for dispersion and independence of replenishment. This suggests that the warning of impending attack which in the past has normally been available from the massing of forces in preparation for aggression, will not necessarily be granted to the defender. This in turn suggests that defensive deployment on the actual, or potential, battlefield must always be as complete and ready as possible. For this reason, also, it is essential that the force deployed shall be independent of mobilization reinforcements which may in any case never arrive.

The Tactical Shape of Nuclear War

Against this background it is necessary to consider how the land battle will be fought with the threat of the tactical nuclear weapon dominating every phase. As a first principle, neither in the attack, nor the defence, the counter-attack, the advance, the pursuit or the withdrawal, must either side—if it can possibly be avoided—concentrate in the lethal area of one nuclear weapon a force sufficient to constitute a worthwhile target. "Concentration" must remain a principle of war but it must be applied in new ways. However, it is idle to speculate on the size of force which will, in given circumstances, justify its destruction by nuclear means; it must be assumed that the nuclear weapon will be used by the enemy whenever he considers its employment to be justified for the furtherance of his tactical aims. The necessary dispersion to avoid nuclear destruction must therefore, on occasion, be balanced—as a calculated risk—against the concentration of force necessary to fight the tactical battle; as far as possible then, any lack of vital dispersion must be off-set by concealment and protection.

The general principle of dispersion creates a further field within which both sides will be seeking new methods of fighting. The aim will be to achieve favourable tactical conditions on the battlefield as far as possible by means other than those which in the past have demanded greater or lesser concentration of forces, or at least to vary the stages in the tactical battle at which concentration occurs.

Less than one hundred years ago armies fought each other in massed formations. This they did because it provided a means of achieving concentrated fire, and this they were able to do because the weapons which the enemy could direct at them had no width or depth of killing area, and he could not therefore take full advantage of the concentrated target. Then came the machine gun and the projectile which burst on impact, both of which extended the lethal area and demanded dispersion beyond the limits of that area, or the provision of protection against the actual projectiles. Later still, the introduction of the A.F.V., the V.T. fuze and the bombing or straffing aircraft continued this evolution. Now the nuclear weapon has vastly extended the scale of dispersion and protection necessary; so vast is this extension that what was once a complete battlefield now becomes merely the lethal area of one projectile, and the possibility of effective protection will frequently be beyond economic attainment.

Until the introduction of the nuclear weapon, the essential dispersion forced on armies in the field was broadly balanced by the increased range and effectiveness of the conventional weapons available to those armies. The nuclear weapon must, however, destroy this balance and an antidote must be found either in new weapons or in altered methods of using existing weapons. For example, in the pre-nuclear era, effective destruction of enemy defensive positions by the attacking force, or of enemy attacking forces by the defence, required the concentration of conventional artillery to a degree which can no longer be accepted; this can only be answered, in the future, by the greatly increased range and by the greater destructive power of projectiles which weapons of the future will supply.

Again, in the attack or counter-attack, the copy-book answer has always demanded concentration on a narrow front of the necessary force, echeloned in depth to maintain its essential impetus. This conception simply will not do under nuclear conditions. From the principle of dispersion, the defence must be more widely spread and there is therefore likely to be less need for concentration of the attacking force. More important, however, is the need to achieve the necessary concentration without presenting a target to nuclear weapons. The answer may be found on occasion by the use of air-transported forces, but more generally by converging attack starting from widely separated assembly areas, concentrating only on the objective so that owing to the close contact of the opposing forces neither is vulnerable to nuclear attack, followed by immediate dispersion as soon as the tactical aim has been achieved.

In the advance and the withdrawal, concentration has always tended to occur at "bottle-necks", of which built-up areas and bridges provide the most obvious examples. These bottle-necks, and the concentrations which occur at them, are peculiarly vulnerable to nuclear attack and they must therefore be avoided or at least spread so wide—in the case of bridges—as to be no longer worthwhile targets. This demands increased cross-country ability, and equipment capable of maintaining movement at speed, in all elements of the force and over all obstacles.

As a corollary of this point, certain obstacles—particularly major waterways—are likely to assume greatly increased tactical importance. It is impossible, for example, to visualize, in the conditions of nuclear warfare, any such operation as the assault crossing of the River Rhine in March, 1945; in no way can General Eisenhower's comment on that operation fit the picture of nuclear tactics:

" . . . Our preparations for the crossing north of the Ruhr had been so deliberately and thoroughly made that the enemy knew what was coming. We anticipated strong resistance, since we could achieve surprise only by the timing and strength of the assault. . . ."

The answer must be found in the use of air-transported forces and widely spread crossings supported by ferrying operations.

In all phases of war, dispersion will increase the strain on the machinery of command and control in battle. Both must be exercisable over the greatly increased ranges involved. Both must be capable of surviving when subjected to nuclear attack. This suggests the need for smaller, more mobile, headquarters at all levels, equipped with lightweight, long-range communications. It also suggests the need for duplication of headquarters and great flexibility of control in battle. To achieve this flexibility the initiative of subordinate commanders must be the greater. To quote Field-Marshal Sir William Slim:

" . . . Dispersed fighting, whether the dispersal is caused by the terrain, the lack of supplies, or by the weapons of the enemy, will have two main requirements—skilled and determined junior leaders and self-reliant, physically hard, well-disciplined troops. Success in future land operations will depend on the immediate availability of such leaders and such soldiers, ready to operate in small, independent formations. They will have to be prepared to do without regular lines of communication, to guide themselves and to subsist largely on what the country offers. Unseen, unheard, and unsuspected, they will converge on the enemy and, when they do reveal themselves in strength, they will be so close to him that he will be unable to atomize them without destroying himself. Such land operations, less rigidly controlled and more individualistic than in the past, will not be unlike ours as we approached the Chindwin and the Irrawaddy, and stalking terrorists in a Malayan jungle is today, strange as it may seem, the best training for nuclear warfare. The use of new weapons and technical devices can quickly be taught; to develop hardihood, initiative, mutual confidence and stark leadership takes longer. . . ."†

The tactical picture must also be qualified by the need for forces in the field to be virtually self-supporting for considerable periods, or at least to be capable of relying only on restricted methods of supply. This qualification must influence the composition and organization of the forces and particularly of their administrative services. Because ports, railways, canals and other normal channels of supply are so vulnerable to nuclear attack, the problem is even more acute in the case of countries supplied across the sea. Thus in a war in Western Europe, countries such as the United Kingdom and the United States will be less able to augment stocks existing in Western Europe at the outbreak of war than may continental countries. This suggests the need for extensive pre-dumping of essentials by overseas countries or for some reliance by them on supply from continental countries. Whatever the answer, it is obvious that economy of resources in their widest sense is essential, and that, in addition, the greatest possible use must be made of air supply, with the accompanying proviso that as much as possible of the necessary equipment must be capable of being carried by air.

Apart from the air battle at the strategic level and the tactical fire support by aircraft of the land forces, a vital task of the Air Force must, therefore, be that of supplying the Army. Undue preoccupation with more offensive roles must not prejudice the carrying out by the Air Force of this supply, without which, even with the most rigorous economy, the Army is bound ultimately to be paralysed. With the nuclear weapon and long-range rockets or guided missiles at their disposal, the Air Force will no longer need massive concentrations of bombers. In due course, too, the guided missile will reduce the need for fighters. Thus the balance of air effort can swing towards the logistic sphere.

It is now possible to examine the tactical battle in rather more detail and to decide how it is likely to be fought. Conditions are bound to vary widely so that any such consideration must, at the best, be confined to generalities.

If a defending force is to survive it must not provide targets for nuclear attack and its defended localities must, therefore, be relatively small and widely separated on the ground; given time, they must also be dug-in and

† "Defeat into Victory."

concealed to the greatest possible degree. As an essential contribution to dispersion, concealment and protection, every possible use must be made of ground and in particular of natural or artificial obstacles. To cover the increased gaps between defended localities, very much greater use will have to be made of fire-power and counter-attack forces; as has already become clear, the ranges involved are likely to be so great that the majority of the fire-power will have to be provided by long range cannon or rockets, guided missiles or aircraft.

The attacking force must take account of the weakness inherent in the dispersion of the defence, but must equally be based on dispersion. If the lessons of past wars were to be accepted without qualification, it might appear that it would be more severely prejudiced than the defence by this need for dispersion, but certain factors will tend to restore the balance in favour of the attacking force. For one thing concealment of offensive plans cannot fail to become more effective because no major concentration prior to the attack will occur, and surprise will therefore be easier. For another, no individual strong-point in the defensive system need jeopardize the plan of attack for any appreciable time because its ultimate destruction is assured, if necessary by nuclear means. For yet another, the power of the nuclear weapon will be neutralized once the attacking and defending forces are in close physical contact, and the initiative resting with the attacking force should allow it to achieve concentration at that stage before the defence has a chance to close from its wide dispersion.

The offensive is likely, therefore, to be conducted on a wide front, without appreciable warning and by well dispersed and relatively small formations. Its aim will be to penetrate the defensive position as quickly as possible between the widely dispersed defended localities. Any vital objective which might impede this aim, and which justifies such a step, will be neutralized by nuclear attack. Once the penetration has been effected, converging attack will be launched on particular defensive positions and, after their elimination, the attacking forces will disperse for further attacks, or will consolidate on the same widespread basis as the defence. The fire-support for this type of offensive action and for the subsequent consolidation demands equal dispersion and great flexibility. The logistic support must similarly be dispersed and must not be restricted to narrow lines of communication; this can best be answered by air supply but, for the rest, must depend on ground movement on a wide front. If the attack is to be launched across obstacles, the same broad technique must be used, but there is increased scope for the use of air-transported forces to establish or reinforce the crossings required by the ground forces.

The defensive antidote to this type of offensive action must lie in fire-power, where this can be effective, and in counter-attack. Until close physical contact is established, counter-attack forces must be dispersed and then, as in the offensive, use must be made of the converging attack. After close contact is established, the same immunity to nuclear retaliation will exist until the action is ended, when of course dispersion will again become necessary.

Of the advance and the withdrawal, little more need be said than that both must necessarily be carried out at the greatest possible dispersion, and both must be planned to avoid bottlenecks. The same will in general be true of the pursuit but with even more emphasis on dispersion because there may be increased incentive for the withdrawing enemy to use nuclear weapons in order to extricate his forces. In these phases, the maintenance of the closest possible contact with the enemy will go far towards prohibiting the use of the nuclear weapon and opposing commanders will be continually assessing the advantage of close contact against that of allowing a gap to open and so being able to use the weapon.

Therefore the picture of the tactical battle is one of great fluidity, of very dispersed movement and the holding of ground by relatively small formations, of rapid concentration as the attack—also conducted initially by small groups—reaches its objectives, and of flexible fire support. This picture obviously demands a very high degree of mobility in all forces taking part and efficient and swift methods of reconnaissance and command. In particular, weapons and equipment must be designed to cater for the greatly increased ranges of movement and fire-power which dispersion will demand.

Above all, while dispersion will be necessary for survival in the preliminary stages of every operation, it will be neither necessary nor desirable when in close contact with the enemy. Every tactical manoeuvre must be so planned as to provide effective concentration when the close range battle is joined, but at no other time. For this type of tactics, the basic essential in all organizations will be that they are capable of forming self-contained, equally mobile teams of all the arms needed to fight the enemy.

Economy of administrative resources must be rigorous, and the means of supply must be flexible and mobile. This will be true of the administrative services on the ground, but for proper economy and maximum flexibility, the greatest possible use must be made of logistic support from the air.

It is clear that, in general, this war of movement must be intimately linked with the activities of supporting air forces. In nuclear war, although no degree of air superiority can obtain complete immunity to nuclear attack, the gaining of that superiority will be essential if air supply is to take the place, even in part, of land methods. It will also be essential in order to allow timely use of the nuclear weapon which, without effective air reconnaissance, cannot be employed decisively.

Characteristics Required of Units and Equipments in the Tactical Battle

If this is the way in which the land battle will be fought, it seems obvious that some reorientation of the tasks of the various arms of the land service may be necessary. Again, it is wrong to start any such consideration from the basis of the Arms as they exist at present, but rather to start from first principles and to decide what types of unit, with what types of equipment, are needed. The guiding principle in this consideration must be that of achieving the greatest possible improvement in mobility without sacrificing the ability to fight.

Infantry

The basic essential must, as always, be a soldier who can move almost anywhere, by any means including his own feet. The Infantryman is needed to hold ground in the defence and on consolidation after attack. He is needed to make every attack and counter-attack possible because ultimately he alone can fight the individual enemy soldier on the ground. He is needed for patrolling and the other activities which demand stealth, powers of observation and the ability to kill at close range. The existence of nuclear weapons cannot alter these facts.

For nuclear war, however, he must retain or improve his mobility, and he will be unable to do so if he is even partially immobilized by equipment which is not essential to his task of fighting, or of surviving. Such equipment must be eliminated and he must be prepared to rest content with simple survival and the ability to destroy the individual enemy soldier. Wherever, also, the task of a particular weapon hitherto needed by the Infantryman can be effectively fulfilled by a longer range weapon operated from behind his battle position, he should be relieved of the need to carry that weapon.

He will be required to protect himself passively against any type of attack including that by nuclear weapons. This he will do by the use of ground in its widest sense. Because of the dispersion which will be forced on him, his weapons must have the longest possible range and killing power consistent with his ability to carry them and their ammunition. Yet, because also of that dispersion and the distances he will be required to travel, he cannot be asked to move only on foot in battle and he must therefore be able to call on suitable transport when occasion demands. Even more important, he may be required, after the launching of the nuclear weapon, to traverse contaminated ground; for this he must have transport.

One point to be considered is whether that transport must also provide him with some degree of armoured protection. The nuclear weapon will not supersede fire from small arms and high explosive weapons; in fact, because of the probable use of longer range and more efficient weapons the Infantryman is likely to be subjected to more intense fire for longer periods. It therefore seems clear that he needs the physical protection provided by some form of armoured personnel carrier which can not only protect him against the fire itself, but also by its speed reduce the period during which he is exposed to that fire. The personnel carrier must have good cross-country performance otherwise it will be impossible for the infantry to concentrate from wide dispersion and so meet the main requirement of nuclear tactics. It must also be simple and light if it is not to decrease, rather than increase, mobility.

Armour

Next, it is necessary to establish the part which Tanks will play in the nuclear battle. In the past, there have been those who maintained that the Tank was the dominating arm; to quote one exponent of this view, General Guderian said:

" . . . to carry-out the great decisive operations it is not the mass of the infantry but the mass of the tanks that must be on the spot. . . ."*

Equally, there have been those who held the opposite view and considered "armour" a supporting arm for the infantry, as it was when it was first created.

In future, the nuclear weapon will be able to supply the large-scale impact on the enemy forces for which in the past reliance has been placed on massed armour. Furthermore, concentrations of Tanks will no longer be permissible because, although enjoying some protection against nuclear effects, Tanks will nevertheless be more vulnerable than ever before and they cannot be exempt from the universal need for dispersion. Yet again, the design of the Tank must undergo radical alteration if it is to play a proper part in the nuclear battle. Hitherto, the continual competition between armour protection and the calibre of the high velocity gun has resulted in ever bigger and heavier A.F.V.s; the resultant characteristics of the modern Tank are the

*"Panzer Leader."

antithesis of those needed for true mobility and for economy of replenishment and administrative support under nuclear conditions.

In fact, the future role and characteristics of the Tank is the biggest single problem to be resolved in the reorganization of the Army to fight the nuclear battle. The present size and weight of the Tank produces a snowballing effect on the dimensions of the many equipments, organizations and other resources required for its support. To quote only two examples: the transporter for the modern heavy Tank can, by no stretch of imagination, be considered an aid to mobility in the Army as a whole; secondly, the bridges required to carry the Tank, with or without its transporter, are so much heavier than the bridges of the past that they inevitably increase the logistic problem and, far more important, take a great deal longer to build.

On the other hand, tracked vehicles with powerful armament and protection, whether derived from armour, speed or inconspicuousness—or some combination of all three—are essential for providing close support for the infantry. In particular they supply the best protection for the infantry against armoured counter-action; this is true even though the development of infantry anti-tank weapons has considerably increased their ability to protect themselves.

It is therefore essential to reduce the weight of the Tank while retaining as many of its offensive characteristics as possible. The crux of the problem lies in the design of the main armament with which the Tank is equipped. Every inventive resource must be concentrated on evolving a weapon capable of destroying the most powerful enemy armour by projectile performance without the need for high velocity; basically it is velocity which demands longer guns and therefore bigger turret-rings and, consequently, larger and heavier Tanks. It is reasonable to assume that the answer will ultimately be found in some form of guided missile or rocket weapon. When this has been achieved, the protection of the Tank must be obtained by speed, mobility and low silhouette rather than by thick metal plates. Until this stage is reached, the design of the Tank will forbid the proper equipment and organization of the Army for nuclear war, and the correct tactical techniques will not be able to be employed.

Artillery

The existence of nuclear weapons cannot affect the need for artillery fire support in all phases of the tactical battle. Dispersion will, however, alter considerably the characteristics of the weapons with which the artillery must be equipped. The dispersion of infantry and armour will demand much longer ranges than can be provided by conventional field artillery. Furthermore, the dispersion which the artillery itself must adopt in its deployment, if it is to avoid attracting nuclear retaliation, will further extend the range.

This can be solved in two ways. Some short-range support equivalent to that provided by artillery must be available and can be achieved by extending the use of mortars, or of their equivalent, closely integrated with the infantry and armour. More important, however, is the need to adopt longer range weapons which can produce flexible fire support from dispersed fire-positions. If the increase in range results in slower rates of fire the balance of fire effect on the ground must be restored by increased destructive effect of the projectiles used.

Even this long-range artillery must still possess the increased tactical mobility which the nuclear battle demands. If the ranges available in the weapon are really great this may be answered, at least partly, by flexibility of range. Apart from this, it is essential that increased range should not lead to larger and more cumbersome equipment, at least for the forward areas. The problem in this case is analagous to that concerning armour. If, for example, the conventional medium gun is adopted to provide the range and hitting power, it will have to be self-propelled to achieve the necessary mobility; it will then introduce all the drawbacks inherent in the heavy Tank.

The ultimate solution must be provided by the guided missile or rocket, either of which will have the necessary range and at the same time allow improved mobility and decreased logistic support. In the meantime, self-propelled medium artillery seems to provide the only answer and the repercussions on mobility will have to be accepted for the time being. In either case, there is increased need for the use of improved mortars, or of some light equivalent weapon, which can be operated in close association with infantry and armour.

Anti-aircraft Protection

Protection of all units and formations against air attack will obviously be of importance. Anti-aircraft weapons, at present held in the forward area, may have some value against enemy reconnaissance and ground straffing aircraft, but they must be augmented, if not replaced, as soon as possible by guided missiles. Because of their great range and flexibility it should be possible to centralize these weapons at no less than divisional level and, yet, still provide protection over the dispersed divisional area. In this way the essential mobility may be obtained through flexibility.

Reconnaissance

Because of the dispersion and fluidity of the nuclear battlefield, reconnaissance and the resulting information will be even more important than in past wars. For major tactical information, including that required for employment of the nuclear weapon, the air provides the only feasible answer and there is a need for aircraft in intimate support of the ground forces. Apart from reconnaissance, aircraft will also be essential for the exercise of command and control over the longer distances which will be involved in tactical deployment. For the latter purpose, in particular, the helicopter is almost certainly the answer.

For more intimate reconnaissance on the ground, and to allow reasonable contact between widely separated formations, there must also be some highly mobile units readily available to formation commanders. Because dispersion will encourage infiltration and active patrolling, such a unit must be capable of fighting. Provided it has the necessary cross-country performance, the best equipment for this purpose is the armoured-car; provided also that its weight and size are kept to the minimum consistent with its ability to do its job.

Engineers

Engineers will retain the majority of the functions which they at present perform, in particular that of assisting in the construction of protective works, but they, in common with the other arms, must dispense ruthlessly with as much equipment as possible, and must make the maximum use of local materials and resources. They must be as mobile as the arms they are supporting. They must also be able to operate in intimate association with armour and infantry in all phases of war and they must therefore possess approximately the same degree of protection.

Their most important function in nuclear conditions will almost certainly be that of overcoming the obstacles to movement which will be beyond the cross-country capacity of even the more mobile vehicles now visualized in the fighting arms. It has already been stressed that obstacles may play an increased part in the tactical battle because they provide the most certain means of forcing enemy tactical formations into such concentrations as to offer worthwhile nuclear targets. Within the limits of practical design, the engineers must be able to open the way over or through obstacles before such concentration occurs or before there is time to launch nuclear weapons against the crossing places. With this object in mind, it is a reasonable assumption that they must be capable of completing their task, at least in the more usual circumstances, in one hour—a very great reduction of the time at present needed for such tasks.

The answer up to a certain point can be found in the self-propelled equipment operated by armoured vehicles; beyond that point, which will be defined by the economic limits of design of the equipment, the crossing of obstacles must be a special tactical operation. It is obvious that the greater the span of the obstacle with which the self-propelled equipment can contend, the less the reduction in mobility which such engineering operations will impose. The weight of the equipment used by the Engineers is directly related to the weight and size of the vehicles which require to cross the obstacle; the more that weight and size can be reduced, the lighter and quicker to employ the equipment of the Engineers can become, and the larger the obstacle for which they can provide the rapid means of crossing.

Signals

The Signal organizations and equipment required in support of all formations must be related to the increased ranges which dispersion will demand, and to the essential flexibility of command and control. This can be answered mainly by the design of suitable communication equipment, but once again the installations must possess the vital characteristics of mobility and comparable protection to that of the arms for which the installations are provided.

Services

Behind and in support of all these arms there must be administrative services. Vital though they are, they inevitably constitute a drag on the mobility of the fighting formations and every means must be used to reduce the effects of that drag. There are three profitable ways in which this can be done: by reducing to the minimum the supplies and replacements which have to be provided, by moving further back in the echelons of administrative support the stocks of as many commodities as possible, and by increasing the mobility of the services.

At least the initial phase of a nuclear war is almost certain to be one of complete dislocation of the main supply base and of the lines of communication forward from that base. While this is so, units—and in particular those in contact with the enemy—must be prepared to forgo all amenities. This will allow the elimination from forward areas of large quantities of stores and transport, and even of certain specialist units. Furthermore, where possible, every essential of life such as food must be so designed as to reduce bulk to a minimum and the movement of supplies must be reduced by carefully planned decentralization to units and even individuals.

A number of essential items of supply cannot be reduced without prejudice to the task of fighting the enemy. Replacement equipment, ammunition, fuel, for example, cannot be rationed or reduced below a certain point and must be available without delay. They can however be deployed more economically than has often been the case in the past. The carrying of successive echelons of ammunition, as a case in point, largely as an insurance against the worst circumstances, must be re-examined. The more echelons there are in a supply channel, the more handling there will be, the more vehicles will be involved and the greater aggregate stocks will be, as each echelon adds its own extra stock for insurance.

Well dispersed pre-dumping will play some part in reducing unnecessary holding, but the main answer must be looked for in longer carry to the front from widely separated maintenance areas, thereby reducing intermediate handling. This, combined with the need for dispersion, demands a high degree of mobility in the supply services. They must be able to move across country and they must be able to move fast. The same will be true for the medical evacuation services, whose task will be to move probably increased numbers of casualties to more deeply situated and more dispersed medical units.

Aircraft undoubtedly provide the ideal answer for these tasks within the limits of their capacity and of their availability. They must, however, be augmented by highly mobile supply and evacuation services based on cross-country vehicles. The more those services can be organized on the basis of supply from rear maintenance areas direct to front line units the less will be the load on fighting formations and the greater the flexibility of administration.

The vehicle and equipment repair services must equally be reduced as much as possible. This can partly be achieved by increased use of component replacement, thereby reducing the individual time of repair and the present very heavy load of spare parts. It will also be achieved automatically if new design results in generally lighter and less complex equipment. It is even likely that in the chaotic conditions of nuclear war, it will be necessary to depend on complete replacement of vehicles and equipment and the abandonment at least in the forward areas of any attempt at repair.

The general picture of the administrative services is therefore one of the greatest possible reduction in their size, particularly in the forward areas, and a considerable increase in their mobility. There is thus an obvious difficulty in transition from peace to war because the former requires a large number of extra services and amenities which cannot be provided when the nuclear war begins. The peace-time organization of the services must therefore be planned as an expansion from the war organization, and so organized that the increments for peace can be withdrawn into the rearward areas on the outbreak of war, or be re-deployed to more essential needs. Above all, a new conception of air-supply as the main, instead of as a subsidiary, channel of replenishment and evacuation must be accepted.

Organizations for the Nuclear Battle

Long experience has resulted in the evolution of certain basic units of the different arms and services. As far as the fighting arms are concerned these organizations are based on the numbers of sub-units and of the individual weapons within the sub-unit, which have been proved to be necessary for minor tactics. The supporting arms are organized in such a way that sub-units are capable of the economic discharge of the task or tasks of that arm, and the number of units and sub-units is directly related to the number of units of the fighting arms which they are required to support. The same is true of the services.

All of these units are, in turn, organized into formations based on the number of units of the various arms which have been proved necessary to carry out the tactical task of the particular formation. Since the introduction of the A.F.V., there have tended to be different types of formation depending on the preponderance of infantry or armour. This has arisen mainly from the conception that infantry exist to fight infantry and armour to fight armour; there have also been administrative reasons for grouping all armour in one type of formation and all, or the majority of, infantry in another.

On the nuclear battlefield, dispersion prohibits the massive grouping of any part of the land forces; all the eggs must never be in one basket. It has also become clear that the battle must be fought by relatively small battle groups of all arms, initially dispersed, quick to concentrate for a close-contact fight, and quick to redisperse. Therefore, all elements in the battle group must, at least in the move to close contact, enjoy the same mobility; all will require roughly the same type of administrative support. Furthermore, the development of the guided missile as an anti-tank weapon, together with the needs of the nuclear battle, will completely alter the conception of the A.F.V.; the major battle between predominantly armoured formations is unlikely to occur. As a result there need only be one type of formation: that composed of all arms suitably balanced for the nuclear battle.

It has been shown that the existence of the nuclear weapon will not directly affect the close-range battle and there is therefore no reason to alter materially the organization of sub-units of the various arms; that is, of course, apart from any changes arising from the introduction of new equipment. There will therefore continue to be sections, platoons and troops, companies, battalions and squadrons, much as there have been in the past. With the proviso that "overheads" must be reduced as much as possible there seems equally to be no reason to alter the general organization of units. Battalions and regiments, and their counterparts, will continue in broadly their present form as the basic tactical organization of the various arms. There will again be detailed changes arising from new equipment or the transference of responsibility for particular weapons; for example, more or improved mortars may be needed in the Infantry Battalion to replace close-range artillery support. But these changes will not be fundamental to the conception of the units as a whole.

It is on the grouping of these units into formations that the influence of nuclear tactics will be greatest. The nuclear battle must be fought by small, highly mobile battle groups. The battalion is the obvious nucleus for such a group and the brigade is from every aspect of tactics and control the proper formation to co-ordinate and control the action of the groups. On the other hand, because of dispersion and the longer ranges available, fire and administrative support can and should be centralized behind brigade, say at divisional level; the greater then the mobility of the battle groups—and of the brigade—will be.

In the past, a brigade has normally consisted of three or at the most four unit groups. In pre-nuclear days, this organization sufficed to provide the depth required in tactical deployment together with the necessary local reserve. Under nuclear conditions, because—as never before—an entire unit group may be virtually obliterated by one projectile, at least one more will be desirable as a nuclear reserve. The need for this additional local reserve is further underlined by the wide dispersion at which brigades will operate, and consequently the increased difficulty of reinforcing any one brigade, in the middle of a battle, from outside its own immediate resources. The obvious objections to including five unit groups (involving six or more units) in a brigade are the problems of control and, to some extent, of administrative support. With new equipment, smaller units and greatly reduced administrative services in the forward areas, these difficulties should not be insuperable. It is a matter for trial in the course of peace-time exercises, but there can be little doubt that the conception of nuclear tactics will be better answered by five smaller battle groups, rather than by four larger ones. This solution has the further advantage of reducing the number of formation headquarters while retaining the same number of fighting units.

Depending on practical trial it seems then as if the brigade should consist of five Infantry Battalions, each smaller and more mobile than at present. Each battalion needs the intimate support of a squadron of A.F.V.s; each brigade therefore needs an armoured regiment of five squadrons, which can of course be grouped as a regiment when the tactical situation demands. The necessary reconnaissance element might consist of a squadron of armoured cars organized into five troops again to match the infantry organization; on this basis a squadron would normally support a brigade and the squadron in turn would be grouped into a regiment at divisional level and would, of course, operate as a regiment under divisional control when necessary.

Precisely the same principle should be followed in the organization of the supporting artillery and engineers, and of the services. Troops, or the equivalent, will exist in fives to allow individual support of the infantry battalions; sub-units—batteries, squadrons, etc.—will support brigades; sub-units will be grouped into units at divisional level. The reduction of the artillery to the single regiment in the division which this principle involves should be possible when the artillery is equipped with the longer-range and more destructive weapons of the future; in the meantime, with less effective weapons, there will certainly be a need for a greater number of units and sub-units.

Brigades must, in turn, be grouped under divisions for control and administration in battle. Again, the question of the optimum number of brigades in the division must be resolved by practical trial in the field. In this case the need for a nuclear reserve still exists, but, because of the distances involved and the likely form of the nuclear battle there seems to be less argument for any extra reserve at the disposal of the divisional commander. It is likely therefore that the division will continue to consist of three, or at the most four, brigades; in view of the size of the suggested brigades, three is probably the maximum.

At divisional level, as has already been suggested, will be grouped the majority of the supporting arms, including anti-aircraft protection, capable however of decentralization to brigades. At this level also will be grouped the essential administrative services. Here too, might be held the armoured personnel carriers needed to provide mobility for the infantry. The scale of their provision is again a matter for trial, but it seems likely that it should be based on the simultaneous lift of the infantry of one or preferably two brigades. When not needed for this task they could be used for supply services; only in this way can the number of vehicles in the forward area be kept to a minimum and, at the same time, the essential mobility of the infantry be ensured.

The headquarters of both brigades and divisions should be reduced to the minimum in size and they should be duplicated. Deputy commanders should be provided not only for this duplication, but also to reduce the load on the commander arising from the increased number of units in the formation, and from their dispersion. To assist control, light aircraft or, preferably, helicopters should be provided. A flight at divisional level, capable of allocating individual aircraft to brigades, would seem to be necessary.

It is obvious that these suggested organizations, both for brigades and divisions, involve a considerable increase in the number of units in these formations, compared with those which have existed in the past. The increase in the size of the respective commands will be partly off-set by the reduction in the strengths of units and also by the reduction of administrative services. Nevertheless, the territorial area of command and the tactical strength of the respective formations will be considerably greater. This suggests that corps, as an intermediate formation between division and army, might be abolished; this will once again reduce the number of formation headquarters on the battlefield and will tend to reduce the number of administrative echelons supporting the division.

At the level of army, the main administrative support of the division would be controlled. There, also, tactical support with nuclear weapons and conventional air support—offensive, defensive and by air supply—will be provided in co-operation with the Royal Air Force.

Conclusion

Thus the ultimate development of the Division which is required to fight the land battle under nuclear conditions might be one consisting of three or four brigades each of five unit battle groups, based on the infantry battalion. Cross-country transport will be provided for a proportion of the infantry in the division. Each battle group will include a squadron of Tanks and, as necessary, the supporting arms required to allow that group to fight when separated from its sister groups to the extent necessary to avoid constituting a profitable target to nuclear weapons. There will be no separate formations of infantry and armour.

Each formation and each unit within the formation must be so organized as to dispense with every component which is not vital to the nuclear battle. Administrative support must be reduced to the provision of no more than the bare essentials of existence and the replenishment necessary for the task of fighting. Air transport will be the chief means of supply and will be augmented by highly mobile and widely dispersed supply by land, which must be organized from the rear to reduce to the minimum the administrative services required in the forward areas.

The equipment of the fighting and supporting arms must be designed to economize in manpower and in administrative support, while maintaining or increasing its contribution to the task of fighting the enemy. The Tank in its present form must give way to a vehicle, depending on mobility and inconspicuousness for its protection, and not on armour; its new weapons will probably be based on the guided missile. Artillery, both for ground support and for anti-aircraft protection, must be given the longer range and increased lethal effect, which dispersion demands and which only nuclear cannon, guided missiles or rocket projectiles can provide. Engineers must be provided with equipment to enable them to maintain the essential mobility of the fighting arms under all conditions; they must be provided with the same protection and mobility as the arms they are supporting. Other supporting arms and services must have comparable mobility.

With these equipments and in these formations, the tactical battle will be fought, under nuclear conditions, on a basis of widely dispersed assembly and movement. Concentration on the ground will occur only in direct contact with the enemy, when vulnerability to nuclear attack ceases until the close range battle is ended.

When this development of equipment and organization has been reached, divisions will be very mobile and hard hitting. Their equipment, although largely on a tracked basis for mobility, will be light and, above all, air transportable. They will have lost none of their fighting power, but they will be capable of being moved anywhere at short notice. They will, therefore, be ideally equipped not only for nuclear war but also for war on a limited scale when no nuclear weapons are used, or for intermediate types of nuclear war when the nuclear weapon may only be used strategically or in the major tactical role. It will also be possible to reinforce overseas forces from the home base, by moving such divisions by air when sea transport has been made impossible, or has been seriously restricted, by nuclear bombardment.

The crux of the problem of achieving this ideal is, however, centred on providing the equipment without which it is unattainable. Until new equipments are produced, conventional A.F.V.s and artillery, in particular, must still be used; their present design prohibits the essential mobility which formations as a whole must attain, and in the case of A.F.V.s may still demand special formations with a preponderance of armour. The same is true of many other types of equipment with which the Army is provided at the moment; not until new weapons, increased in performance but reduced in weight and far more mobile, can be produced, can the Army fight the nuclear war as it should be fought.

Therefore, there must be an interim period during which the broad, tactical techniques required for nuclear war will be adopted, but will be modified to suit existing equipment. Reinforcement overseas will only be possible for the more lightly equipped units; otherwise, the heavier equipment must all be positioned overseas before the war begins. Movement will be relatively restricted compared with what is eventually needed. There will be other necessary modifications, but the reduction in fighting formations to the bare essentials for fighting and the reorganization of the administrative services can, at least, be completed to the limit which existing equipment will allow.

Nevertheless, the ultimate aim must be to reorganize the field Army into very hard-hitting, highly mobile divisions composed of all arms. Those divisions must be larger in terms of subordinate formations and units, but much more economical in over-all man-power, with no dragging, administrative millstone. Only when it is so reorganized and re-equipped will the Army be fully prepared to fight the land battle under conditions of total nuclear warfare.

The Construction of Open Air Ice Rinks

By Lieut.-Colonel D. H. Cameron, O.B.E. (Retd.),
and Major T. H. Mullan, R.E.

Introduction

Ice hockey is an integral part of the Canadian way of life, and it was inevitable that there should be a demand for ice skating rinks as soon as the Canadian N.A.T.O. contingent became established in Germany. Initially, sufficient funds were available for only two rinks, although four were required on the basis of one for each locality, and even so, it was necessary to plan for open air construction to bring the cost within the financial allotment.

It must be unique in the experience of engineer services for a works officer to be called upon to supervise the construction of an ice rink, and for this reason it may be of interest to consider the various factors which influenced the design before giving details of the actual construction.

Design Factors

In order to determine the capacity of the refrigerating plant it is, of course, necessary to assess the heat gained from various sources. With an open air rink the cooling requirements depend upon the following factors:—

Heat received by conduction from the earth.

Heat received by convection from the air.

Heat received by radiation from the sun, and sky, even on cloudy days.

Heat received by latent heat from rain.

Heat given up by radiation during the night.

With an enclosed rink it is necessary to consider also the heat given up by skaters and spectators.

The amount of heat given up by the earth is not so great as might be expected. For example with a water table 5 metres deep, and with the temperature at this depth at + 10°C., the coefficient for heat gained at the ice surface is about:—

0.4 kcal/m^2/hr/°C. without insulation,

or 0.29 kcal/m^2/hr/°C. with an insulating layer of cork 4 cms. thick.

Thus with a brine temperature of − 8°C., the rate of heat gain is:—

7.2 kcal/m^2/hr without insulation,

or 5.2 kcal/m^2/hr with 4 cms. of cork.

But this represents only about 5 to 6 per cent of the total heat received, and the question of providing an insulating layer under the ice surface is comparatively unimportant when considering refrigeration capacity. However, there is another aspect to be considered which determines the thickness of the insulating layer, since without insulation the earth under the ice surface will become frozen and heaving will occur. It is, therefore, necessary, either to insulate the rink bed or to provide a sub-grade of sufficient elasticity to absorb the movement. In practice, without insulation, the earth under the rink becomes frozen to a depth of 2.2 metres; with 4 cms. of cork this depth is halved, and with 8 cms. of cork the earth is unfrozen.

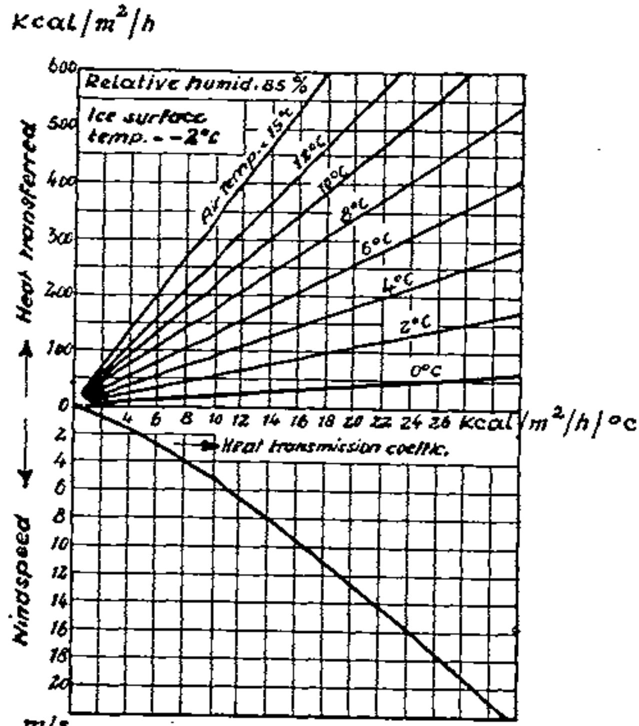


Diagram 1

Heat transfer from air to ice surface

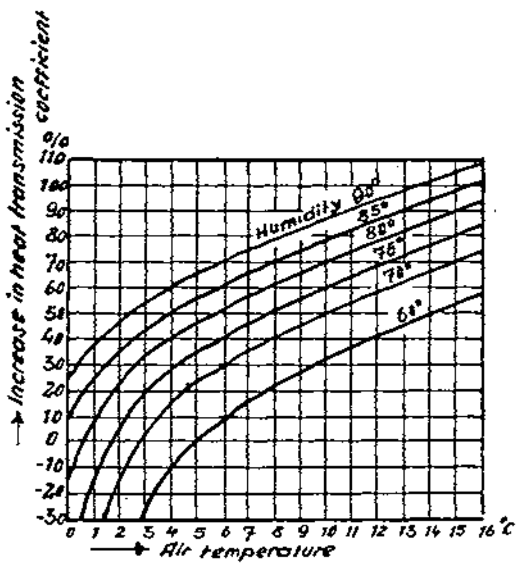


Diagram 2

Increase in heat transmission coefficient through condensation and freezing of water vapour.

Heat gained from the air is one of the biggest factors to be considered, and it is dependent on the ice temperature and ambient conditions. Normally, the ice temperature should be about -1° to -2°C., since lower temperatures will cause the ice to become hard and brittle and splinter under the skate, and higher temperatures will permit regelation to occur. Air temperature, relative humidity and windspeed all influence the transference of heat to the ice surface. Diagram 1 shows the effect of variations in air temperature and wind speed, and Diagram 2 shows the effect of humidity. It can be seen that with a wind speed of 2½ m/sec. (5 miles per hour), air temperature 15°C., and relative humidity 85 per cent, if the ice is maintained at -2°C. the rate of heat gain is about 200 kcal/m²/hr. To minimize the convection loss it is essential that the ice surface should be given maximum protection from the wind. This can be done by suitably siting the spectators' stands and machine buildings.

The effect of radiation is conditioned by several factors. It will depend upon cloud, atmospheric pollution, time of day, time of year and latitude. As an example, in N.W. Europe the rate of heat gain may vary between:—

0 kcal/m²/hr at 0830 hrs. in December.
100 kcal/m²/hr at 1200 hrs. in December.
200 kcal/m²/hr at 0830 hrs. in April.
320 kcal/m²/hr at 1200 hrs. in April.

With an open air rink, the biggest disadvantage is the heat transferred by rain. On a normal rainy day, the rainfall may amount to about 2 mms./hr. and, assuming that all the rain falling on the ice surface becomes frozen, the heat transfer rate is about 160 kcal/m²/hr. To absorb this amount of heat means quite a sizeable increase in the cooling plant, and it is not practicable to consider installing plant of sufficient capacity to cater for heavy rainfall, which can be five to ten times greater than normal.

The heat given up by the ice surface during the night depends upon so many factors that it is not possible to make allowances for it when calculating the capacity of the refrigerating plant. It is of practical value, however, in reducing the refrigerating load when freezing by night.

The cumulative effect of these factors is illustrated in Diagram 3, which gives typical curves for the total heat received during a 24-hour period in each month of the season (September to April inclusive). It will be noted that very high peak conditions occur, but, assuming that sufficient storage capacity exists during the off-peak hours, the average continuous cooling requirements can be assessed from the mean curve which is also shown for each month. The seasonal requirement, shown in Diagram 4, can be obtained by extrapolating the values given by the mean curves in Diagram 3.

This seasonal requirement, which is based upon the assumption that the plant works at full capacity throughout each 24 hours, storing refrigerating power during the night to meet the peak daytime load, gives the rated capacity of the plant required (German compressor rating with -10°C. evaporator temperature and $+25^\circ$C. condenser temperature). Modern practice, however, is to use larger capacity plant and to omit the brine reservoir which used to be installed to supplement the cold reserve in the brine pipes and rink beds. At the design stage, it follows that the period during which the rink is to be used has a considerable influence on the capacity of the plant required, e.g. a capacity of 120 kcal/m²/hr is sufficient for the period mid-

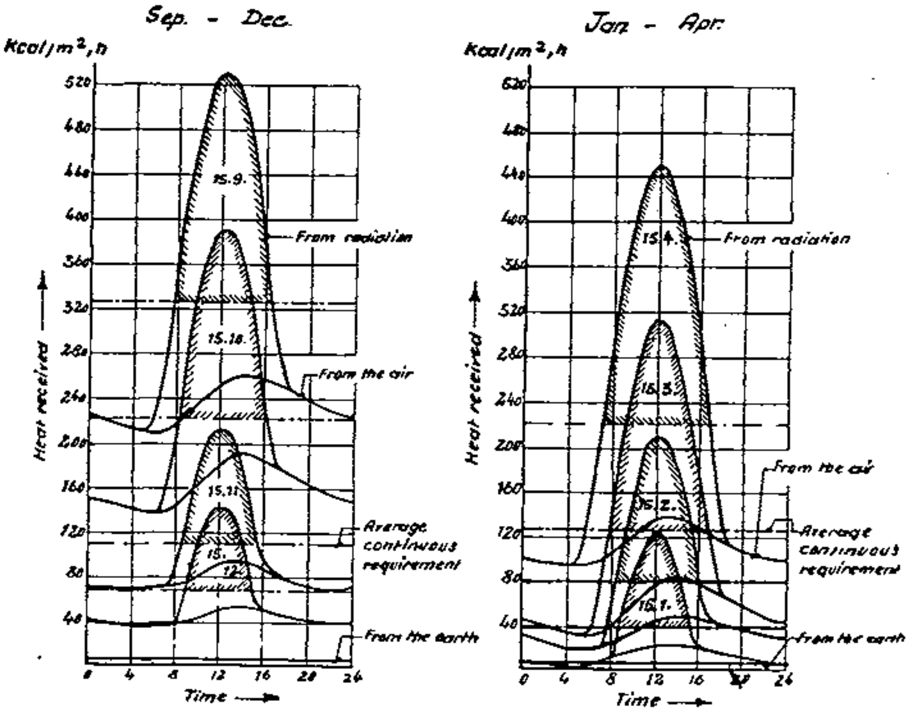


Diagram 3

Heat received by an open air ice rink during one day in each operating month.

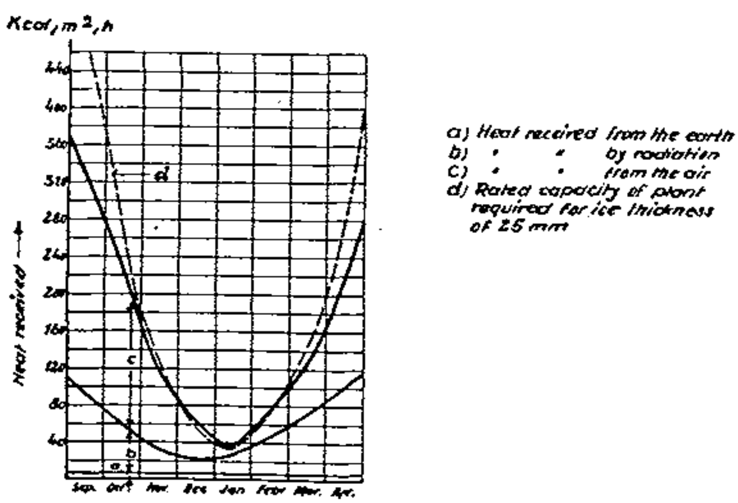


Diagram 4

Heat received and average plant capacity required by an open air ice rink.

November to mid-March whereas a capacity of 220 kcal/m^2/hr is required for full season mid-October to mid-April.

Rinks with ice surface as large as 10,000m^2 have been built, but the standard size now is dictated by ice hockey requirements and is 60 m. × 30 m. that is 1,800 m^2. When designing the rink bed the main consideration is to prevent or to absorb any movement of the earth under the ice surface. Various types of bed with either sand or concrete surface are in use, but with the former, care must be taken to prevent water seeping through it otherwise freezing will occur within the bed and damage may be caused by expansion. The relative advantages and disadvantages of the sand surface as compared with concrete are as follows:—

Advantages

(i) Cheaper and quicker to instal.
(ii) Cheaper to repair.
(iii) Better conductor, hence brine temperature need not be so low, and heat distribution to the ice is better.
(iv) Better cold reservoir.

Disadvantages

(i) Not suitable for out of season activities such as roller skating.
(ii) More difficult to clean. (Leaves and other debris collect in the sand during the summer months.)
(iii) Porous when not frozen allowing seepage of rainwater into the bed.

Details of construction of different types of bed are shown in Diagram 5.

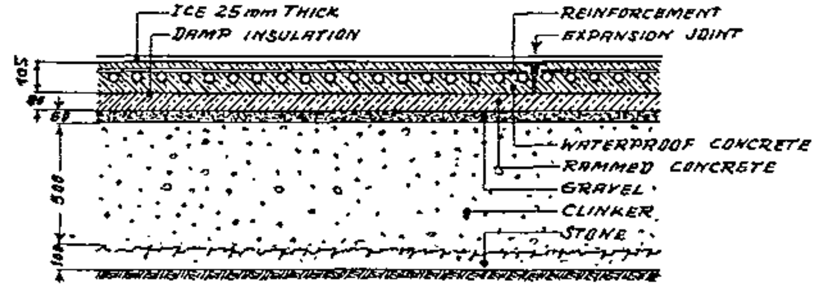
To ensure an even formation of ice throughout the rink, it is essential that the spacing of the brine piping is correctly arranged, and that sufficient brine is provided to maintain a temperature difference of not more than 1½°C. at the brine inlet and outlet. Usually the piping is arranged in four sections with both flow and return headers on the same side. By keeping both headers to one side, only one pipe duct is required, and since this must be large enough for a maintenance fitter to walk through there is a considerable saving in expense. By having four separate sections of piping it is possible to freeze each section in turn during abnormally high temperature conditions. In this connexion it should be noted that installed plant capacity is normally that required to maintain the ice surface and not that required to produce it. A typical piping layout is shown in Diagram 6 which also gives a schematic layout of the conventional ammonia refrigerating plant which is standard for most ice rinks.

Details of Construction

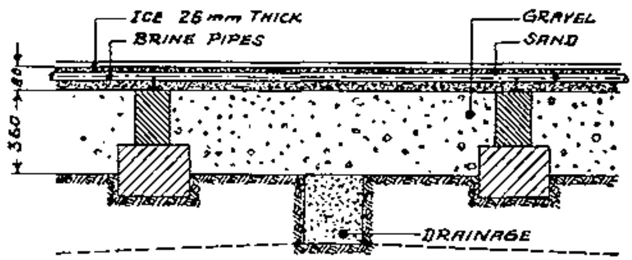
To save time, the first two rinks were constructed by different contractors. The technical installation work at Fort York was carried out by Gesellschaft fur Lindes eis Maschinen Ag (Linde) and that at Fort Prince of Wales by Brown, Boveri and Cie (B.B.C.). A description of the Linde rink is given in detail, but salient differences between the Linde and B.B.C. rinks are noted later.

Layout

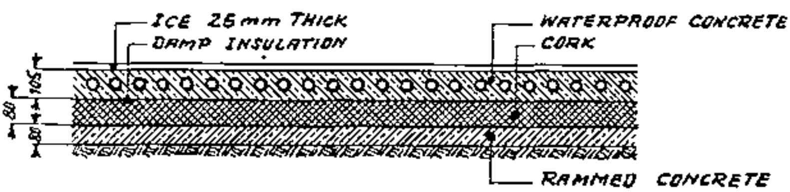
With the funds available it is not possible to provide "bleachers" on both sides of the rink. Only one stand was provided, which also housed the dressing-room and lavatories, and this was sited with the machine house to



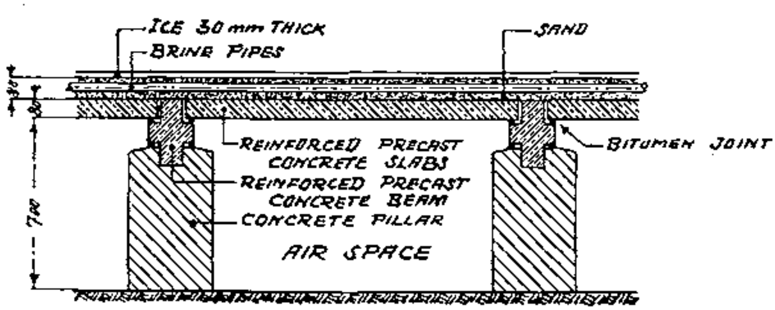
ⓐ PIPES IN CONCRETE



ⓑ PIPES IN SAND



ⓒ PIPES IN CONCRETE WITH CORK INSULATION



ⓓ PIPES IN SAND – SUSPENDED BED

TYPES OF RINK BEDS Diagram 5

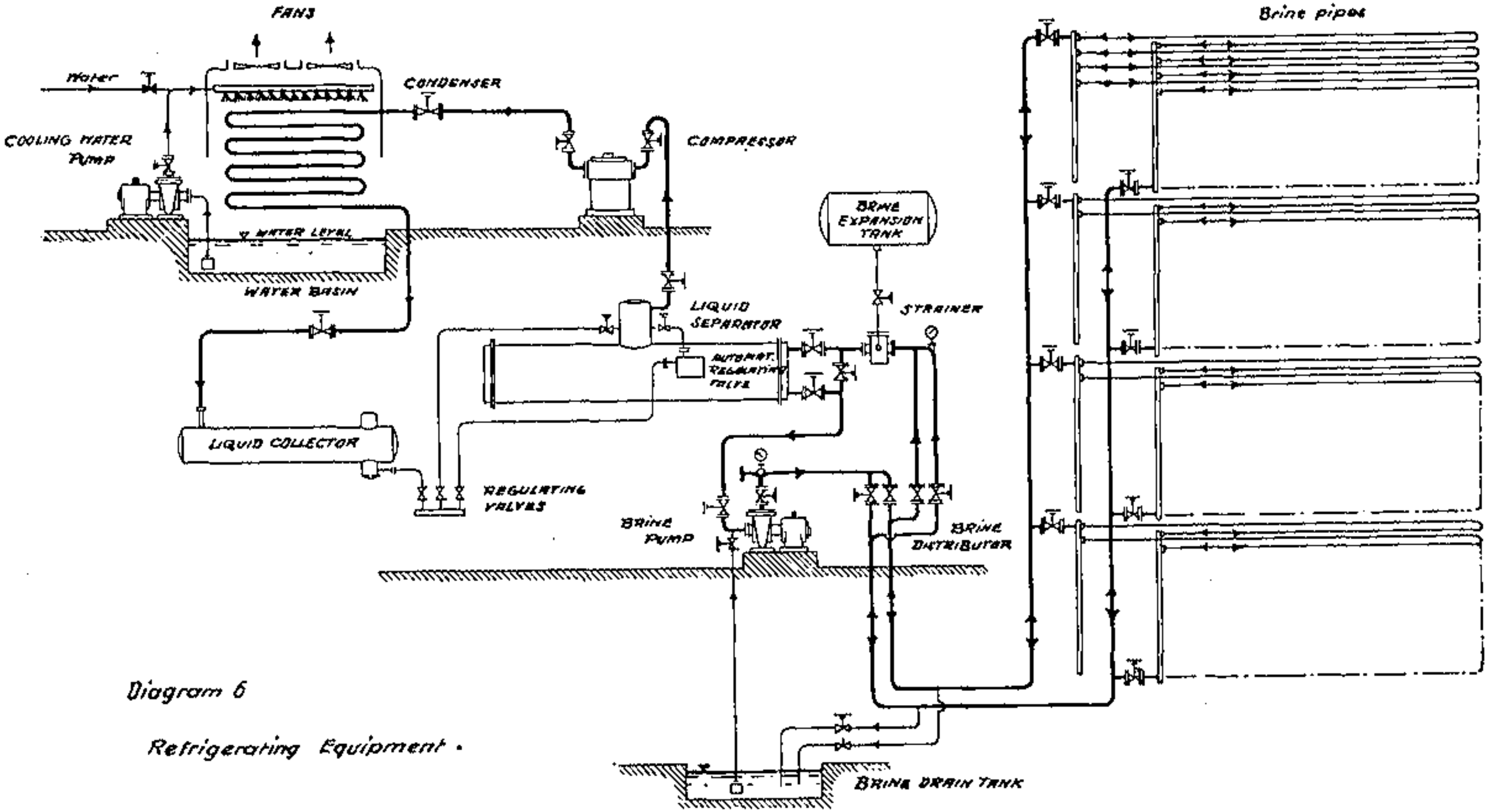
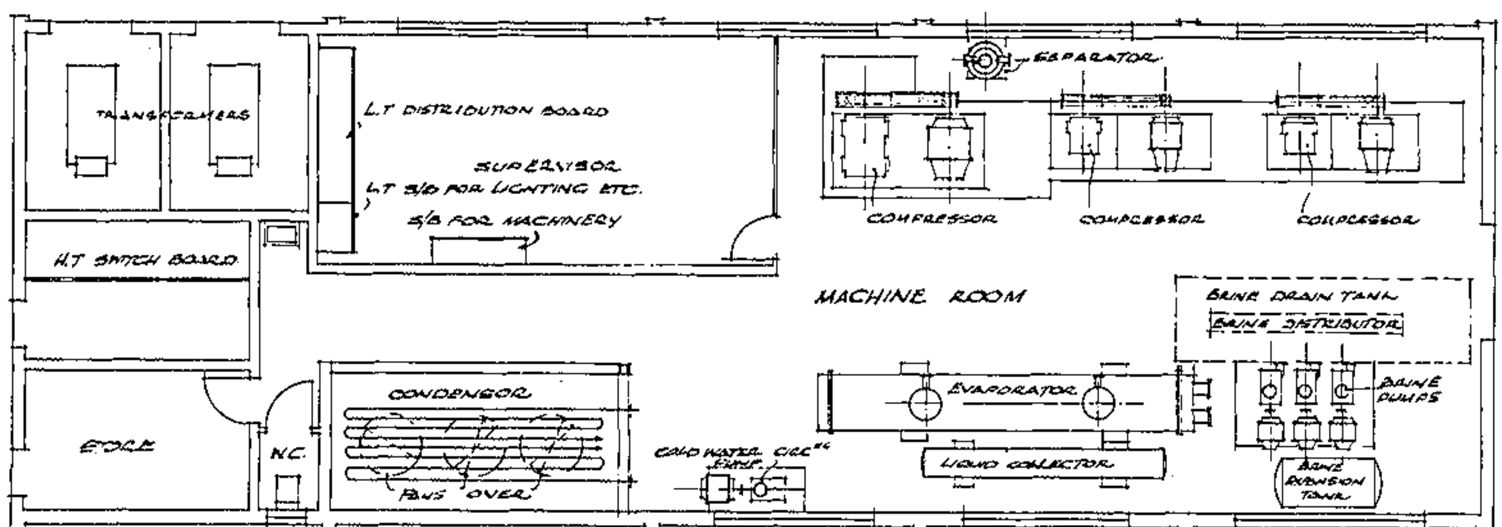


Diagram 6

Refrigerating Equipment.

•LAYOUT OF MACHINE ROOM FOR ICE RINK•

Diagram 7



protect the south and west sides of the rink. In this particular instance the north side is protected by the adjacent cinema and on the east side a bund was formed by the soil excavated from the header duct and rink bed.

Machine House

A plan of the machine house is produced as Diagram 7, which shows the layout of the main items of equipment.

Ammonia Circuit

The ammonia compressors are vertical double acting machines, one with a rated capacity of 420,000 kcal/hr and each of the other two with a rated capacity of 210,000 kcal/hr. These capacities are for inlet and outlet ammonia temperatures of − 10°C. and + 25°C. respectively, although the actual capacity in use depends on adjustable inlet valves so that the load can be varied down to about half full load, and also to permit off load starting. Driven by electric motors through multiple vee belts, they run at 500 r.p.m.

After compression the ammonia gas is led to an evaporative type condenser. This type was installed because it was estimated that the cooling water requirement for the ordinary tube type condenser might be as much as 60 m^3/hr. The condenser actually installed consists of closely packed bundles of tubes through which the ammonia flows, the upper row, being the warmest, is finned and cooled by air only, so as to reduce the amount of deposit from the cooling water. The remaining tubes are sprayed with water which is pumped from a collecting basin under the condenser, and make up water is delivered through a float valve to this basin. Three large fans are mounted above the tubes to draw air through them, and with this system the water consumption is less than 3 m^3/hr.

From the condenser, the liquid ammonia flows to a liquid collector and from there via the regulating valve and liquid separator to the evaporator. The regulating valve is of the automatic float type, but a by-pass is provided to permit manual regulation. The evaporator is fed from the bottom of the liquid separator and the suction line to the compressors is taken from the top to ensure dry compression.

The evaporator consists of a horizontal cylinder, normally filled with ammonia gas and liquid, containing a number of tubes through which the brine flows. It has an output of 560,000 kcal/hr equivalent to the combined actual output of the three compressors when working at a suction temperature of − 15°C. Provision is made for oil separation on both evaporator and compressors.

Brine Circuit

The brine flows in a closed circuit through the evaporators to the suction side of the circulating pumps, thence via the brine distributor and main flow pipe to the rink headers, through the rink piping, return headers, and main pipe back to the distributor, and thence to the evaporator. Three electrically driven direct coupled brine pumps are provided, each with an output of 135m^3/hr.

Uneven cooling is obviated by using the brine distributor, which allows the direction of flow of the brine to be reversed at will.

A brine expansion tank is provided at the highest point of the system and a brine drain tank is installed for use when the system is drained.

Ancillaries

To allow maximum use of the rink, a system of flood lighting has been installed. The rink is illuminated to an intensity of 15 ft. candles by means of 265 watt, high pressure, mercury fluorescent lamps suspended in ten rows, each of five lamps on catenary wires fixed to concrete pylons.

Maintenance of the ice surface is carried out with the aid of special equipment which includes:—

One ice planer.
One sweeping machine.
Four squeegees.
Eight steel scrapers.
Two water barrels with mobile spraying attachments.
Ten pairs crampons.

Also provided is a combined baro-thermo-hygrograph which records the weather conditions, and assists the operator to estimate the cooling effect required.

Comparison

The salient differences between the Linde and B.B.C. installations are as follows, but for full details see Appendix A. With the B.B.C. installation:—

(*a*) The compressors are single acting and water cooled,
(*b*) there is no air-cooled finned tubing in the condenser,
(*c*) there is no liquid collector,
(*d*) the evaporator has twin cylinders,
(*e*) there is no brine distributor,
(*f*) there are only two brine pumps.

Costs

A breakdown of the cost of the Linde rink is roughly as shown below:—

Refrigeration plant including rink piping	£27,100
Building work, rink and machine house	£17,800
Building work, spectators' stand and changing rooms	£11,500
Electrical sub-station	£2,900
Lighting and heating installation	£1,500
Site preparation	£2,400
Externals (water, drainage and H.T.)	£1,700
Ancillaries	£700
	£65,600

Time for construction

From the moment that site preparation began the time taken to produce an ice surface was just over 4½ months. Owing to the delay in finalizing the design of the spectators' stand this was not completed until six weeks later, so that the over-all time for constructing the complete rink equipped with all the paraphernalia required by the ice hockey enthusiast was six months.

APPENDIX A

Comparison of the Two Installations

Item	*Linde*	*B.B.C.*
Compressors		
Number	Three	Three
Rated capacity kcal/hr − 10° to + 25°C.	1 × 420,000 2 × 210,000	1 × 320,000 2 × 160,000
Actual capacity kcal/hr − 15° to + 30°C.	1 × 280,000 2 × 140,000	1 × 250,000 2 × 125,000
Cylinders	1 × 2 2 × 1	1 × 8 2 × 4
Cooling	Air	Water
r.p.m.	500	950
Drive..	V belt	V belt
Motor h.p.	1 × 153 2 × 85	1 × 147 2 × 67
Motor r.p.m.	1 × 1,465 2 × 1,450	1 × 1,480 2 × 1,450
Condenser		
Type	Evaporative	Evaporative
Rated water cons.m³/hr	3	3.3
No. of fans	3	3
Air output m³/hr each	25,000	40,000
Motor h.p. each	5	8.8
Pump output m³/hr..	75	140
Pump head metres	11	12
Pump motor h.p.	8.2	14.7
Evaporator		
Type	Single cylinder	Two cylinder
Capacity kcal/hr	560,000	500,000
Brine pumps		
Number	3	2
Output m³/hr. each	135	175
Head metre	20	20
Speed r.p.m...	1,450	1,450
Motor h.p.	20	30
Brine piping in rink		
Outside dia. mm.	38	38
Distance apart centre to centre mm. ..	90	100
No. of pipes	666	600
Effective length km.	20	18

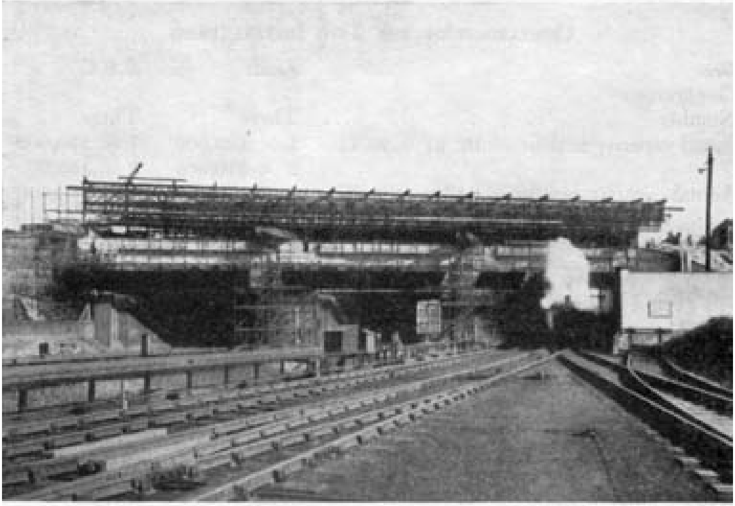


Photo 1. View from the south side showing full bridge together with the Bailey above.

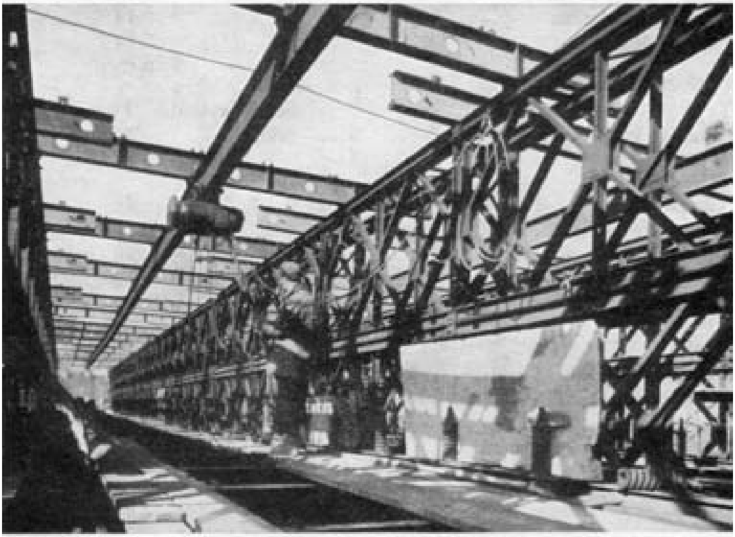


Photo 2.—General view along centre span. The suspension springs can be clearly seen.

Unusual Use Of Bailey Bridging Equipment 1 , 2

An Unusual Use of Bailey Bridging Equipment

By D. L. Roberts (late R.E.)

Introduction

The following article is an account of the use of Standard Military "Bailey Bridging" Equipment to carry out a job in civil life which is probably unique, both for the type of job and the manner in which the bridge is employed.

The writer was fortunate enough to be in the happy position of having had previous experience of Bailey equipment and had the opportunity to put to good use knowledge gained during "Sapper Training", both in regard to the planning of the bridge and subsequently teaching the men on the site erection procedure.

Description of Contract

The contract on which the equipment is being used is the reconstruction of the superstructure of a three-span bridge carrying the "Northern Outfall Sewer" over the main line railway tracks (steam and electric) between West Ham and Plaistow stations in the East End of London.

The Northern Outfall Sewer consists of five brick sewers, each some nine feet in diameter, which run side by side in a "sewer bank", above ground level, for several miles across East London, on their way to the outfall works on the Thames at Beckton. Generally speaking, where roads and railways intersect the path of the sewer bank, the former go over the top and the latter underneath and where this occurs the construction of the sewer changes from brick to cast iron.

Three of the sewers were built in the year 1860, a further two being added in 1909, and as the size of London has grown so has the volume of sewage, until today, particularly in the case of heavy rain or thunderstorms over North London, the sewers run to capacity.

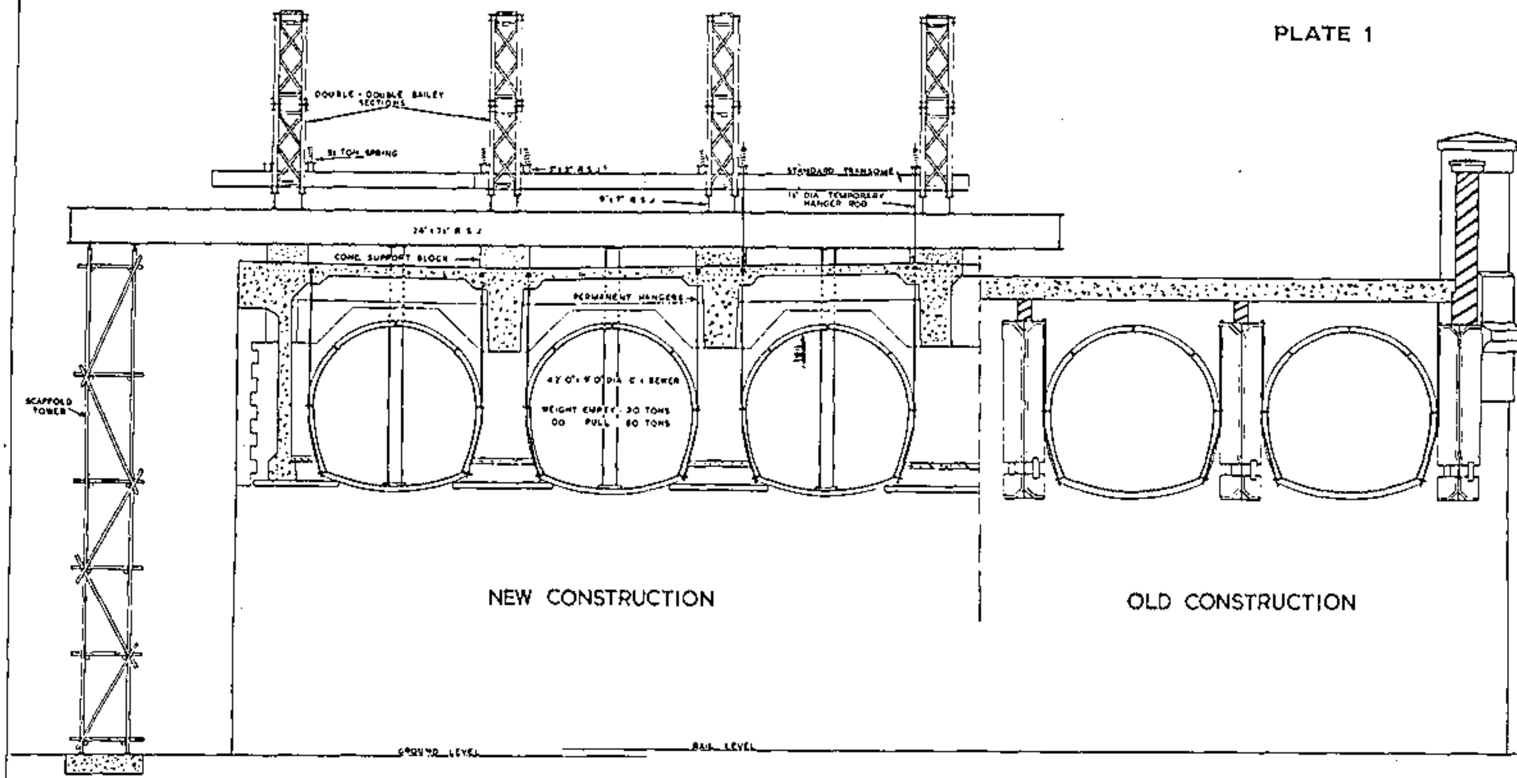
The particular bridge with which we are concerned has each of the five sewers split into three independent spans of 42 ft. each, formed of bolted cast iron segments, with gaps of some 7 ft. over the two piers where the sewer is formed in the brickwork of the pier. Since the sewers are not by themselves capable of spanning the tracks they are suspended by a series of "hanger-rods" from the top flanges of 10 ft. deep wrot iron plate girders, which also act as supporting beams for the decking to the roadway above. (See Plate 1.)

Because of the general deterioration of these girders and the iron decking it became necessary to reconstruct the bridge from the invert level of the sewers and the seating level of the girders, and it was decided to carry out this work in reinforced concrete.

Considerations Affecting Method of Working

The main consideration governing the method of carrying out the works was the fact that only one sewer out of the five could be closed for long periods (except that the closure of a second sewer for periods not exceeding 48 hours at a time was permitted, provided the weather conditions were favourable) and this meant that the sewers must be kept "live" and the flow of sewage catered for.

PLATE 1



SECTION

RECONSTRUCTION OF SEWER BRIDGE - PLAISTOW.

The major problem was obviously "How to support the sewers (with sewage) while the existing girders were removed and replaced by reinforced concrete beams", and the obvious answer was "prop-up from underneath". Two further considerations ruled this out however, one, that none of the spans could be closed to rail traffic (except for periods of $3\frac{3}{4}$ hours during the night) and two, that no reduction of the existing headroom was permitted, since this was already less than the Ministry of Transport Standard requirements, and likewise, there was no available room between the sides of the tracks and the bridge—indeed, on one span, the bridge pier had been chased to allow the necessary clearance for the door handles on the District Line trains! The only solution was therefore that the sewers must be hung from above, together with all the formwork, reinforcement and concrete during the re-construction.

As vehicular and pedestrian traffic had also to be catered for over the bridge it was decided to tackle the job in two stages of three sewers and two sewers respectively. The loadings of each of the 42-ft. spans was 30 tons when empty and 80 tons when full, which meant that in the first stage of the job, suspended loads of over 700 tons were being dealt with, without taking into account the formwork and concrete, a further 500 tons. These loads would also fluctuate as the level of the sewage rose and fell during each 24 hours.

Obviously some form of bridge over the existing bridge was the answer, but a further limitation was the fact that the permitted loadings on the sewer bank were a mere 4 cwts. per sq. ft., which meant that if a single bridge of 150 ft. span were used, the problem of coping with the end loadings at the bank seats would be almost insurmountable. It was decided therefore to split the bridge into three spans of 50 ft., and to sit the ends of the bridges on girders, spanning from a pier outside the limit of the bridge to the section of bridge to be reconstructed in the second stage of operations.

Why Bailey Bridging Equipment?

The problem then was "What kind of a bridge"? and since it was quickly realized that due to a fluctuating loading any bridge of ordinary dimensions would have a variable deflection under loading, while the sewers were almost rigid and incapable of any real deflection without breaking, here were two problems in one. Further consideration also showed that heavy constructional steelwork with cranes for handling was out of the question due to the bank loading limitations, and that some form of light, rigid, easily handled and erected component structure would be ideal, and even more so, something that was readily available "ex-stock" and not in two years' time. From this moment on "Bailey bridging" was the answer.

Design and Layout of Temporary Works

"Double-double" girders were selected and calculations showed that, under the range of loadings to be applied, a deflection of $\frac{3}{8}$ in. could be expected—this incidentally, was allowing for the use of the then little known "expanding type panel pin", which is a taper-pin inside a split-sleeve and pins adjoining panels together without the "play" which the standard "slack" pin allows. Nevertheless, $\frac{3}{8}$ in. was considered excessive and as going into "triple-double" or "triple-triple" did not appear to be the answer, some means of compensating for this deflection had to be found.

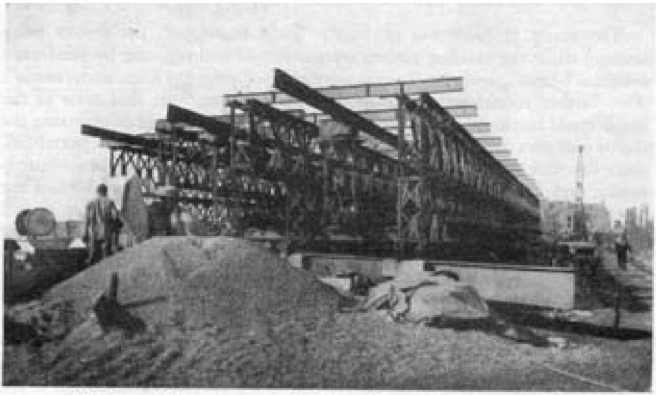


Photo 3.—View from one end of the bridge showing concreting plant.

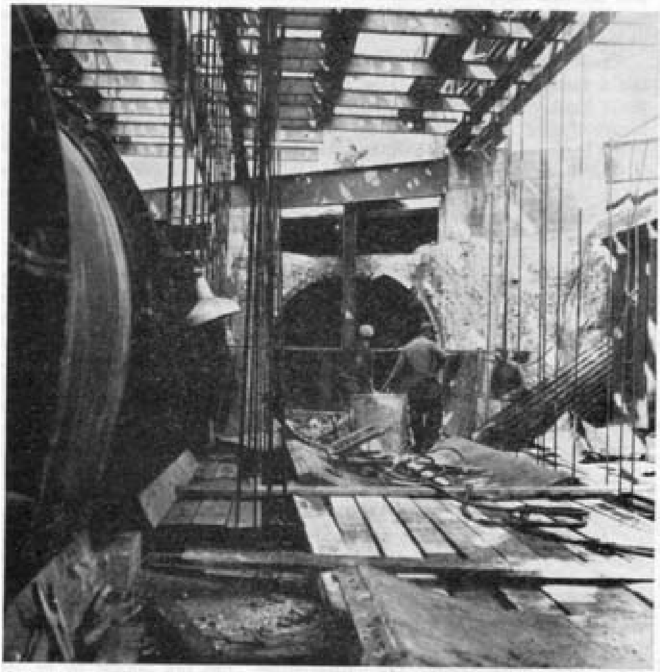


Photo 4.—Demolition of the third sewer almost complete. A rebuilt sewer is on the left. A "shutter-sleeve" can be seen in position. One of the existing wrot iron girders is on the right.

Unusual Use Of Bailey Bridging Equipment 3 , 4

It was at this stage that the idea of using spring washers was born and this proved to be the right idea. Compression springs were designed, which were 11½ in. long when open and 9½ in. closed, an operation that required a load of 5½ tons. As can be seen in Plate 1 and Photo 2, these were incorporated on the tops of the "hanger-rods" and transmit the sewer loads via 5 × 3 in. R.S.J.s to the transoms and Bailey girders.

Function of the Springs

As each pair of sewer hanger-rods is disconnected from the existing bridge girders, an extension piece is fitted and the load transferred to the Bailey overhead, by screwing up the nut on top of the rod, thereby closing the spring. The amount which the spring is closed is carefully calculated so that when the sewer is empty, a considerable "upward pull" is exerted, which tends to lift the sewer off its seatings and at the same time deflect the Bailey. Further loading of the sewer causes it to transfer its own load, together with a proportion of the added load, back on its seatings, the deflection on the Bailey remaining constant. The springs also enable this calculated upward pull to be measured by closing them to the required length, a calibration chart having been prepared from results obtained by testing the springs.

The other function of the springs is that when the shuttering and wet concrete loads are hung from the Bailey, further deflection is caused, but as the Bailey deflects, so the springs open out to accommodate this, loosing only one-third of a ton for each eighth of an inch they open. If, during concreting the Bailey had deflected appreciably, the springs could have been steadily tightened to cater for this, but in practice the further deflection has been found to be less than one eighth of an inch, so that the springs are not altered.

Other Complications

Due to the non-standard use of the equipment, several other problems were encountered but rapidly solved, and working from the hanger-rods outwards they were as follows: *firstly*, the Bailey girders were required to be a distance of 12 ft. apart and staggered to suit the "skew" of the bridge, so that only at one end of the transoms could a standard transom clamp be used, the other ends being secured by "Lindaptors"—special clips enabling any steel sections to be bolted together without drilling or otherwise altering the sections. *Secondly*, because of the skew, end-posts could not be used without special brackets of some kind being fabricated and attached to the cross supporting girders. To avoid this, and because the bottom chords of the panels would have failed in shear under the loads applied, 9 × 7 in. distribution joists were attached to the bottom chords as shown in Plate 1—lindaptors being used. *Thirdly*, sway braces could not be fitted due to the altered spacings, and as some form of brace was felt to be desirable, transoms were clamped at intervals across the tops of the girders—a runway later being suspended from these and electric hoists used for removing the demolition and placing the concrete. *Fourthly*, the heaviest cross girders which were readily obtainable to take the ends of the Baileys were 24 × 7½ in. R.S.Js. and as these were not capable of carrying the loads without intermediate supports, steel columns were used, which seat on the inverts of the sewers over the abutments and piers. When the concrete beams directly under the Bailey girders are poured, the total load amounts to some 92 tons (100 tons being the safe maximum load) and to take this loading temporary concrete supports are put in off the new work and directly under the ends of the Baileys. *Fifthly*, the flow of sewage across the 7 ft. gaps between spans had to be catered for and to this end special steel "shutter-sleeves" were designed and fabricated. In practice, so that the brickwork dividing two sewers over the piers and abutments can be cut away and replaced with concrete, the second sewer is shut down for 48 hours and a hole knocked in the brickwork of the crown to gain access. The sleeves are lowered in in sections, rapidly put in place and bolted up and the sewer returned to use. The demolition then proceeds round the sleeve which also acts as a shutter for the pouring of the concrete, entry to the sewer being made later and the sections removed.

Additional Works

Shortly after work began on the bridge and when the decking had been stripped away, the 1860 sewers were found to be badly worn in places and renewal was decided upon. In order that work could proceed during the daytime, R.S.Js. were suspended under the barrels and between the flanges of the sewers, decked-out in the gaps and demolition and reconstruction proceeded with. The sewers were erected sitting on the suspended R.S.Js. while some 1,100 trains carrying over 270,000 passengers per day, passed only inches below.

The first stage of the reconstruction is now almost complete, so that the two following problems are expected to be the last. Namely the transfer of the loading from the Bailey bridge to the newly constructed bridge and the transfer bodily sideways of the Bailey and R.S.Js. to their new position for the second stage of the works.

The former is a problem for the following reason. Assume that the hanger-rods are disconnected from the Bailey and bolted to the new bridge one at a time, working from one end along any beam. By the time the load of the centre rod is transferred the concrete beam will have deflected under the loadings and unless the sewer deflects a like amount, the rods already connected to the beam will no longer be carrying any load—a state of affairs which would let the sewer "break its back". In order to avoid anything of this nature, the springs will be incorporated initially on the hanger rods so that results can be examined.

The latter is a problem for the reason that dismantling and re-erecting seems to be time wasting and costly job and the moving sideways *en-masse* by far the quicker way. Unfortunately, the writer's sapper training did not include the answer to this one, but one or two ideas have already been worked out.

The work is being carried out for the London County Council under the direction of Mr. J. Rawlinson, Chief Engineer, and Mr. F. M. Fuller, Divisional Engineer. The contractors are Wilson, Lovatt and Sons Ltd. of London and Wolverhampton.

The Photo-Reconnaissance Section R.E.

By Major-General C. H. Foulkes, C.B., C.M.G., D.S.O. (Retd.)

On the inside of the arch of the South African War Memorial at Chatham the names are inscribed of all the R.E. units that took part in the Boer War. The last name on this list is the Photo-Reconnaissance Section and it is doubtful if many present members of the Corps can explain its appearance there.

Years before that war, and before men flew in aeroplanes, photographs had been taken from free and captive balloons; and on land, undeveloped countries had been surveyed rapidly and economically with the rather elaborate Bridges-Lee camera. But photographic ground reconnaissance on active service was carried out for the first time in history by a Royal Engineer unit in the Boer campaign.

When this war broke out I was on leave from Sierra Leone, and as the prospect of being sent out to South Africa, except in one of the regular units, seemed remote I thought that it might be possible to create one of my own for the purpose.

I had learnt photography at "the Shop", where "the Captain"* was always anxious to serve as a model, and I took it up seriously in West Africa. So I wrote a memorandum to the War Office pointing out that photographs had great advantages over the free-hand sketches with which officers were being taught to illustrate their reconnaissance reports, and that the necessary equipment was practical and portable: it could, in fact, be carried on a couple of bicycles. Hand cameras had come into use, so that the cumbersome tripod could be dispensed with: orthochromatic plates (or, better, cut films, to save weight) when used with a light filter reduced the harmful effect of atmospheric haze in landscapes; while, by employing the telephoto lens, too close an approach to a hostile position could be avoided. Photographs were exact representations, free from "artistic licence",† and they could be quickly reproduced in any number. Papier-mâché dishes, tabloid chemicals and gas-light printing papers took very little space, and I had exposed a plate, developed it and printed from it (wet) all in the space of seven minutes—a time, of course, which has been much reduced with the photo-finish apparatus now used on racecourses.

My camera was a 5 × 4 twin-lens Newman and Guardia, a sturdy instrument scientifically constructed for use in the tropics. It had T spirit levels sunk in the body, and a central horizontal line drawn on the focusing screen, so that if the compass bearing of any recognizable object was noted, a quite useful survey could be plotted from panoramas taken at both ends of a measured base. The telephoto negative element was mounted on a short

*A dwarfish character of mysterious antecedents who had been allowed for years to attend all parades, standing at attention on the sideline, in a bowler hat and with a cane tucked under his arm.

†There was an amusing example of this licence a few months later when one of the London illustrated journals published a double-page drawing by a famous artist (Caton-Woodvillle, I think) of the Boer position at Paardeberg. It showed a line of towering cliffs, whereas actually our infantry had to attack slit trenches in the banks of the Modder River across 1,000 yards of practically dead flat country.

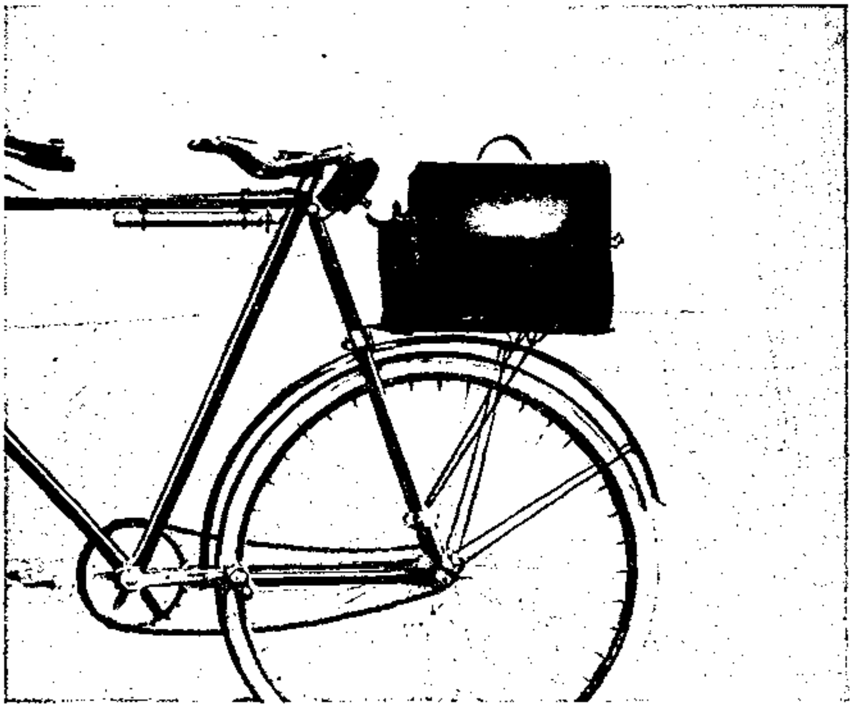


Photo 1.—Photographic equipment on bicycle (showing camera and daylight changing bag).

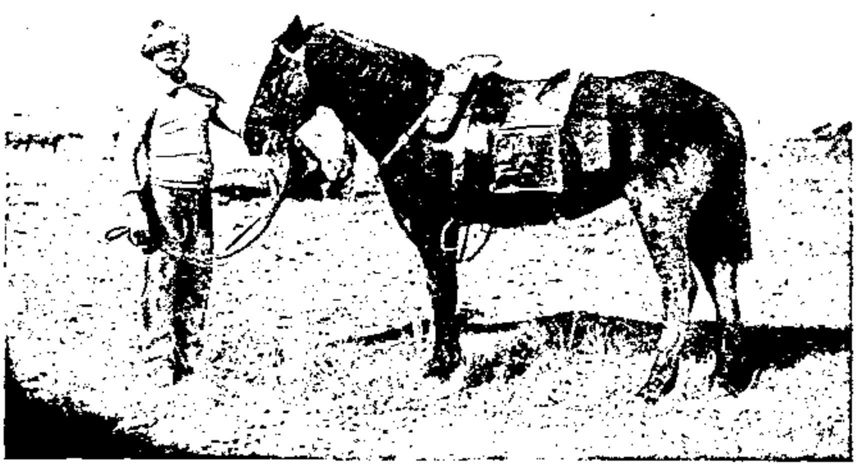


Photo 2.—Photographic equipment carried on saddle.

extensible aluminium tube screwed, when required, into the back of the camera lens: and this tube had the figures 2, 3, 4 marked on it to indicate the magnifications that would result at these extensions. There were corresponding marks on the extension of the camera bellows, so that with both set at the same figure, accurate focusing could be ensured automatically: otherwise it would have been slow and difficult owing to the loss of light. Small rectangles marked with the same figures in the centre of the focusing screen showed the areas of the image which would fill the whole plate when the telephoto lens was in use.

To my surprise I was summoned to the War Office—a rambling converted building in Pall Mall, where the Automobile Club now stands. I took my bicycle, with the camera strapped on the rear carrier, into the room occupied by General Salmond—a good friend to all R.E. subalterns. He led me along a narrow dark passage to the Adjutant-General, Sir Evelyn Wood, telling me to shout at him as he was very deaf; and he in turn took us both to the Commander-in-Chief. But Lord Wolseley was too busy to consider the proposal and he asked Sir Evelyn to use his own judgement in the matter. A little while before this I had sent to the War Office some good photographs of the coast batteries at Dakar, taken from my passing steamship, and Sir Evelyn said to me "Well, my boy, you did us a good turn just now and I am going to do one for you": and so it was settled. Although I already possessed all the necessary equipment Salmond insisted on writing me a cheque for £100, and with this I had two new bicycles painted khaki colour and bought two Mauser pistols to strap on their handle-bars, as well as a *tente d'abris* and a few odds and ends. A second leather case on the carrier of the other bicycle would contain enough materials for several months' work (see Photo 1). I asked for a photographic assistant to help me with developing and printing and Corporal Ford was detailed from the S.M.E. He and I formed the Photo-Reconnaissance Section R.E. and we left the country five days later.

At Capetown I asked to be attached to the Cavalry Division which was then operating on the Colesberg front, but soon after we arrived I realized that cycling would be difficult on the sandy roads and veldt if I was to keep up with mounted troops: so I obtained an Argentine pony from Remounts and had saddle-bags made to hold my camera on one side and a full nosebag on the other as a counterweight (see Photo 2). I reported to Sir John French, but both he and Colonel Haig seemed highly amused at this queer War Office idea and they were unable to help me in any way—for instance in finding me a batman: they did, however, promise to let me know when any cavalry reconnaissances were planned.

Ford and I shared the *tente d'abris* (which also served as a dark room at night) and we drew our bully beef and the hardest ration biscuits that can have ever been supplied to an army, as well as fodder for the horse which I tended and groomed somewhat inadequately. To add to our discomforts there was a scarcity of water, and frequent sandstorms swept across the camps, while the swarms of flies that were attracted to the horse-lines made any occupation difficult that required the use of both hands simultaneously. I even had, on one occasion, when I went by train to De Aar to collect chocolate boxes for Ford and myself—Queen Victoria's New Year gift to the troops—to tether my horse to the railings outside Naauwpoort station and pick it up again on my return two hours later.

Photo 3.—Boer position around Colesberg.

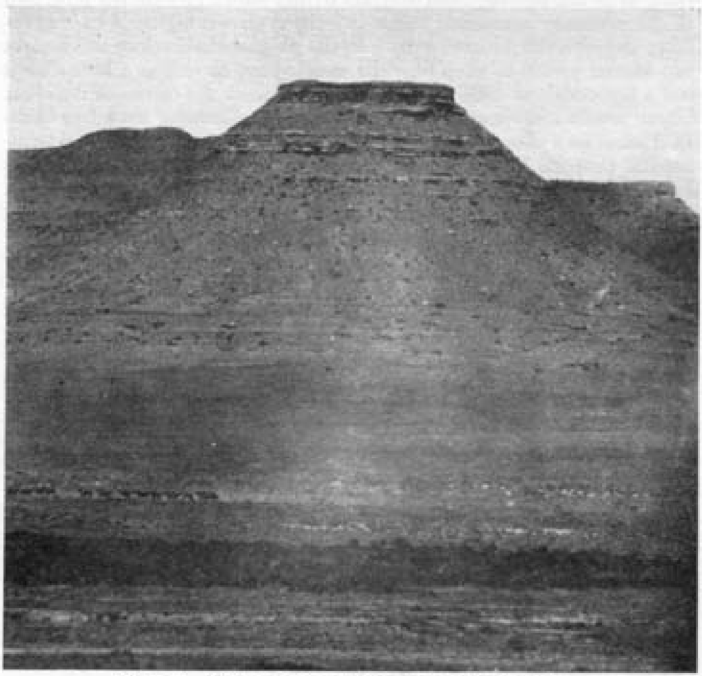


Photo 4.—Colesberg reconnaissance—telephoto of Coleskop.

The Photo Reconnanisance Section RE, 3 , 4

French's instructions at this time were to threaten the Boer communications, without committing his small force seriously, in order to ease them out of any prepared positions and make them believe that the main British advance was planned on this front. I accompanied many excursions, sometimes far behind the Boer front, and was once for several days with Rimington's Guides (the "Tigers") in which Major Gale, R.E. was serving as second-in-command. There was little of value to record on these expeditions except railway demolitions, details of which were urgently wanted by the Director of Railways, but I believe that Major Lawrence, French's Intelligence Officer (whom I met again in 1918 when he was C.G.S. in France) used some of my photographs for illustrating his dispatches. Once, when about 2,000 Boers were firmly established at Taiboschlaagte, before they retired to Colesberg, our cavalry picquets held a line of kopjes that flanked the Boer position and faced the road and railway line between Arundel and Rensberg. About two miles beyond our front, a demolition on the railway line was visible through field glasses and I wanted to get information about it to enable repairs to be carried out without delaying our advance. I still had my bicycle and told the outpost commander (of a squadron of the 6th Dragoons under Major Allenby, to whom Prince Alexander of Teck was attached) of my intention. The Boers must have been puzzled when they watched me bumping at full speed over the railway sleepers, and when I reached a point opposite the centre of their position, and about 1,500 yards from it, I photographed and made notes of the demolition while a few rifle shots were fired at me from long range. (This demolition consisted only of about sixty yards of the line being overturned and twisted.) I then took a panoramic photograph of Taiboschlaagte and noted where sangars were visible on the skyline, etc., and was preparing to fit in the telephoto lens to record a "nek" in which a field gun was supposed to be mounted when a small party of Boers began to gallop in my direction; so I had to pack up hastily and ride back under cover of the fire from the Inniskillings. On another occasion, after the Boers retired to Colesberg and occupied a strong position covering that town, I rode across the veldt towards it as near as I dared, spent about five seconds in photographing it from the saddle and got back unharmed (see Photos 3 and 4). There was another railway demolition unpleasantly close to the Colesberg kopjes, but out of our sight. A supply train standing in Rensberg station had had its brakes released one night by a kaffir sent in by the Boers, so that it slid away unobserved for four miles down a gentle slope until it was derailed at a culvert at Plewman's Siding, where it was looted at leisure and then burnt. I was under cover most of the way while I cycled to this spot, and also after I reached it. I photographed the debris and measured the girders and their span while rifle bullets rattled against the steel and woodwork overhead, after which, during a lull in the fusillade, I made my way back at full speed.

Boer marksmanship was, I think, greatly exaggerated, and at long range it was very poor. Perhaps they excelled in snap-shooting at point-blank range, as when after game and in their assaults at Majuba and Spion Kop, but I doubt if they ever reached the standard of our own regular infantry at the beginning of the First World War, which resulted from the policy of rewarding skill on the ranges with increases in the men's pay. In the wide turning sweeps made by the Cavalry Division in its advance on and beyond the Boer

Photo 5.—Modder River reconnaissance. Nels Drift.

Photo 6.—Modder River reconnaissance. Demolished Glen railway bridge.

The Photo Reconnanisssance Section RE, 5 , 6

Capitals, men, twenty yards apart, moved forward in a succession of lines that stretched almost to the horizon, and though they came under fire every day for weeks at a time I never remember seeing any men or horses hit. On one occasion, when I was taking my turn as galloper for the Field Troop with French's staff, the general remained mounted as he examined a line of kopjes in enemy occupation—Haig using a telescope and seeming to be restraining his chief's impetuosity—while bullets from several makes of rifle whined either wide of the group or overhead. Nobody was hurt during the ten minutes that we spent there, motionless, which was the more remarkable because French was as usual accompanied by about one hundred men, escort, A.D.C.s, gallopers, interpreters, etc.

Photographic work of the kind described went on during French's occupation of Coleskop and on the advance to Kimberley, Paardeberg and Bloemfontein, but I found myself being gradually absorbed into the Field Troop under Hunter-Weston, and as this interfered with my special work I asked the Chief Engineer at Cape Town to transfer me to the Natal front. Orders to this effect actually came through, but French claimed that I could not be spared and the move was cancelled.

During the halt of several weeks at Bloemfontein I was sent to reconnoitre the Modder River front, about fifteen miles beyond that town. We spent four days over this and covered 120 miles, Ford driving a Cape cart which I had acquired. As the compass was unreliable I had to sketch the country entirely by eye, timing the horse and estimating the distance and direction of prominent objects and intersecting them in the same manner from points farther on. I photographed the six "drifts" which might have to be crossed in our next advance and noted the work that would have to be done on them to ease the approaches, remove boulders and fill in holes, to improve them for wheeled traffic (see Photo 5). (One photograph was of a major demolition of the Glen railway bridge, see Photo 6.) There were no British troops on the river at this time, though Karee Siding, 7 miles beyond it, was occupied in force a few days later. We observed a few solitary riders in the distance but we were not interfered with, even when bivouacked at night near the river bank. The sketch of the country between Bloemfontein and the Modder River mentioned above, as well as another similar reconnaissance north of Pretoria, are in the R.E. Museum at Chatham.

By this time I had been taken on the establishment of the Field Troop and was given command of Russell-Brown's section (now called a troop, the whole unit having been renamed a squadron) when he was wounded. Mozley and Charles—later the Chief Royal Engineer—were the other two subalterns. We were present at the action at Diamond Hill, after which my troop was detached to accompany Broadwood's Brigade which helped in the capture of Prinsloo with more than 4,000 men at Bethlehem, and then took part in the (first) pursuit of De Wet. I was appointed Staff Captain for Intelligence with this force, in addition to my other duties, but after about a year my further service in South Africa was cut short by a peremptory recall from the War Office to complete the second half of my tour of service duty in Sierra Leone, where I was long overdue. Meanwhile Ford had accidentally wounded himself when cleaning his Mauser pistol and he was evacuated. I believe that he became later, Warrant Officer Instructor in photography at the S.M.E.

From Sierra Leone I sent a fully illustrated report of our work in South

Africa to the War Office. I do not know if this influenced army practice, but during the First World War I noticed that the long panoramic photographs of German trenches that lined the operations rooms of Corps and Divisional headquarters were taken with a telephoto lens, magnification × 4, and were printed on 5 × 4 sheets. Perhaps, too, Ford and I were pioneers of the field photographic units which take part in all modern campaigns, for none of the war correspondents with the Cavalry Division had cameras with them and they pestered me for prints from my pictures of camp life. Among them were Mortimer Menpes and "Banjo" Paterson;* the latter had been nicknamed "the Australian Kipling" and he was attached to the New South Wales Lancers and represented a Sydney newspaper. He became famous, later, as the author of "Waltzing Matilda", the battle song of the Australians in the first war. Mr. C. S. Goldman also obtained permission to use a number of my photographs to illustrate his book *With General French and the Cavalry Division in South Africa.*

I think that the experiment in the Boer War was considered a success, because soon after completing my West African tour I was invited to reconnoitre a strongly-fortified tropical island, the mysteries of which had so far defied investigation. This involved work similar to that in South Africa and I used the same equipment, but it was concerned with coast batteries and their armaments, a subject with which I was familiar from my duties in Freetown. Though I did not have to operate under fire on this assignment I had to act with the greatest circumspection, because the sight of a camera aroused immediate suspicion in this area and any unusual activity was closely scrutinized. I spent three months there and took more than 200 photographs, many of them with the telephoto lens. When this report was received another and more ambitious project was suggested which I had to decline for family reasons: otherwise I might have continued in this kind of employment for years—or at any rate until I found myself in a concentration camp.

The camera I used proved to be ideal for reconnaissance work in the field. The reflex, which succeeded the twin-lens, was smaller, but not so sturdy, because of its delicately-balanced movable mirror viewfinder, while the miniature cameras that are now so popular, such as the Leica, would have been quite unsuitable. My camera (later fitted with double dark slides for colour photography) survived many years of rough use in the tropics, as well as a glancing kick from a mule in the Khyber Pass. One of its spirit levels burst from the terrific heat on the rocks while I was photographing the Boussa rapids on the Niger (where Mungo Park lost his life), but the instrument is now as serviceable as when new, though I doubt if it would fetch £5 at a second-hand sale.

* His claim to this title may be judged from the following verses which he scribbled in my notebook one day—on the spur of the moment and without a single correction:—

"No class"

Oh, when we took Pretoria we thought the war was done.
We thought we'd do some marchin' past and finish up the fun.
But walkin' all round Africa a'trampin' down the grass
In chase of Christian De Wet—well that's *no class.*
For where we go and what we do is hidden from our sight
We 'ave to work, we 'ave to starve, we 'ave to rouse and fight
I think I'll start and write a book to make the journey pass
"With Hunter off to Hell and back—Return No Class".

The R.E. Headquarters Mess —A Postscript

By Colonel J. M. Lambert, O.B.E.

Photographs Nos. 1–4 here reproduced were sent to me by a reader of the article "The R.E. Headquarters Mess" published in the March, 1957, Journal.

Photograph No. 2 is known to have been taken in 1922 or 1923. The others do not bear any date, but they are old enough to be of considerable interest.

Photograph No. 1 is of the dining-room before the addition of the North and South Annexes.

The fireplace in the south wall was presumably matched by a similar one on the other side of the "Band Alcove" which is just outside the photograph. In the north wall there was probably one large window in the central arch, opposite the "Band Alcove". The ceiling in the photograph is a different design from the existing one (see Photo No. 2) and for this reason it seems possible that the photo dates from before 1874 when the original ceiling was destroyed by fire. Another pointer to an early date is the fact that there appears to be no electric light or gas; the brackets on the walls are for candles which would be renewed each evening.

The following can be identified in the photograph: the portraits of Queen Victoria and Prince Albert; these now hang in the North Annexe: the sideboards below the pictures; these are now between the pillars of the south wall: "Gordon's Throne" (acquired in 1860 or 1861); this is now in the same position: the chairs, the majority of which are still in use but have been reseated; the china pots for flowers, etc.; these are still used for the same purpose.

Amongst the silver on the tables; the Crimea Memorial (1856) on the south table, and the East India Company Memorial (1862) on the north table, will be recognized. The statuette above the fireplace has so far not been identified.

This photograph proves conclusively that the Ladies' Gallery mentioned in the previous article was not at the west end of the room.

Photograph No. 2 shows the east end of the dining-room in 1922 or 1923; except for the electric lighting it is little different today.

The chandeliers, of which there were three, were replaced by the existing hemispherical ceiling lights in 1923. The twin lights over the pillars were taken away at the same time. (I am told that the story which I retailed in the earlier article about the new lights having been offered as a gift, is apocryphal.)

The portrait of King George V has now been replaced by one of H.M. The Queen. "Gordon's Throne" has been moved back to its original position (see Photo No. 1). The mouldings in the corners of the flat ceiling were removed some years ago; this was because one of them became loose and bits started to fall off.

Photograph No. 3 was probably taken soon after the North Annexe had been built, in 1886 or 1887.

The picture apparently on an easel, at the far end of the room, is the portrait, now at Gordon Barracks Mess, of General Gordon. This, and the black hangings, seem to point to this part of the room having been, for a time, set apart as a memorial to Gordon, who a year or two previously (1885) had been murdered at Khartoum. The bust which can just be seen to the right of the portrait may also be of Gordon.

Although no structural alterations have been made since the photograph was taken, the appearance of the North Annexe is nowadays considerably different. This is due mainly to the grey marble (or scagliola) pillars having been painted. The decorative treatment of mouldings and other features in contrasting colours has also largely disappeared. The portrait on the right-hand wall and the bust above it have not been certainly identified.

The gas lamps in the ceiling have been replaced by electric ones.

Photograph No. 4 shows the conservatory with its original "greenhouse" roof. This was replaced by the existing barrel-vaulted roof in about 1934. At the same time the tiled floor was replaced by a wooden one, and the large end windows were replaced by smaller ones.

Except that the photograph must have been taken before 1934 it is difficult to assign a date to it. Electric lighting had been installed but not apparently central heating as evidenced by the stove in the corner. It also appears that, at any rate in the central doorway into the dining-room, the mahogany doors had not yet been installed.

It is not known when the sun-blinds were removed but certainly before 1920; the cleats for them are still there.

Photograph No. 5 shows the conservatory as it is today. The apparent lengthening of the room in comparison with Photo No. 4 is due to the shorter focal length of the lens used in the modern camera.

Photo 1.—R.E. H.Q. Mess. West end of Dining Room, probably prior to 1874.

The RE Headquaters Mess-A postscript 1

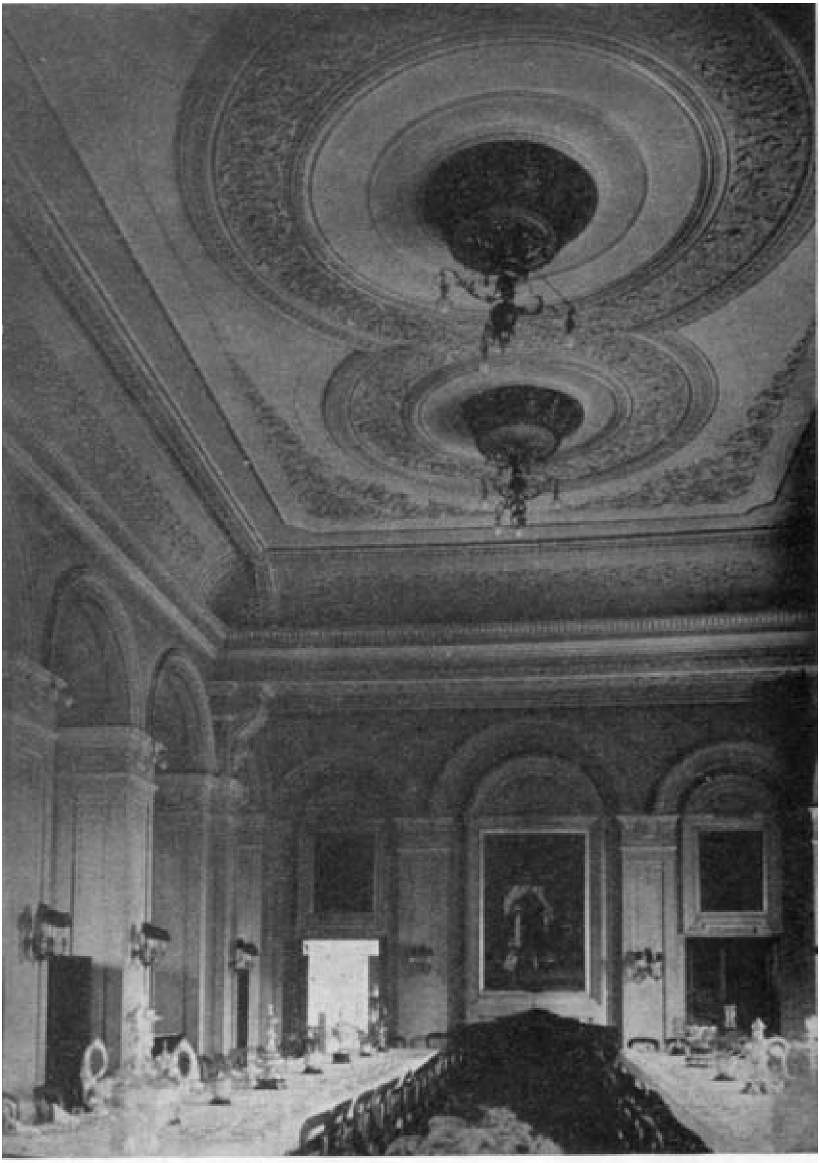


Photo 2.—R.E. H.Q. Mess. East end of Dining Room, about 1922.

Photo 3.—R.E. H.Q. Mess. North annexe, about 1886.

The RE Headquaters Mess-A postscript 3

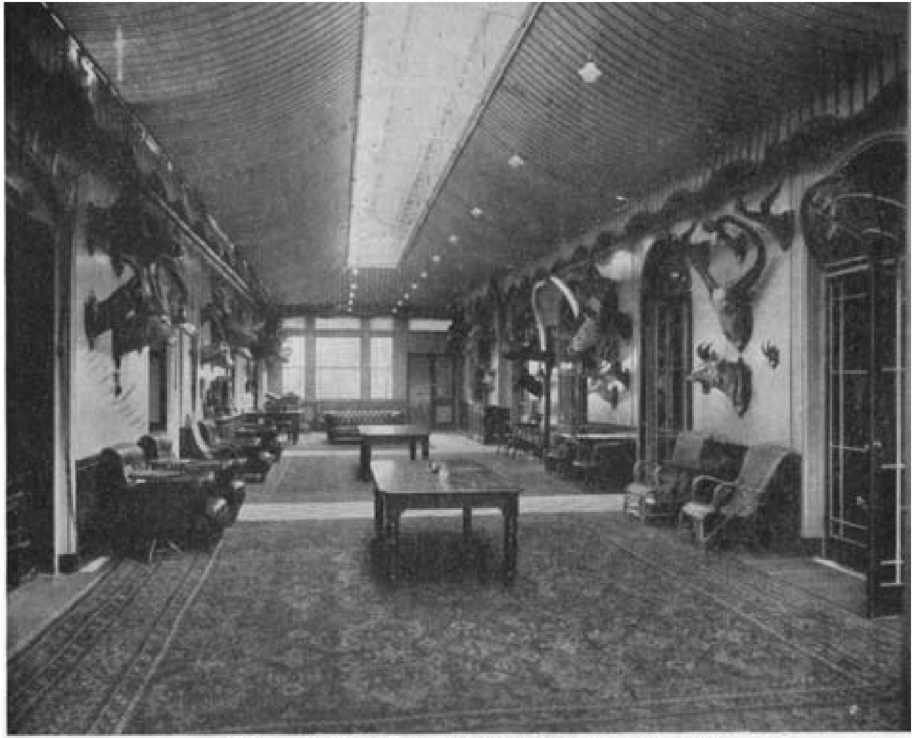
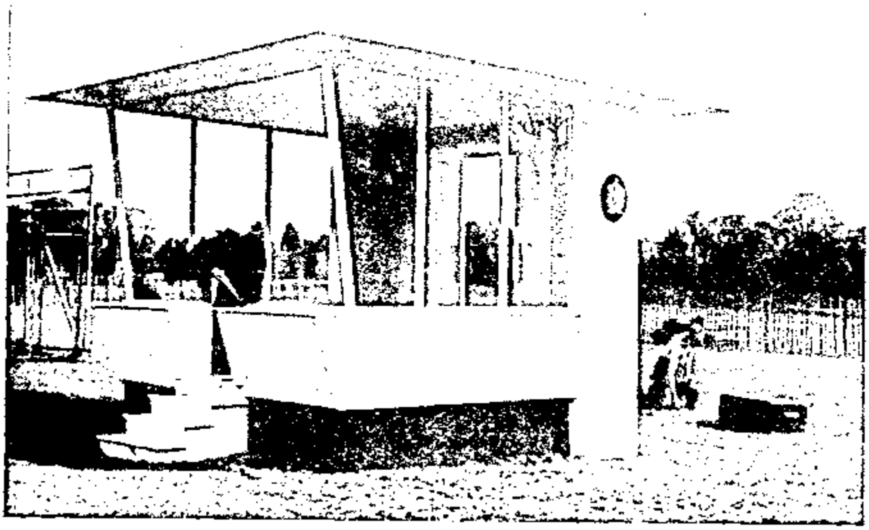


Photo 4.—R.E. H.Q. Mess. The Conservatory, prior to 1934.

Photo 5.—R.E. H.Q. Mess. The Conservatory, 1957.

The RE Headquaters Mess-A postscript 5

Presentation to H.M. The Queen by the Corps of Royal Engineers of a Polo Pavilion



Polo Pavilion.

After the visit of H.M. The Queen to Chatham on 24th October, 1956, the suggestion was made that the small covered stand, from which Her Majesty had watched the demonstration at Gordon Barracks, might have some permanent value. It was offered to The Queen, and Her Majesty was graciously pleased to accept it as a polo pavilion in Windsor Great Park There it has now been re-erected and it is thought that all ranks may be interested to hear more of this unusual gift from the Corps to the Sovereign and their Colonel-in-Chief.

As those who were present at Chatham for H.M. The Queen's visit will remember, the Royal Box was originally set high in the centre of the spectators' stand, flanked by twin stairways. The Box was designed and built entirely in the S.M.E. workshops. It was planned to incorporate in the Box and its setting samples of as many R.E. trades as possible.

The general design of the Box was approved in April, 1956, and soon afterwards work commenced in the Workshops; the framework and cladding were made by the Carpenters and Joiners, the balustrade handrail moulding were cut by the Wood Machinists. The balustrade itself was a joint effort. The parts were cut from mild steel, formed, assembled, and welded up; the departments concerned in this stage of the work being the Machine Shop, Blacksmiths, and Welding Bay. Included in the design was a paved fore-court, embodying the National Emblems; the Rose, the Thistle, the Daffodil and the Shamrock, cut in low relief in stone and set to surround a flower bed. This paving provided work of great instructional value to the Masons.

The Corps crests were produced from a pattern carved by an ex-Sapper National Serviceman. The crests were sand-cast in the Park Foundry and, apart from the normal fettling, required no further treatment before they were finished in Corps Colours and mounted on roundels; two on the sides of the Box, and two on the approach stair piers.

The construction of the Box for the demonstration at Gordon Barracks had been treated as a training project. When the decision was made to present it to Her Majesty it became necessary for the Corps to purchase it and this was the first step taken.

Meanwhile the exact siting on Smith's Lawn was being discussed. Prince Philip himself took a close interest in this and also suggested modifications to enable the pavilion to be moved if necessary.

In its new position the Box, or pavilion as it had now become, was to stand directly on the ground. The height of the original grandstand was lost and various schemes for mounting it were considered. A plain plinth 2 ft. high was decided upon and constructed. On 8th April, 1957, the pavilion, still in its dismantled state, was taken to Windsor to be erected.

This was done by a party of nine volunteer regular soldiers under the charge of Sgt. W. Beard, R.E., and the work was completed on 16th April, including the decoration. The exterior colours are white and royal blue and the interior is finished in pale powder blue. Progress was watched almost daily by the Royal Family and on one occasion the Queen stayed to speak to each of the men on the site.

A small plate is now fixed to the Box, which reads:—

"THIS STAND WAS MADE BY TRADESMEN OF THE ROYAL ENGINEERS UNDER INSTRUCTION AT THE R.E. PARK, SCHOOL OF MILITARY ENGINEERING, CHATHAM, FOR USE BY HER MAJESTY THE QUEEN DURING HER VISIT TO THE HEADQUARTERS OF THE CORPS OF ROYAL ENGINEERS ON THE 24th OCTOBER, 1956."

de Lesseps Comes to Roost

By Brigadier M. C. A. Henniker, C.B.E., D.S.O., M.C.

What has de Lesseps, the Suez Canal engineer, to do with 1st British Corps Signal Regiment or 38 Corps Engineer Regiment, both stationed in Germany? Nothing in particular, you might say; but you would be wrong. He plays an important part in the memories of the officers of both regiments. Here is the story.

Each year the officers of these two regiments dine together at a Regimental Guest Night to commemorate the joint ancestry of the Royal Engineers and the Royal Corps of Signals.

In 1955 the event was held in the Officers Mess of the Signal Regiment and it had an unexpected sequel. After the dinner some young Sapper officers kidnapped the statuette of Mercury (Jimmy) which graced the Signals' Officers' Mess. It is a fine statuette of the symbol we all know on the Royal Signals' hat badge. It stands about 3 ft. 6 in. high and is cast in bronze. The trophy was taken to the Officers' Mess of the Engineer Regiment and a signal was made to the Signal Regiment as follows:—

"Signalman Mercury now in 38 Corps Engineer Regiment's Guard Room. Send escort."

The Adjutant of the Signal Regiment was only running on three cylinders after his exertions the night before and did not see the significance. He verified that there was no such signalman in the Regiment and inquired from the Chief Signal Officer's staff which Regiment included a Signalman Mercury. The C.S.O. was sparking on all six cylinders and hatched a cunning plot. He telephoned to the Chief Engineer complaining of the infamous behaviour of the young R.E. officers. They had been invited as guests; they had been entertained royally; and what did they do? They perpetrated a silly, childish prank in the worst possible taste.

Over the telephone the C.E. could not tell that the C.S.O. had his tongue firmly in his cheek. Nor did he know that the C.S.O. had already telephoned to the Signal Regiment. He (the C.E.) however told the C.O. of the Engineer Regiment to have the trophy returned at once and a suitable apology made.

The C.O. sent the orderly officer to the Mess to collect the trophy, to return it, enjoining the greatest care, both because of the value of the trophy and as a precaution against damage in transit. Imagine his horror when he found that Jimmy had gone: vanished, stolen: and who was to blame? It was some time before it dawned on him that Jimmy had been recaptured by his rightful owners. Meanwhile he had some anxious moments.

Of course the game could not be played indefinitely and it all ended happily. On the whole the score was judged as fifteen all.

Next year, 1956, the annual Guest Night was in 38 Corps Engineer Regiment's Officers' Mess. A speech of welcome was replied to by the C.S.O. in a few felicitously chosen words; but before he was allowed to resume his seat he was pressed to accept a presentation on behalf of the Sappers. The present, tactfully draped in a flag of Royal Signals colours, was the now famous Jimmy. Unknown to all it had been kidnapped again. It was a complete and utter surprise to everyone; and the score was deemed to the thirty-fifteen to the Sappers.

Before the party this year certain senior officers were fearful lest the harmless exchange of practical jokes might, in search of fresh prizes, be pushed too far. Fun is fun; but there can be too much of *it*. The C.S.O., however, was confident that *his* officers would restrain their exuberance. The Sappers felt they could do the same.

The dinner was held in the Signals Officers' Mess on 27th June, 1957. The C.S.O. proposed the health of the Sappers and the writer of this account was called upon to reply. Finally the C.O. of the Signal Regiment rose to his feet.

"Gentlemen," he began; "I do not intend to make a speech, but there is a pleasant duty that I am called upon to perform." He then explained how his Regiment had accompanied the Anglo-French Expedition to Port Said in the autumn of 1956. He also pointed out that the senior R.E. guest at their table had also had the privilege of being in Port Said as Chief Engineer of the allied force. He explained how, when the force withdrew in December, 1956, the said Chief Engineer had given orders against "indulging a temptation to loot", and had even set an example himself by not pocketing the magnificent binoculars that he found in the drawer of his desk in the Suez Canal Building where the H.Q. had been.

"But," continued the C.O., "it was noticed that on the verandah outside the Sapper offices, amongst the typewriters and stationery for packing, was a heavy wooden box labelled *H.Q.R.E. 2 Corps, Mons Barracks, Aldershot. Fragile. Handle with Care.*" This box excited the curiosity of some Signallers who happened to know its contents. In consequence, they allowed themselves the liberty of opening the box, removing its contents and substituting two pieces of concrete from the harbour wall. What they found in the box was most instructive.

"Presently," continued the C.O., "I will show you what it was; but for the record I feel bound to say that there was a note in the box saying *They even need Reservists to help them pack.*" (Loud laughter.)

"Now, Gentlemen," he concluded. "I have much pleasure in returning to the Sappers their rightful loot from that box labelled *Fragile.*"

Whereupon a screen at the end of the dining-room was removed and there, standing on an ornamental plinth, suitably engraved was a head and shoulders bust of de Lesseps executed in plaster of Paris.

The bust is now on its way to the R.E. Museum in Chatham where, let us hope, it will rest in peace. It may now be the only one in existence. For the Egyptians, if one may believe the Press reports, on recovering control of Port Said after the Anglo-French Expedition had sailed, systematically expunged all trace of de Lesseps. The great statue on the mole was destroyed by dynamite and fell headlong into the sea; and this plaster of Paris bust would probably have crumbled at the same time beneath an Egyptian hammer.

That, however, is conjecture. Of one thing there can be no doubt, the Signal-Sapper score in the series stands at game and set to the Royal Corps of Signals.

Author's Note. The above paper has been contributed to both the *Royal Signals Journal* and the *Royal Engineers Journal*—on a "no cost" basis—and it is hoped that the two Editors will be able to see their respective ways to a more or less simultaneous publication.

Editor's Note. It will appear in the *Royal Signals Journal* in November. The bust of de Lesseps is now in the R.E. Museum at Chatham.

Memoir

MAJOR-GENERAL J. C. F. HOLLAND, C.B., D.F.C.

Photo by Chidley, Chester

"JOE" HOLLAND (as he was known throughout the Corps) died after a very brief illness on 17th March, 1956, at his home in London. He was born on 21st November, 1897, and was the son of Sir Thomas Holland, a distinguished member of the Indian Civil Service. He was educated at Rugby and the Royal Military Academy, Woolwich, and was commissioned in the Corps on 28th July, 1915, being posted to the Signal Service Training Centre at Woburn, Bedfordshire.

Major General JCF Holland CB DFC

In 1916 he was attached to the Royal Flying Corps with which and the Royal Air Force he served throughout the remainder of the 1914–18 war. In the latter part of that war he served at Salonica and took part in at least one raid on Sofia, an extremely hazardous operation as, owing to the range, there could be no escort of fighters. For his services he received the D.F.C., and was mentioned in despatches.

Back with the Corps he served with "Signals" in 1920 in Ireland, where he took a very active part in the troubles of that period.

In October, 1920, he was posted to Cambridge on a Supplementary Course, but during the Xmas vacation he was seriously wounded in Ireland. As members of the Armed Forces who did not live in Ireland were not then allowed to visit that country on leave, exactly what happened has never been easy to ascertain, but his many friends have always regarded this as a typical "Joe" performance. Apparently before he left Ireland he knew that, for certain reasons, somebody was after an Army friend of his. When he heard of his friend's violent death he resolved to do something about it and going over to Ireland he waited in a "pub" for that somebody to appear. The barmaid, realizing the risks he was running, begged him to leave, but without avail, and eventually his courage and patience were rewarded. In the shooting which immediately took place he was severely wounded but managed to stagger out into the road where, by a stroke of good fortune, he was picked up by an armoured car patrol and taken to hospital. Rumour has it that the Secretary of State for War, who in later years became Prime Minister, on hearing the story decided that the breach of the regulations should be forgotten. It must have been a story after his own heart.

Having recovered from his wounds he joined a later Supplementary Course at Cambridge where he played rugger for his college—Jesus.

In 1924 he was appointed to a post of distinction—Adjutant of the 1st Divisional Engineers and in the same year he married the daughter of Sir James Brunyate who, like his father was a distinguished Indian Civil Servant.

Early in 1928 he went to India and was posted to the Bengal Sappers and Miners, being appointed to command No. 1 Field Company in July, 1929. This was a life which he loved, both on and off duty, and he soon became a polo enthusiast, where his fine horsemanship stood him in good stead. In 1931 he passed into the Staff College, Quetta, where he soon distinguished himself both in work and in sport and became a keen member of the Quetta Hunt.

After a spell of Corps duty in England he was appointed Staff Captain 49th West Riding Division, T.A., and subsequently a G.S.O.3 in S.D. at the War Office. In October, 1937, he was appointed G.S.O.2, S.D.7, the section of the War Office which dealt with the organization and equipment of armoured fighting vehicles. Here his vivid imagination and keen grasp of essentials soon brought him to the notice of the V.C.I.G.S. and in 1939 he was appointed G.S.O.2 in charge of a section carrying out research into vital problems postulated by the V.C.I.G.S. Meanwhile in January, 1938, he had received the brevet of a Lieutenant-Colonel. On the outbreak of the war his appointment was upgraded to G.S.O.I. and he had greater opportunities of making use of his remarkable talents.

For security reasons his remarkable achievements in that section cannot be fully described, but they included the commando conception and the idea of regular specially trained troops operating apart from, but on a plan integrated with major forces.

In October, 1940, he returned to regimental duty as C.R.E. 48 Division and subsequently held two appointments as D.C.E. of a command.

In April, 1942, he returned to the War Office as D.D.S.D., where he played an important part in the early stages of lease/lend, when he had the difficult task of assessing the order of importance of our many deficiencies. At the end of 1942 he became Deputy E.-in-C. at the War Office where he developed the conception (which may have been his own) of Assault Engineers. In this he was greatly helped by his previous close association with Major-General Sir Percy Hobart who commanded all the specialized armoured units that were being formed for the campaign in North-West Europe. This was a task to which he applied all his talents and energy, and those who were closely associated with him at the time recall how determined he was "to put the Sapper back where he belongs, leading the Assault". How well he succeeded was shown by the success of the Assault Engineers with their A.V.R.E.s and other specialized equipment on "D" Day. In September, 1944, he was appointed Major-General, Royal Engineers at Allied Forces Headquarters in Italy, where the impact of his personality soon made itself felt. Unfortunately, ill health, due partly to the effect of his wounds and partly to the effect of severe dysentery which he had contracted in Salonica in the First World War, forced him to vacate this appointment after a few months and he was invalided to England. In January, 1945, he was awarded the C.B.

In March, 1946, he was appointed Major-General in charge of Administration Western Command, and on the introduction of the Chief of Staff organization to Home Commands in 1947, he was appointed Chief of Staff Western Command, a change of appointment which was exceptional. In July, 1948, he was appointed Deputy Quartermaster General at the War Office, but recurrent ill health forced him to relinquish this appointment in February, 1949.

After serving on various War Office committees ill health finally forced him to retire in December, 1951. On his retirement he lived with his family in London and could often be seen riding on Wimbledon Common, a form of exercise of which he was extremely fond throughout his life. He also took up painting at which he rapidly reached an effective standard.

"Joe" Holland was a man of outstanding ability. He had a brilliant brain, great determination and unlimited courage, both moral and physical. Being able to see the solution to a difficult problem more quickly than most people, he would at once initiate a course of action to achieve that solution. Thereafter, he would ensure that nobody impeded the achievement of the object. Persons less able than himself (of whom there were many) who could not see so clearly how the result was being achieved were apt to resent the ruthless way he pursued the object and he inevitably made some enemies. He was never a man to suffer fools gladly. However, compared to his host of friends their numbers were small. With his sardonic smile, his keen sense of humour and his great ability as a raconteur he was always a delightful companion. Had it not been for his consistent ill health he would, in all probability, have reached the top.

His married life was entirely happy and he leaves behind a widow, a daughter and a son, who is a Major in the Corps, to whom the deep sympathy of his brother officers has been extended. It will be a very long time before his name will be forgotten in the Corps to which he was so devoted.

W.M.B.

Book Reviews

HISTORY OF THE SECOND WORLD WAR

GRAND STRATEGY—VOLUME II

By J. R. M. BUTLER

(Published by H.M.S.O. Price 42s.)

The volumes of the Official History of the Second World War dealing with "Grand Strategy" are being written by more than one author, and in consequence they are not being published in chronological order.

Volumes V and VI were published first and dealt with the last two years of the war, from August, 1943, to August, 1945. They were reviewed in the R.E. Journal for December, 1956, and June, 1957, respectively.

Volume II now under review deals with the period September, 1939, to June, 1941, and Volume I, when published, will deal with the pre-war events.

The two most interesting, and important, phases of Grand Strategy are undoubtedly the beginning and the end of a war. At these times a democratic government has to make difficult decisions co-ordinating policy and military management, which at the beginning rally world opinion and uncommitted Powers against an aggressor, and at the end set the pattern of the country's future. 1939/40 were momentous years in Britain's annals, and this account of how our leaders dealt with the fearful problems of deploying small resources to parry attack on our vital interests all over the world makes an absorbing story. Mr. Butler's constructive approach to military history is stimulating; he sums up each episode by questions which bring out salient problems of interest for future study, and whenever possible, indicates to what conclusions the evidence seems to point.

The start of a war is the time when pre-war defence policy is put to the test and when events prove whether the conclusions drawn from staff studies are well grounded or fallacious. One is apt to think of the events in the crisis years as a series of mistakes and disasters, and to forget the wise decisions which steered our initial efforts in the right direction and laid the foundations of ultimate victory. This history shows that the lessons of 1914/15 greatly influenced our war policy in 1939/40. Our leaders could not then forecast how victory was to be won, but immediate and vital decisions on the aims of long term strategy and of the pattern of the forces required to achieve them had to be taken in the light of past experience. If there is to be a "next time" our survival may well depend on the lessons drawn from this volume of military history.

The narrative flows smoothly so that it is easy to follow each separate episode, and at the same time to appreciate how the many weighty and simultaneous problems influenced policy decisions and strained the machinery at the centre.

The story highlights at every stage the effect of human factors in leadership and the importance of the impact of the personalities on each other and on the course of events. The author ends, most fittingly, with an assessment of Mr. Churchill's personal contribution and pays him a tribute as the greatest British war leader since Chatham.

A feature of this book is the penetrating inquiry into the art of national leadership in war. This important contribution to the study of Grand Strategy is well illustrated by the historian's treatment of the opening phases of the war.

The author explains how in 1939 the allied democracies were handicapped by being militarily unprepared, by lack of resources, by the problem of countering the enemy's initiative while preserving a balance of effort for expansion, by their scruples in political dealings with neutral nations and by humanitarian sentiments. He notes the difficulty of deciding how to exploit new weapons of war with no battle experience on which to assess their effect on strategy.

Three issues are selected from the ensuing debate to show how the past is made to point challenging questions for the future.

The first is whether these honourable scruples were realistic; certainly they were inconsistent with the policy of waging economic war with "the gloves off" and were, in some measure, responsible for the disasters suffered by Allies and neutrals. The question is whether a ruthless strategy is, in practice, politically possible for a democracy in the opening phases of the war. This discussion brings out the broad problems of winning the emotional support of world opinion in favour of using maximum force even in a just cause.

The second is the contrast of the passive defence up to the fall of France with Churchill's later insistence on taking the offensive at any opportunity. To what extent can the defensive tactics of maintaining an offensive domination of "no-man's-land" be applied in the strategic field? Churchill's audacity was, on balance, justified by results, but not all his projects were possible or even desirable.

The third is the intrusion of science into the realms of the highest levels of strategic direction. The author's discussion of air power, of the time and effort entailed in developing sophisticated weapons, and of the controversy as to whether bombing should have absolute priority as a strategic aim, bring out the kind of problems created by new weapons of such devastating potential that their use may dictate the broad strategy of war. He describes how the scientists were brought in to advise, and wonders whether they may be given an even greater responsibility in the future.

G.N.T.

SEVEN ROADS TO MOSCOW

By Lieut.-Colonel W. G. F. Jackson, O.B.E., M.C., B.A., R.E.

(Published by Messrs. Eyre & Spottiswoode, 1957. Price 30s.)

A few years ago, in one of his waggish moods, Field-Marshal Lord Montgomery said that obviously, in a war against Russia, the one thing not to do is to march on Moscow. Lieut.-Colonel Jackson has now investigated the matter in this book and he comes to much the same conclusion. Only the Vikings made much of a job of controlling the vast tract of country, known as Great Russia, which lies to the east of the Dvina and the Dnieper. They achieved it from the Baltic by way of those two great rivers and came originally in quest of trade under Rurik. They established the same kind of loose stability, which Great Britain gave later on to the traders of her colonial empire. The only other marcher on Moscow, who ever arrived there, was Napoleon. For one reason or another, the others all turned away, but the Golden Horde of Ghengis Khan and the Mongols of Tamerlane hung about on the lower Volga for several centuries. Charles XII, whose fiery belief in offensive war recalls that of Winston Churchill, set the pattern for the more modern invaders of Russia. It took three years for Generals Mud, Space and Winter to soften up his veteran Swedes sufficiently to enable Peter the Great to defeat them in 1710 at Poltava.

When the German roads to Moscow come into the picture, Colonel Jackson's treatment of events becomes perhaps a little humdrum and unenterprising. The campaign of the White Russians in 1919 ran on a south-north axis with British participation at Murmansk and on the Caspian Sea. Its course was distinctly relevant to the theme of the book and might have received a mention. Where your reviewer chiefly ventures to differ from the author is in his summing up of the causes of the German failure in 1941/45. He sets them out with great knowledge and clarity, as in a text book, but they all take equal rank and escape the emphasis which the historian should apportion to them. No doubt the German Army attempted too much with too little—like Wavell's Army did in North Africa. Nevertheless the German Army of 1941 came far nearer to defeating Russia than either Charles XII or Napoleon and it cannot be tarred with quite the same brush. The causes of failure, which call for special emphasis, are two. Firstly the failure in 1941 to maintain the drive on Moscow, which Army Group Centre had so successfully begun and secondly the political failure to arrive in Russia as the liberators of the people from the yoke of Communism.

Nothing helped Stalin more to unite his different kinds of Russians than the political ineptitude of the German Commissars with their ridiculous theory of the racial superiority of the Nazis. They quite failed to make Russia her own executioner by developing the internal dissensions, which could have been the ruin of the Kremlin government. This inherent weakness of Russia is still the same today and it cannot be emphasized too strongly. As in his "Attack in the West" the author has provided a sequence of most admirable sketches to lighten the task of his readers, as they follow the story of the "Seven Roads to Moscow". Undoubtedly a fascinating study.

B.T.W.

LIFE IN THE ARMY TODAY

By Brigadier M. C. A. Henniker, C.B.E., D.S.O.

With Foreword by Field Marshal Sir Gerald Templer, G.C.B., G.C.M.G.

(Published by Messrs. Cassell & Company, Ltd. Price 10s. 6d.)

"An Army based on the voluntary system bears no relation to War—None!" This remark, most eloquently declaimed, was one of the favourite utterances of Sir Henry Wilson, when he was C.I.G.S. in the nineteen twenties. How right he seemed to be in those days of home battalions consisting of barely 300 men! Yet he was wrong. For over eleven years of peace, our "nig-nogs" have been admirable, their regiments have been admirable, even the War Office has been admirable—all doing their best to make conscription work. Although a wonderful social experiment, it has proved now, alas, to be only a most useful stopgap and unsuitable for the military needs of Britain.

The voluntary system is to be made to produce a sufficiency of regular N.C.O.s and men, who will take up soldiering as a profession, just as regular officers do. This expensive looking problem has to be solved by 1962, when National Service fades out and only regulars are to remain. Thus the scheme—whether it will come off, remains to be seen.

If Brigadier Henniker had known all this, he would no doubt have given his competent and unbiased *Life in the Army Today* a somewhat different slant. Even so his book still remains a fine compendium of information about the Army. It will make an equal appeal to future National Servicemen and to all those who, for one reason or another, are attracted to the idea of a military career. Let us hope that the latter category will come up to the expectations of the 1957 White Paper on Defence.

B.T.W.

ENGINEERING STRUCTURAL FAILURES

By Rolt Hammond, A.C.G.I., A.M.I.C.E.

(Published by Odhams Press. Price 25s.)

In engineering as in many other practical fields, more can be learnt from the study of failures than can be learnt when all is apparently in order. Tests to destruction are the accepted method of establishing design theories and the suitability of finished products, but cost seldom permits the test to destruction of a full-scale engineering structure. When, however, destruction of a full-scale structure occurs unintentionally it must be a subject of great interest to engineers and subsequent investigation should provide valuable knowledge.

This book describing the failures cannot help being of interest to engineers and, provided that certain parts of it are by-passed, even to those with only a superficial contact with engineering design and construction.

Sir Bruce White in his excellent foreword to the book states that what is of concern is not careless design mistakes, but genuine errors of judgment in design and execution and in failure fully to understand site conditions and to foresee their consequences. Some of the failures described, however, appear almost to be due to careless design mistakes.

The fields of structural and civil engineering are well covered in the chapters on earthworks and foundations, dams, bridges, tunnels, buildings and welded structures, but the inclusion of failures of welded ships and of the Comet aircraft seem out of place. One imagines that both the ship designer and the aeronautical engineer would feel that his subject is not covered to any useful extent. There is an unsatisfactory inconsistency in the conclusions drawn from failures. In some cases conclusions are clear and experimental work undertaken to avoid repetition of similar failures is fully described: in other cases one is left with a number of conflicting suggestions as to causes and in at least one instance the book gives a confusing number of systems of design to guard against failure. Although this book is one which does not set out to cover detailed design and should, therefore, have as its aim the statement of principles, in the cases of resistance to earthquakes and of avoidance of vibration effects due to machinery, formulae are introduced which serve no precise nor useful purpose. They merely leave one with the realization that one must turn elsewhere for more complete assistance to solve the problems. Such formulae could, therefore, have been omitted with advantage.

To readers of this issue of the *R.E. Journal* the final chapter of this book on "Lesson of Failures" will be of interest, since emphasis is placed on the need for testing structures for which the use of resistance strain gauges is recommended.

Despite its shortcomings, which are due to the lack of a clear aim, this book is full of interest both for the serious engineer, who will obtain much food for thought, and for the casual reader, who cannot fail to be impressed by some of the truly remarkable, and in some cases disastrous, failures recorded. C.E.W.

STRENGTH OF MATERIALS

By G. H. Ryder

(Published by Cleaver-Hume Press Ltd. Price 22s. 6d.)

When an author embarks upon the task of writing a text book on a subject that has been so adequately covered as this, he should ask himself two questions: Have I anything new to say? Can I say it better than it has been said before? In the case of this book the answer is yes for the second question and a qualified yes for the first.

The subject matter is well presented and easy to follow. The author's undoubted skill as a teacher, as opposed to a lecturer, is obvious from his frequent use of sketches instead of long pedantic descriptions, and his acknowledgement of the principles of what is known in the army as Methods of Instruction. Each lesson is followed by a summary against which attainment achieved can be measured.

Much of the matter presented is new in a text book of this nature, and in the past was only available in the more abstruse books on the subject or in articles which occasionally appeared in the technical press. His treatment of beams on elastic foundations; plastic theory of bending; struts of varying cross section; the use of electrical resistance strain gauges; and photo elastic stress analysis is to be commended, although the last two items are admitted to be only by way of an introduction to these new techniques in modern material testing.

In only one instance could the charge be laid at the door of the author of being over ambitious. This is in his treatment of stress concentrations. Little is to be gained in a text book by giving empirical methods for treating problems of stress concentrations caused by special shaped holes in special members, which is the method chosen.

An invaluable contribution to the subject could perhaps have been made if instead of this approach the author's flair in exposition had been devoted to an introduction to the relaxation method of solving the problem.

In conclusion it should be clearly stated that this book, in addition to covering these new developments in the subject, very adequately covers the ground normally covered by the classic text books on Strength of Materials. J.P.F.-S.

EXPERIMENT AND THEORY IN PHYSICS

By MAX BORN

(Published by Dover Publications Inc. Price 60 cents)

It would appear that no right thinking man would attempt to arrive at conclusions concerning the real nature of things, or formulate expressions governing behaviour of a natural phenomenon from purely theoretical considerations. The folly of attempting to do so is copiously illustrated with examples throughout this book. The author develops with considerable skill the argument that all real development in science has been derived from the inter-dependence of theory and experiment. He does not detract from the theoretical achievements of inspired geniuses like Maxwell and Einstein, but rather points out how even their most abstract theories were, in fact, founded on a very sure foundation of solid experience.

The author differentiates between analytical induction and synthetic deduction, a difference he illustrates with lively and homely examples. The former he finds the more common, and that class of discovery is represented by the work of engineers and physicists who design a piece of apparatus on well established theory and expect it to work. The other form he finds comparatively rare; but when it happens, as it did with Maxwell's electromagnetic wave theory and Einstein's theory of relativity it opens up the field of discovery as no amount of purely experimental work ever could. The author is at considerable pains to point out that even here the value of their work would have been meaningless if others had not discovered from their observations what was the meaning of the quantities in the expressions derived by the process of deduction.

Besides the development of the argument which few would contradict, the book is also interesting as a guide to the background of some of the most recent developments in science, such as the quantum theory, and the structure of the atom, by one who has taken part in these pioneering advances, and who can speak with first-hand knowledge of the personalities concerned. J.P.F.-S.

NOMOGRAMS FOR THE ANALYSIS OF FRAMES

By J. RYGOL

(Published by Concrete Publications Ltd. Price 18s.)

Nomograms can be of considerable assistance in the solution of problems involving complex repetitive calculations, particularly where the problem involves a design by trial and error. Where a calculation using assumed values of variables proves unsatisfactory a new solution based on revised figures is much more quickly obtained than by direct calculation.

In this book Mr. Rygol has provided a set of 26 nomograms for the solution of single rectangular portal frames with rigid or hinged bases under all normal conditions of loading. The nomograms provide a series of non-dimensional coefficients for each type of frame under each condition of loading, from which the reactions and moments on the structure may be simply derived. In addition, graphs are provided giving similar coefficients for the case of columns with fixed bases and hinged connections at the top. The coefficients, which are based on a general elastic analysis similar to Kleinlogel's formlae, are equally applicable to design in steel or reinforced concrete.

The text of the book gives full instructions for the use of the nomograms to find reactions and moments and effects of lateral restraints, and a number of worked examples are also included.

The nomograms themselves are clearly laid out and their accuracy is at least as good as is required for normal design work. The sheets, which are not bound into the book, contain diagrammatic instructions for use so that with a little practice there is no need to refer back to the text.

These nomograms would undoubtedly be of great value to anyone engaged on any considerable amount of design of framed structures. C.R.S.

Technical Notes

ENGINEERING JOURNAL OF CANADA

Notes from *The Engineering Journal of Canada*, March, 1957.

The Design of Sorel Stadium

The importance of soil investigation is appreciated by modern engineers. It is vital in commercial construction, where cost of foundations must be balanced against cost of superstructure to ensure an economic return, or rent value, compared with total outlay. This paper describes how an economical design was achieved in unfavourable soil conditions, by using groups of concrete caisson piles.

High Voltage D.C. Transmission

This discussion of the advantages and drawbacks of high voltage direct current transmission is of particular interest in view of the recently signed agreement for the transfer of power between the British Central Electricity Authority and Electricité de France.

Although in general A.C. transmission has become standard practice, the use of D.C. has important technical advantages for particular purposes, notably in submarine cables, for tie lines between two large systems, and for linking two A.C. systems of different frequency.

The technical factors are simply and clearly set out, and operational experience in Sweden, Japan, and Russia is briefly reviewed.

Notes from *The Engineering Journal of Canada*, April, 1957.

McGill Coal Burning Gas Turbine Project

The Engineering Journal for June, 1955, included an interesting discussion of the economics of the gas turbine (see *R.E. Journal*, December, 1955). This issue includes a short account of experimental work done in the past seven years to develop a gas turbine engine using coal as fuel.

Any new member of the family of prime movers is of interest in modern conditions, and the results so far achieved at McGill University indicate that there may be a useful future for this exhaust heated machine, particularly in power generation and in locomotives.

High Capacity Piles for the Support of a Large Basilica

In designing the foundations for the Sorel Stadium (see above), the economic factor was a vital consideration. This aspect is not discussed in the present paper, which describes the installation of foundations for an unusual and complex structure, primarily an octagon 175 ft. in diameter, supporting an eight-sided dome rising to a height of 242 ft. A total of 195, 16- and 20-in. welded steel pipe piles were driven to bedrock at depths exceeding 90 ft., and were filled with concrete. Soil investigation, pile driving, and load testing are described.

The Kelowna Floating Bridge

The Kelowna bridge, across Okanagan Lake, will replace a car ferry on the highway connecting the north-western United States with British Columbia. It is to carry a 35-ft. roadway, two 6-ft. footways, and two 12-in. solid concrete handrails.

Original designs for (*a*) a suspension bridge and (*b*) a rockfill causeway were abandoned because of extremely poor soil conditions, and the floating bridge design is particularly interesting because the twelve reinforced concrete pontoon units will be rigidly connected to form one continuous floating structure 2,100 ft. long. Each of the ten main pontoons, 200 × 50 × 15 ft. deep, is divided into fourteen watertight compartments. There are three steel approach and transition spans, each 175 ft. long, and one 260-ft. lifting span. Design and methods of construction are described in some detail.

The only horizontal loading investigated was a combination of ice and wind pressure, but the lack of waterway through the floating structure is presumably justified by the fact that the water level in the lake is controlled within a 4-ft. change in elevation, and that no afflux appears to be anticipated.

Notes from *The Engineering Journal of Canada*, May, 1957.

The May issue of *The Engineering Journal of Canada* comprises a record of Canada's engineering and industrial achievements in 1956. Though predominantly statistical, it contains a lot of information of interest to engineers, especially to those seeking a wider understanding of the characteristics and potentialities of the Dominion, and it is illustrated throughout by excellent photographs.

The following few examples indicate the vastness of modern Canadian undertakings:—

Oil and natural gas.—During 1956, production increased by 32 per cent compared with 1955, which had shown a similar increase over 1954; 740 miles of main pipeline were completed, involving a total of 3,100 miles including collection and delivery lines.

Power.—One million horse power was added to capacity, mainly hydro-electric, and construction was in hand to add 1½ million h.p. in 1957, and 2½ million h.p. in 1958. Atomic research is taking concrete form at the N.P.D. 20,000 kW. power plant.

Construction.—Twenty per cent of all expenditure on end products and services was for construction work. At the end of the year the St. Lawrence Seaway project was up to schedule, and almost half completed.

THE MILITARY ENGINEER

Journal of the Society of American Military Engineers

January–February 1957.

A Message from the Chief of Engineers by Major-General Emerson C. Itschner, Chief of Engineers.

The new Chief of Engineers poses the big question: Can the Military Engineer do what would be required of him in the event of war? He will be required to perform more difficult feats in the future than any he has performed in the past. Since the last war the gap is continually widening between the engineer's present technological capability and the anticipated requirements of the future. This gap can only be closed by redoubled efforts in every branch of military engineering. It will require leadership, personal incentive, imagination and hard work at all levels, and by every individual, in every activity of the Corps. He considers his greatest responsibility as Chief of Engineers, is to assist each one in performing his individual mission as an integral and important part of a gigantic engineer team in its service to the nation.

Electronic Computors in Military Engineering by Joel D. Aron.

The author, a West Point graduate and now Applied Science Representative for the International Business Machines (I.B.M.) Corporation makes an interesting case for the use of Electronic Computors in Military Engineering, but while costs of these machines remain at the level of £5 to £50 per hour, according to speed and complexity the average engineer will find it difficult to justify their use other than for specialist work involving a multiplicity of laborious repetitive calculations. The introduction of the electronic digital computor has certainly simplified the work of the atomic scientist and engineer, but this powerful tool does not yet seem to be within the range of the general practitioner in spite of the author's belief that its introduction means that the revival of applied mathematics in civil and military engineering is imminent.

Protective Sealcoats for Bituminous Pavement by Charles L. Shattuck.

The author was for twenty years in charge of asphalt paving construction for the City of Detroit and is now a consultant with a lifetime experience in his subject. His view is that the most economical and effective method of maintenance for bituminous pavements is treatment at about a fifth of a gallon per square yard with a coal tar pitch emulsion sealcoating. These sealcoats are not true emulsions but are dispersions of coal tar pitch in water by means of irreversible mineral colloids. At ordinary temperatures they have a consistency of mayonnaise and cure to a tough, heat and weather resistant, grey-black protective coating which is impervious to water, has a minimum volatilization rate—a direct function of weatherability of tars, has a far greater resistance to weather than ordinary bitumen, and is resistant to petroleum derivatives which dissolve asphalt. By these properties and by sealing in the oils which give bituminous pavements their required flexibility this type of sealcoat increases several fold the life of the bituminous pavement it protects. Jet blast damage is restricted but not prevented. On an annual basis this emulsion is more economical than ordinary sealcoats.

CIVIL ENGINEERING

Notes from *Civil Engineering*, January, 1957

The Vacuum Process for Concrete on a Rockfill Dam

The vacuum process for concrete on the face of a rockfill dam was first used on the Lough Quoich section of the Garry Hydro Electric Scheme, 14,800 sq. yds. of concrete between 12 and 15 in. thick being placed by the method described in the article. Briefly, the method is to apply a vacuum to the formwork in which concrete has just been poured and thus remove some of the water not required for hydration of the cement. The effect of this reduction in water cement is to enable shuttering to be stripped earlier than it could be otherwise, and incidentally to improve the quality of the concrete from the point of view of strength, liability to shrink, and finish.

The shuttering panels used were 20 ft. long, 2 ft. wide and between 12 and 15 in. deep. They consisted of $\frac{5}{8}$ in. thick waterproof plywood, face screwed to a channel steel frame. The front face of the plywood was sealed around its edges with timber battens $\frac{1}{8}$ in. thick bedded in Bostik. The air space required to develop the vacuum over the face of the shutter was achieved by laying fly gauze on a 16 gauge $\frac{1}{4}$ in. mesh screen with a linen cloth covering the flywire and also forming the surface of the shutter. Holes $1\frac{1}{2}$ in. diameter connecting the air space were drilled at 3 ft. centres, to which a pipe manifold was connected by a 3 in. diameter main from two rotary pumps. One with a 25 h.p., and 348 cu. ft. capacity per minute: the other 15 h.p., and with 275 cu. ft. capacity per minute. This pump arrangement permitted a 15 to 20 in. of mercury vacuum reading to be obtained on two sets of four shutters. It was found that a shutter gang of four men assisted by a derrick could concrete between two and two a half bays 20 by 20 ft. in a ten working hour day. The derrick was necessary as each of the shutters was filled with backing concrete to give them sufficient weight to resist fluid pressure due to concrete laid at the slope of the water-retaining face, which was 1:1.3.

The arrangement described permitted the first shutter to be lowered into position, the concrete to be poured, and the vacuum applied. The same sequence was followed for the second shutter, and so on: by the time the fourth lift had been completed, the concrete under the first shutter had hardened sufficiently to permit it to be removed and used again. With this method of leapfrogging, a complete bay could be completed in $2\frac{1}{2}$ hrs.

To achieve this careful maintenance was required. At the end of each day's work the shutters, including the $1\frac{1}{2}$ in. dia. pipes, were hosed down, the linen covers being left in position unless they required renewal. It was found that the linen lasted about twenty uses, the mesh and gauze 180 uses, while the shuttering was still serviceable after 750 uses.

The only trouble experienced was a tendency for water in the pipelines to freeze in cold weather. The finish achieved was a linen finish which was left untouched. Tests carried out during construction showed that the concrete was stronger and more dense than similar concrete placed using normal methods. The article is illustrated with six photographs showing the work in process; but unfortunately does not include a diagram of the shutter.

Four-Storey Factory Extension

An interesting article, well illustrated, describes the work in connection with the expansion of Messrs. E. H. Cole's factory at Southend.

The feature about the work is that precast concrete sections, never more than 2½ tons in weight, were built into a fully continuous frame building by means of prestressed post tensioned cables and a very limited amount of *in situ* concrete. It would be difficult to describe the way this is done without the aid of the reduced scale drawings included in the article.

None of the advantages of prestress concrete construction was lost by the method, which permitted the column grid of 32 ft. to be maintained with an increase in spacing to 46 ft. on the four central columns. The system of prestressing used is the P.S.C. system using its four wire cable ducts with its consequent ease of threading wires through the ducts.

The beams were no more than 18½ in., and the floor slabs using "hollow box" construction were 10 in. deep on the 32 ft. spans and 15 in. deep on the 46 ft. spans

The article is complete with four photographs and three diagrams.

The Collapse of Excavations

The Factories Department of the Ministry of Labour in their quarterly Bulletin draw attention to the fact that collapse of excavations is responsible for the greatest number of fatal accidents in the building industry in proportion to the number of people employed in that trade. It lists the causes under five headings:

1. Taking a chance where work is not to be open long.
2. Lack of knowledge of soil susceptibility to slip.
3. Failure to appreciate the effect of climatic conditions, that is, effect of the rain and heavy frost.
4. Effect of nearby vibration, such as the passage of trains, or nearby equipment operating.
5. False economy in only partially supporting works.

The article describes some recent fatal accidents, the result of not appreciating the dangers listed above.

Foxcote Reservoir Scheme

Earth dam construction is by no means unusual in this country. The distinctive feature of the work carried out at Foxcote is the fact that a clay puddle core is not used. The whole embankment consists of clay found within the area to be flooded.

The dam is 880 ft. long and 30 ft. high; for stability the upstream slope is limited to 1:3½, while that on the downstream side was kept to 1:2¾. The whole area was shown to consist of clay or silty clay and consequently the cut-off trench in no case was more than 16 ft. deep. The total amount of clay required for the embankment was 43,000 cu. yds., although the stripping of 9 in. of top soil in the area that would be uncovered by a 14 ft. drop in the water level, and the removal of the 12 in. layer of weathered clay in the embankment area entailed the removal of 50,000 cu. yds. of spoil.

The stages in construction consisted in diverting the brook, using 6 ft. dia. flexibly jointed concrete pipes cast in 16 ft. lengths; site stripping over the embankment area and excavation of the diversion culvert, which was completed using a Smith 21 dragline; transporting the pipe; using bogies and gantries travelling on jubilee track. This work was followed by the cut off trench excavation. The infilling of the trench with clay was effected by the Smith 21 dragline assisted by dumpers and wobbly wheel rollers, and a TD14 bulldozer to spread. Strict control was maintained on the material to be used in the embankment, silty or sandy material only being used on the downstream faces. In the first instances this was done by a dragline, but this was later superseded by a face shovel, as soon as a face could be formed. Care was taken to maintain the floor of the excavation at the slope of 1:100 away from the face. Placing of the embankment fill started after a 15 in. gravel drainage mattress had been laid with a 6 in. top and bottom layer of sand. In the wet weather work was restricted, and under dry conditions moisture content was controlled. Winter working progress was maintained by the use of locomotive-drawn skips on the jubilee tracks instead of by dumpers.

Particular care was taken to ensure that each day's work was compacted, and sealed against possible rain, and in any event the monthly maximum lift was limited to 4 ft. A check on stability was thus maintained by observation of pore water pressure cells, built in at various levels. During construction these recorded negligible pressures.

The protection of the dam against wave action was ensured by 6 ft. × 6 ft. × 5 in. cast *in situ* slabs laid on a 6 in. thick gravel layer extending from the toe wall to the top wave wall. The article is unsupported by any diagrams describing the work, but it does include two general photographs of the completed scheme.

Notes from *Civil Engineering*, February, 1957

Timber Supplement

An extremely useful series of articles form the timber supplement to this month's issue of *Civil Engineering*. They will be invaluable to anyone interested in the design of timber structure, and give much information difficult to obtain in the textbooks on the subject. The articles, "Modern Building in Timber"; "Wide Span Timber roofing", "The Design of Timber Structures in Canada", cover many problems in design and give some new approaches to the use of built-up structural members and stressed skin structures. Articles included on specification and the correct use of timbers are: "The Specification of Timber"; "Timbers for Engineering purposes"; "Plywood—A Versatile Material"; "Timber Preservation and Industrial Uses". The articles also include many useful tables. Timber construction is covered by two articles: "Glued Laminated Timber Construction" and a "Short Survey of Portable Woodworking Machinery". A feature of the supplement is the many advertisements associated with timber technology and these are not the least valuable part of the supplement.

Notes from *Civil Engineering*, March, 1957

The Use of Rubber in Concrete Work

The intriguing use of rubber in two totally different roles is described in this article.

The first method is to use textured rubber sheets in formwork for the exposed faces of concrete, to reproduce these textures without further subsequent preparation or tooling after the formwork is stripped. It is not recommended that rubber sheeting should be stripped off until the concrete has well set to avoid plucking out the pattern from green concrete. The oil most suitable to prevent bonding of the concrete with the rubber is castor oil, because of the harmful effect of mineral oils on rubber. Two methods of securing sheeting to formwork have been used. One is bonding the rubber to the timber, and the other clipping it to the formwork.

The other role that rubber can play in concrete manufacture is the medium through which a vacuum can be supplied to a concrete surface. It can thus provide a ready means of lifting concrete slabs in a fragile condition because of the uniform nature of the support, or in cases where curved or complicated shapes make it difficult to attach normal lifting hooks. This aspect of development is being carried on by the

Vacuum Concrete Division of Millars Machinery Co., Ltd., and also Pilkington Bros., Ltd., who are using a similar technique in connection with removal problems in their large sheet glass manufacture.

Tunnel Linings

Some interesting generalizations on tunnel linings are discussed in the first of a series of articles by Mr. O. Dawson, B.Sc., M.I.C.E., M.I.C.E.I. He summarizes the requirements for a tunnel lining:

(*a*) Low maintenance cost to give indefinite life.
(*b*) Small deformation under load especially in built-up areas.
(*c*) Ease of construction independent on workmen's skill.
(*d*) Desirability of using local materials.

Lining is said to account for one third of the cost of construction, which alone is reason enough to study methods of reducing the cost of this item. Tunnel driving under all conditions has progressed until now tunnels in clay are driven at twice the speed accepted in 1930; while in rock, the introduction of heavy equipment means a miner can break and load 10-12 tons per shift. All of which indicates that more attention must be given to the problems of lining, if this is not to lag behind the driving operations.

The findings of the Building Research Station are quoted, from investigations carried out by them on tunnels lined with cast-iron segmental rings in the London Underground railways. In these they found that stresses in the tunnel linings do not alter with time. Cast iron is an excellent material; but its cost is rapidly rendering its use prohibitive, especially in the large diameter tunnels required for traffic purposes. It is pointed out that the method of driving the tunnel may well control the stresses in the lining. If jacking from previously built rings is used stresses may be from 20-30 tons/jack and this may be critical. The surprising result is stated that the caulking of flanged joints with lead produced the largest stresses. The article discusses the shape of cross sections and some of the traditional linings such as timber and brick that have been used. It appears that our future tunnels will mostly be lined with interlocking concrete segments. The article is to be concluded.

Some Notes on Hydrophobic or Waterproof Cement

A new cement which is just coming into production promises to solve one of the outstanding problems in large army projects, especially overseas, that of storage of bulk supplies of cement without fear of deterioration. Known as Pectacrete, it is a Portland cement to which an additive has been introduced in the last stage of manufacture by means of spraying. This prevents hydration of the grains unless the coating is abraded by mechanical action. The amount of abrasion achieved in a normal concrete mixer is usually found to be sufficient; the cement is thus protected until required. The cement has been tested in the Harry Stranger Laboratories at Elstree, and as produced conforms to B.S. 12:1947, requirements for ordinary Portland cement. Although not the prime reason for this development, cement manufactured with Pectacrete is claimed to be more resistant to moisture penetration than normal Portland cement and is also said to exhibit sulphate-resistant properties. A use for which this cement is well suited is in stabilized soil projects, where the cement can be positioned beforehand along the road without regard to weather conditions. It is expected that supplies of Pectacrete will be available all over the world at about 20s. to 25s. a ton above the ruling price for Portland cement.

Notes from *Civil Engineering Review*, April, 1957

Connah's Quay Power Station Site Reclamation and Construction

When it was decided to reclaim 70 acres of saltings at Connah's Quay on the south bank of the Dee it was proposed to do this by building banks to 2 ft. above the maximum high water level and then filling in the areas so bunded by sand pumped from a dredger.

The area to be bunded was divided into two parts by a temporary bund, and these areas were filled one at a time. An interesting feature in the construction of the bund is the method of protecting the sea faces of the banks by brushwood fascines staked into the bank, with an armouring of stone at ½ ton/sq. yd. on the seaward faces. A method that preserves the porosity of the bank with consequent reduction of scour. The suction dredger, which incidentally was prefabricated in nine sections, was capable of dredging from a depth of 7 ft. to 50 ft. The suction pump used was a single stage centrifugal pump driven at 275 r.p.m., through suitable gearing from a three-phase 2,200 volt electric motor, which was capable of delivering 1,500 gallons/minute at 230 ft. head. The pipe line from the dredger was 1¾ miles long, of which three sections of 60 ft. and fourteen sections of 20 ft. were floating. It was found that up to 60 per cent by weight of sand could be carried by the water.

The article is well illustrated by photographs and drawings and is to be concluded.

DESIGN AND RECONSTRUCTION OF THE WEST PIER, ROYAL DOCK, GRIMSBY

The replacement of the old timber pier at Grimsby twice in a hundred years, because of the ravages of the marine timber pest Limnoria Lignorum led the commissioners of the Humber Ports to consider the use of a simple concrete pier. The design is unusual in that it is intended to take very little in the way of vertical loads, while the horizontal loads are unlikely to be more than that which might be expected from small craft. In addition, the old pier was timber sheeted to afford some protection from high seas in the tidal basin. This feature received recognition in the design by using a continuous steel sheet pile wall, centrally under a heavy section capping beam, which is supported laterally by raking piles 18 × 13 in., some 42 ft. 6 in. long. A trapezoidal shaped diaphragm is supported at each pair of raking piles at 12 ft. 6 in. intervals, and these form the cross supports for the precast stringers. There are two variations in the fendering arrangements, which are of timber construction, to provide in one case a wharf for dredgers, and in the other case protection against a scouring vessel which is literally forced along a narrow navigation channel alongside the pier by hydraulic pressure, thereby cutting the channel to its own shape. One side of the pier has, therefore, to be protected against accidental contact with this vessel at the end of its run.

ELECTRICALLY DRIVEN EQUIPMENT FOR THE PUBLIC WORKS CONTRACTOR

The Suez crisis brought home to contracting firms the dependence of this country on foreign fuel oils. A solution to this problem which has been tried with some measure of success is the substitution of electrical power units for the internal combustion engines normally met with in contractors' equipment. The author points out that in isolated sites, where power may have to be brought from a long way, this may not be economical; but in sites where the Electricity Board wires may be brought in at reasonable cost, and the work is of sufficient magnitude to bear the installation costs, then electrically driven equipment will show a favourable comparison.

The article includes a review of available electrical distribution and protection equipment that is sufficiently robust and weatherproof to be mounted on poles without elaborate switch houses. Pole-operated isolators for isolating individual circuits and pieces of equipment are manufactured by one firm in ranges of voltages from 660v. to 110Kv., with current ratings of up to 2,000 amps. An interesting feature is that fuses are often used in these circumstances for fault protection, sometimes in combination with isolators. All these appliances comply with the Institution of Electrical Engineers' regulations and relevant British Standards. Amongst the equipment which is now available for driving by electrical power are concrete mixers, batching plant, vibrators, hoists, cranes; and even mobile plant such as exavators. The cable in the latter case being paid out and taken in automatically on a cable drum. In cases where the operating conditions favour the use of pneumatic equipment, the advantages of both systems can be retained by the use of electrically driven compressors.

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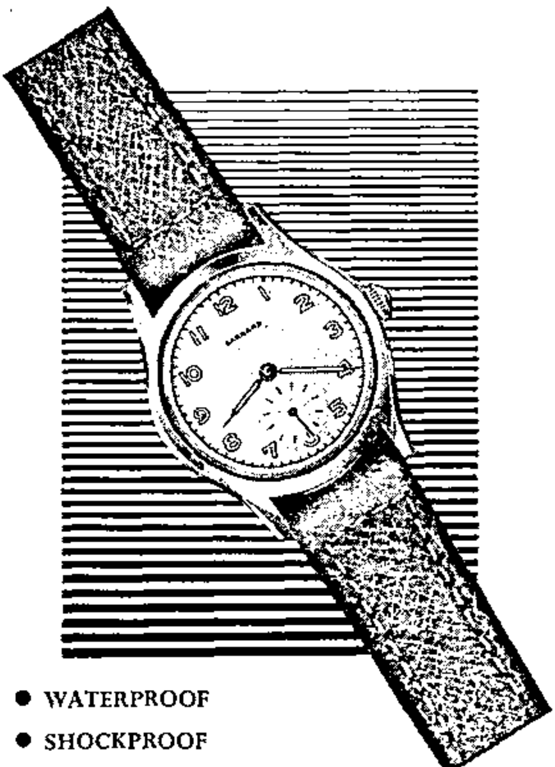

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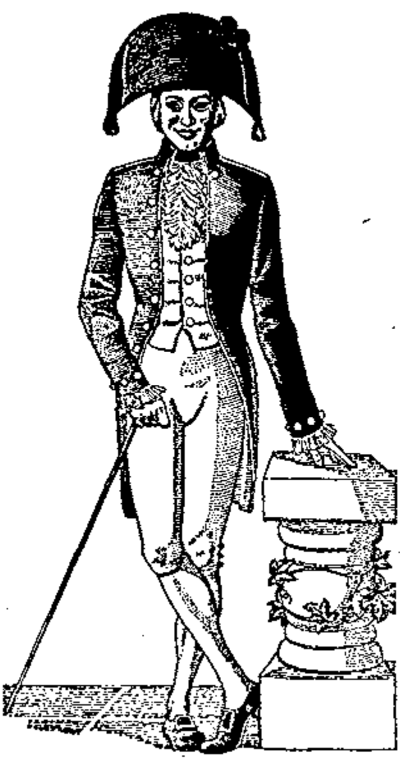

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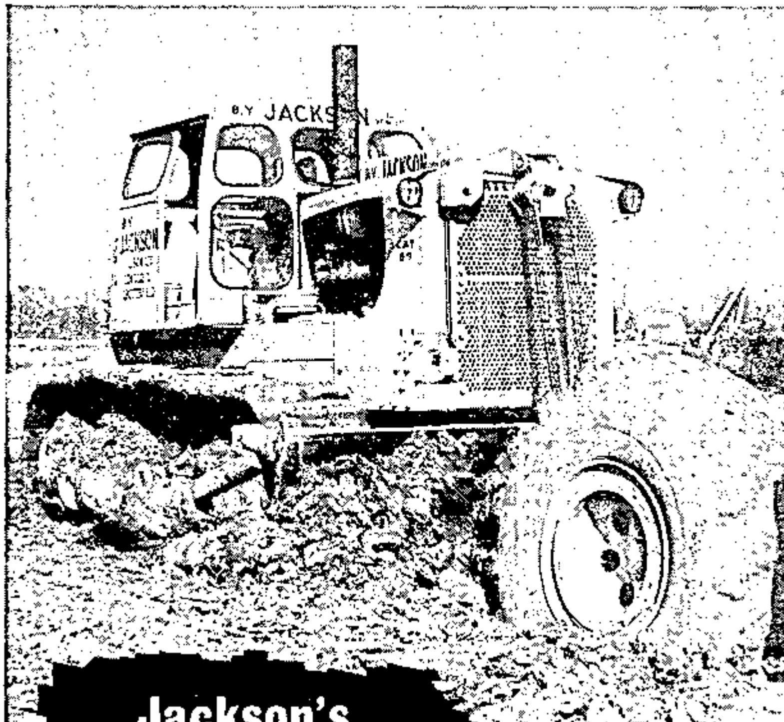

REDUCED SCHOOL FEES PLAN

FOREWORD

In bringing to your notice the plans which are illustrated in this brochure, careful study has been given to various methods by which parents can gain some relief from the necessarily heavy impact of paying for school fees during the few years that a boy spends at school, the cost of which has to be found by parents from greatly taxed incomes, making the problem of a Public School education difficult.

The ordinary Educational Endowment Assurance Policy does not normally take into consideration the peculiar difficulties and the varying conditions of each parent.

The following scheme has been produced for parents to consider. There is no obligation for them to undertake the plan, but it is recommended that they should consult Colonel Finch (retired), of Messrs. Harold B. Finch & Co. Ltd., Associated Insurance Brokers, in order to see what assistance can be provided to meet each individual parent's requirements. The same scheme can equally be applied to any school according to the amount of the fees, and is not restricted to any one school, though some have adopted it.

Under normal circumstances where parents are of an average age and the plan is initiated at the birth of the child, a sum approximating to his fees at school can be provided, guaranteed, and secured against the death of the parent, at a cost making a saving of several hundred pounds on the average normal fees.

Should a parent be so unfortunate as to die during the child's infancy, then a maintenance income, as well as a sum towards the cost of education, becomes available immediately.

It is unwise to consider the problem of fees solely in regard to the five years a boy spends at his Public School, since entry thereto is by the Common Entrance Examination, for which Preparatory Schools are especially equipped to prepare the boy. It is, therefore, prudent to consider the matter in terms of a continuous run through education, including Preparatory School, in addition to a Public School.

GENERAL REASONS FOR PLAN

The type of policy usually provided by Life Assurance Offices as an "Educational Endowment" involves payment of premiums *up to* the time the child starts school. If the child is one year old, this means cramping the payments into twelve years (for Public School entrance at 13), or six years if provision is also to be made for Preparatory School. The former is expensive, and the latter completely impracticable. In any case, the expense often occurs during the early years of married life and is unwelcome, if not impossible to meet.

The plan recommended would achieve a spread of payments over longer periods and, in special cases, it might be possible to start off with a lower premium during the first few years.

PERSONAL PLANS

The plans permit the individual needs and circumstances of each parent to be considered. They are flexible and do not bind parents to use the policies for payment of fees at any particular School, if, for any reason, the boy should not enter that School. The examples given later in this brochure are designed to show only the general principles; a fully personal plan will be sent to parents who use the attached enquiry form.

OBJECTIVES OF THE PLAN

1. To spread the cost over as long a period as is economically sound.

2. To reduce the actual cost of the education by the use of life assurance and by taking the utmost advantage of income tax reliefs and allowances. The reduction can amount to 25 per cent. in some cases.

The plan also provides, if the parent should die:

(*a*) A sum towards the payment of the fees.

(*b*) A maintenance income (to help during holidays, and the cost of clothing, etc.).

EXAMPLES

These have purposely been made simple, but the actual plans can be arranged to include more than one child, *e.g.*, whole families can be included. Existing Life Policies can be taken into account and the addition of subsequent children is simple to arrange.

Plan 1.—The intention is to send a boy, who is not yet one year old, to a Preparatory School at say £240 p.a. when he is eight years old for five years, and then to a Public School at say £309 p.a. for five years.

10 years education at fees normally payable in those 10 years, would cost ... **£2,745**

Under the plan, the cost, spread over 16 years, after allowing for the maximum tax reliefs and allowances (current rates), would cost about £121 per annum until the boy goes to the Preparatory School and would gradually increase each year to about £170 in his last year at school. Starting at £10/2s./0d. per month.

Total cost would be about **£2,185**

Saving about **£560**

If the father died, the plan would pay the sum assured towards the fees in one lump, and £100 yearly from the date of death for the boy's maintenance.

Plan 2.—The intention is to send a boy, who is not yet one year old, to a Public School in his thirteenth year for five years, independent arrangements being made for his schooling prior to entry.

5 years at a Public School at approximately £309 per annum, normally payable in those 5 years, would cost **£1,545**

Under the plan the cost, spread over 17 years, after allowing for the maximum tax reliefs and allowances (current rates), would cost about £65 per annum until the boy starts at a Public School and would gradually increase each year to about £88 in his last year. Starting at £5/8s./4d. per month.

Total cost would be about **£1,185**

Saving about **£360**

If the father died, the plan would pay the sum assured towards the fees in one lump, and £100 yearly from the date of death for the boy's maintenance.

In these examples it has been reckoned that the father's age is 30. The annual outlay on the plans varies chiefly with the age of the boy—the younger he is the lower the outlay each year.

ENQUIRY FORM

Will you please fill in this form and send it to Colonel Finch,
C/o. HAROLD B. FINCH & CO. LTD., "REVESBY," HUTTON ROAD, ASH VALE, Nr. ALDERSHOT, HANTS.

Parent's Name..

Parent's Address..

....

Telephone No...

Profession.. ....

Date of Birth of Parent.............................

Each Child or Children's Name(s)......................... ....

Date(s) of Birth ....

Date(s) of Entrance to Preparatory School......................... ....

Fees of Preparatory School ....

Name of Public School..

Date(s) of Entrance to Public School ....

Fees of Public School ....

Date(s) of Leaving School ....

Since we try to employ all existing means available, it will assist if you please state Provisions already made:

(a) Insurances already taken, giving detail in full, Name of Company, Sum assured, Date of Maturity.

....

....

(b) By other means ....

(c) Any other information ....

Signed..

Date ....

To: Col. H. B. Finch, M.C., (Retd.)
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