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VOL. LXIV

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JUNE, 1950

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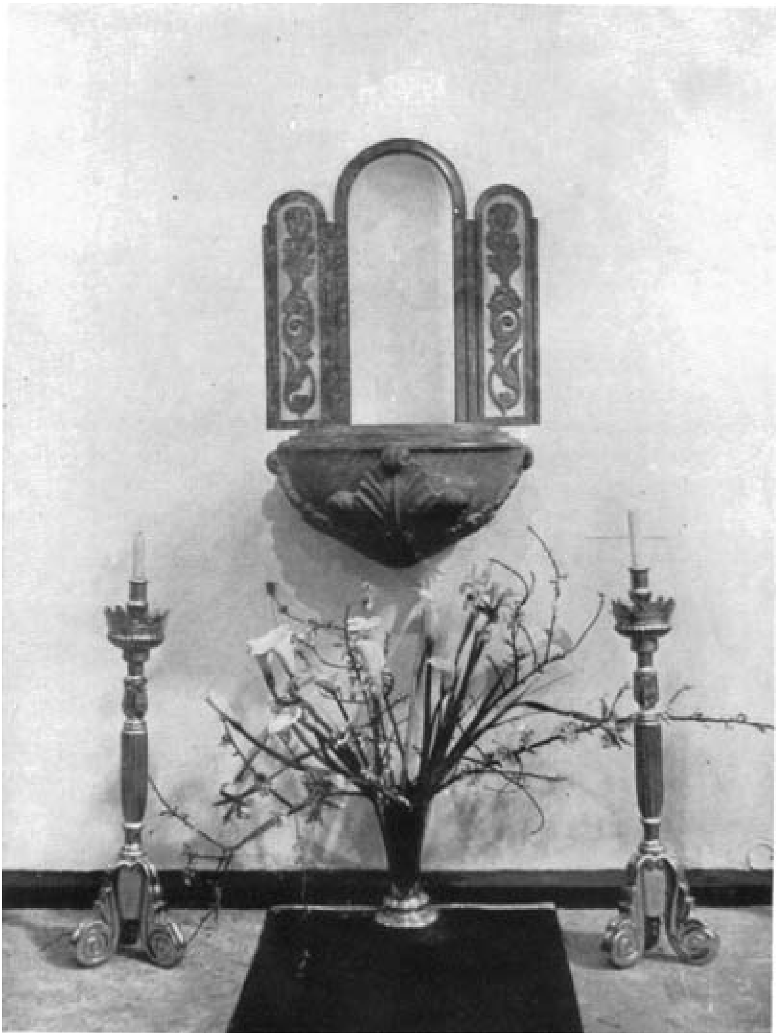


Gift Of A Font To The King's Chapel, Gibraltar, By The Corps Of Royal Engineers

GIFT OF A FONT TO THE KING'S CHAPEL, GIBRALTAR, BY THE CORPS OF ROYAL ENGINEERS

THE King's Chapel was built by the Spaniards in 1530 as a convent chapel. It has been used as a Garrison Church since 1704. It suffered damage during the Great Siege of 1779–83.

Many Regiments and Corps have been closely associated with the Chapel in its long history, but few traces can be seen of these associations. To make good this deficiency the Governor in 1948 invited Regiments and Corps which have played a prominent part in the history of the Fortress to make gifts to the Chapel. Some have given colours, others Seville lanterns ; the Corps of Royal Engineers has provided a font. The design is in the form of a shell carved out of grey marble ; over the font is a marble edged niche for a vase or figure, and the niche is flanked on each side by a marble panel carved in a Spanish design.

The font was dedicated on 12th February, 1950, and the service was attended by H.E. the Governor and C.-in-C., and the O.C. Troops and by a detachment of Royal Engineers.

A font is an appropriate gift by the Corps, which was actually born on the Rock when the first company of Military Artificers, from which the Corps is descended, was formed at Gibraltar in 1772.

EXPLOSION AT CHATHAM IN 1861

DURING some recent repairs to a house outside Ayr, a sheet of *The Times* dated 22nd January, 1861, was found behind the felt covering a door. The sheet is in most excellent condition and one of the main items on it, is an account of a terrible explosion at Chatham.

The explosion occurred in what was then known as the North Gun Shed of the Engineer Establishment and which is described as being just outside the main Barrack area. From this description it would appear to refer to the North Square of Brompton Barracks.

The explosion was apparently caused by carelessness in filling a grenade, which became ignited and subsequently ignited other loose explosive used for filling the grenades and finally blew up a complete barrel of gunpowder. There were about thirty men working in the shed at the time and of these about a dozen were seriously injured and some were not expected to recover. Many of the men who escaped serious injury had their clothes torn off them.

Colonel Harness, C.B., was director of the Engineer Establishment at that time.

This interesting portion of *The Times* is now preserved in the R.E. Museum.

THE PLACE OF THE ENGINEER IN LAND WARFARE

By MAJOR-GENERAL SIR EUSTACE F. TICKELL, K.B.E., C.B., M.C.

A Lecture given at the R.U.S.I. on 16th March, 1949, and reproduced from the *R.U.S.I. Journal* for August, 1949, by permission of the Council.

GENERAL SIR SIDNEY C. KIRKMAN, K.B.E., C.B., M.C., in the Chair

THE CHAIRMAN: We are very fortunate in having General Tickell here this afternoon. There are probably few people who know more about engineering problems in the field than he does, because he has had vast experience.

He was in the Middle East as Chief Engineer before the war, then he was Director of Works, and later on Engineer-in-Chief, in the Middle East throughout the period of fighting in the desert. He then came home to assist in planning the invasion of Normandy, and ended up Engineer-in-Chief in B.A.O.R. He came back as the Engineer-in-Chief at the War Office, so you will appreciate that he has a vast experience of the things about which he is going to speak.

LECTURE

BEFORE talking about his place in land warfare, or for that matter anywhere else, one should be fairly clear about who this fellow is. In other words, one should try to define the meaning of the word "engineer."

A modern mechanized army depends for its terrific power to move and hit upon *engines*—tens of thousands of them. Wars are no longer fought by men and horses, but by men and horse-*power*, with the result that a very high proportion of the *men* are engineers, in that they deal in some way with engines. These men exist in every arm of the Service, and there are certain corps—for instance the Royal Mechanical and Electrical Engineers—who consist almost entirely of highly skilled and highly trained officers and men, all of whom are engineers in the modern meaning of that word. Long ago, however, an engineer meant a man of genius, or at any rate of ingenuity, who devised and operated "gins" or "engins"—in other words gadgets. Men of his type were used in armies to work the catapults, battering rams and other forms of engineer plant employed in building, defending and attacking fortresses, occupations which, incidentally, took up a lot of time and energy in the wars of those days. From these ingenious fellows grew the Corps of Royal Engineers.

Since the advent of the internal combustion engine they can no longer claim to be the only, or even the largest, collection of engineers in the army. On the other hand the places of engineers other than Sappers are fairly well laid down ; their own tasks are allotted to the several technical corps (the Royal Signals, R.A.S.C., R.A.O.C. and R.E.M.E.) and to the technical members of all arms. But the tasks remaining to the Royal Engineers are not so clearly defined, and perhaps it is for that reason that I have had the honour of being asked to talk to you today. I shall, therefore, deal mainly with the place in land warfare of the *Royal* Engineer.

He stands in the place of the residuary after all specific legacies have been allocated, and he never quite knows until the time comes what he is going to get. Although so much engineering is now the duty of others, an ever increasing amount seems to be left over for the residuary legatee. This should surely cause no surprise. The modern mechanized army is a thing of tremendous power, and one man in the front line can now do things that thousands could not have done before mechanization. But there is another side to the picture. This endowment of the fighting man with such powers to shift and strike must be paid for by very great increases in the efforts put in behind him to make sure that his engines keep running and do not keep running out of petrol—that his guns and signals keep working and do not keep running out of ammunition, electricity and spare parts. The teeth have got far sharper, but they must have a fatter tail. We shall see that mechanization has increased very considerably the demands made upon the Sappers in the teeth area, but it has also quite rightly done the same at the other end—in fact, throughout the whole long length of the body of the Army.

If you look in the Army List with the help of a Latin dictionary you will discover that one of the mottoes of the Sappers reads *Ubique* (" Everywhere "). I hasten to assure our Chairman that I have not forgotten that another regiment shares this motto. However, I do think that it is, perhaps, the quickest way of defining our place in war. I will try to go very quickly through the tasks that at present fall to our lot and to show that they do occur almost everywhere, and have little tendency to become fewer or for that matter lighter.

THE SAPPERS' TASKS

We have in the past been concerned with the bearing, fostering and weaning of many children, and it has been our custom to throw some of these off when they became too big, or when it seemed better that they should stand on their own feet. For instance, we were concerned with the infancy of naval mines and torpedoes, signals, searchlights, sound-ranging, trench mortars and even aircraft, and at the time of the Boer War we drove the first military M.T. Many more children have been born to us, but they are still living at home. Our parental responsibilities are therefore getting rather onerous, but I will try to show why each of these offspring still hangs about the house, and why I think it right that it should. This is perhaps not a very healthy state of affairs, because the experiences of many wars have shown that something brand new is liable to drop into our laps as the result of the ever-changing technique of fighting, and I cannot help thinking that it is a good thing for the Sappers to *start* a war with their hands not quite full. We are, however, trying to take steps to grow a bit, so that we shall be in a better state to meet the unknown new jobs that are bound to arise in the future. But let us look at the individual members of this rather sprawling happy family, as it exists today, starting from the enemy and working back and down to the uttermost depths of depravity at the very bottom of the base.

Mines

The enemy—No man's land, the Sapper playground of 1914. Our old friend the wire of the 1914–18 war has, I think, been largely replaced by the mine, and I am one of those who think that the late war may have left us rather complacent about the mine. The Western Desert was definitely not a mine country—there was too much of it. After that the Germans never really had the transport, etc., to lay mines in quantity ; moreover, it was not until nearly the end of the war that they began using really difficult mines. It does not require much imagination to foresee a possible time when combinations of mine fuses will have defeated all possible anti-mine devices, and then the beast will become the Queen of Battles—the weapon with no answer and no antidote. Is this mine-laying, mine-detection and mine-lifting really engineering ? I think that it must at any rate remain one of our tasks. We must have a body of people who exist from the front to the rear (for remember that during advances the mine menace is just as bad in back areas), a body of people who are for ever studying changes in enemy fuse technique, perfecting their own, and, what is very important, surveying and trying to record our own and enemy mine-fields. I think the Sappers are the best people for this.

The study of mines and their ways is closely related to that of bomb disposal, and this rather thankless task must, I think, also remain with us. Incidentally, it often involves fairly heavy timbered excavations, pumping, tunnelling, etc. I do not think the R.A.F.

want to take it all over, although presumably it is someone's air force, and not their army, that drops these things about.

Now to our front line itself. Who can say what the future holds in store, supposing we are on the defensive, which is sometimes apt to happen to the British Army when the curtain first goes up? Shall we go back to that vast slough of very demi-semi-engineering—trench warfare, with all its dugouts, mine galleries, tramlines, pumps and gas? Or will the pill-box (at 200 tons of reinforced concrete a time) come back into favour, or will even deeper and stronger funk-holes be wanted against the new weapons? We must at least be ready.

In the offensive when it comes, there will, as already mentioned, be the mine detection and destruction problems, which are almost certain to be even more difficult than any we have ever yet tried to solve.

Against the enemy permanent fortifications we are now able to offer a new form of assistance with our armoured assault vehicles. I am sure they have a great future, and I am equally sure that they should be manned by Royal Engineers. They and the bulldozers were some of the first troops ashore on D-Day, and helped with the many jobs that fall to our lot during assault landings.

Bridging

Now I come to our traditional task—the helping of armies to cross natural obstacles—in a word, bridging assisted by rafting. I could, given time, speak at length on this subject alone, but will confine myself to a few remarks showing how different and difficult this bridging problem has become. It is one that is so very important now that armies can move much faster and farther.

When I joined the Army, we had two types of bridge—one for men in single file and one (incidentally not much stronger) for men four at a time, which carried all other traffic except a few heavy guns and howitzers, which did not move about very much. Since then, although the lightest loads have not changed, the heavy ones have grown and grown and grown. We managed to cover the spread between the loads in the late war with really only one bridge—the Class 15 to 40 that took everything up to tanks. We had a quickly erected light floating and very temporary and wobbly lorry bridge, and could strengthen our Class 40 to take tanks on their transporters. But the war was really fought at Class 40.

We are now faced with a much greater spread—bridges far stronger and far wider, may be wanted for front-line fighting vehicles. If we are not careful we shall spend our time bridging quick and light, and then having to replace immediately by something stronger and wider, with the result that twice as many men will be locked up, and twice as much transport required to move this duplicated mass of steelwork from the base to the front. The increase in width and loading, in other words, is tending to make us play with too many types of bridge and raft.

There is another aspect of this problem. Many army vehicles are now too big for the railways and too heavy for the majority of the civil bridges of the world, but they have got to get into the battle. It is quite clear that we shall not only have to replace blown bridges, but also replace or reinforce large numbers that have never been touched by the enemy or our own Air Force. This assessment of the strength of existing bridges and the improving of their carrying capacity may well become a major task, and one which will require a very specialized technique and a good deal of arithmetic. I know that there are many who think that in the past we have often been over cautious in applying our factors of safety. I do not agree ; but anyhow future loadings are going to break or, at any rate, kink many a camel's back.

However you look at it, this bridging problem is bigger than it was, and it was no small one last time. We built over a hundred miles of bridges in the late war, and experience showed that, just as a tank only goes a mile or two to the gallon, so does an army only go a mile or two the bridge. Both the 21st Army Group and our Army in Italy each wanted over 1,500 : and do not think that desert countries require no bridges : we had to bridge the Nile three times, the Suez Canal five times, the Shatt el Arab at Basra and the Euphrates in full flood—all very heavy bridges.

Road Making

Bridging leads naturally to the road problem. From the Sapper's point of view, it is a curious thing that the more mobile does an army become and the greater the country-crossing ability of its vehicles, the more does it demand strong, wide and dependable roads. It is not the front-line troops that do the damage, but that endless stream of follow-up replacement and maintenance vehicles which mechanization has made possible and made absolutely necessary. It is lucky that the Western Desert and North-West Europe campaigns were fought—the one on go-able desert ; the other in one of the best roaded areas in the world. In Italy and Burma, things were far more difficult. Even so, the Middle East campaigns demanded some two thousand miles of brand new road in Egypt, Palestine, and Libya and very great efforts in the maintenance of all existing roads. In North-West Europe, the effort expended by troops and civilians was very great indeed. At one time we were quarrying and using ten thousand tons of stone every day—a tonnage which eclipsed all others.

Will this problem get any smaller? In my opinion quite the reverse. I have had to maintain a lot of roads, and the difficulty has nearly always been the sides. In future, with wider vehicles, I am sure that this frilling at the edges is going to increase our troubles considerably, and I do not believe that however cunningly our forward vehicles are designed to let them cross sand or swamps, we shall ever be free from hoards of standard commercial lorries immediately behind—lorries necessarily designed for, and necessarily demanding, proper road surfaces.

Airfields

Very akin to the road problem is that of the airfields in the land warfare zone. We managed—just managed—in the late war to provide adequate fields to keep the aircraft operating in the air with the army, but for various reasons into which I need not enter, this task is becoming increasingly difficult. The conventional airfield for even the smallest machine is a great big thing. One runway is equivalent in area to thirty miles of the width of road we used from Alamein to Tripoli. The problem of the future, though, as I see it, is not so much that forward airfields will get much bigger, but that they may have to be made far stronger. Instead of thin skins of tarmac, steel sheets, wire mesh or even roofing felt, which was often so very effective, we may easily be faced with having to produce a surface akin to that of a first class road or else made of steel so thick that its transport to the site by sea and land will be quite frightening. It may well be that to get a squadron of fighters airborne may require runways as big and as strong as the Kingston By-pass. No, it is difficult to hope that our airfield commitment is going to become any smaller and, in all conscience, it took a high proportion of our engineer effort throughout the last war.

One word about demolitions. Luckily they did not figure largely as a British Army hobby in the last war, but we saw enough of the effects of wholesale German demolitions, combined with those of our own R.A.F., to see how effective they can be. Against a nation not provided on a lavish scale with equipment bridges, they would be far more effective than they were against us, and against such an enemy if he depended upon modern heavy tanks they would be telling indeed. But demolitions must be carried out in a wholesale way on a wide front; in fact, to be useful, they require very large numbers of trained personnel. It is true that, at the times when they might be called for, other work could be dropped, but they do present a problem in training.

So much for a few of the tasks connected with actual operations—what might be called the showy part. But unfortunately in these days, it is not necessarily the major part. As we have seen, the tremendously powerful mechanized modern army must have a really lavish organization behind to keep it going, and it is in the provision of this organization that so much engineering effort is nowadays required. I will try to run through the major jobs that arise.

Railways

First and by far the most important—railways. It is I think very commonly forgotten how entirely dependent we really still are upon the railway, which has changed so little since it was first used in war last century by the Germans, Austrians and French. As a mover of tons it still has no equal, and it is probably true to say that the German defeat resulted as much as anything from their short-sightedness in not making enough locomotives during the war and the immobilization of those they had by air bombing. I myself look upon the Sappers' responsibility for building and operating railways as quite one of the most important of their duties. Of course we obtain every scrap of assistance we can from the railway material and personnel we find in the country, and are very much dependent for British personnel upon the British Railways ; but experience has shown again and again that we must have a number of highly trained military railwaymen. This railway problem in war is far bigger than many people think. The mileage of new permanent way required on the L. of C., in the base and especially inside Base Depots is surprisingly great—whatever the type of theatre—and repairing demolitions is very heavy work. The difficulties and complications of forcing unusually heavy military traffic in unusual directions along unsuitable lines, often very heavily damaged and badly maintained, produce real problems. We are so used to the reliability and comparative punctuality in our regular peace-time-tables that we are inclined to forget the very different conditions of war. Gauge idiosyncrasies alone cause many a headache.

Docks

Closely linked to the railways and just as vital are the docks, which provide for the whole operation of unloading ships and arranging that their cargoes are cleared by rail, road or water. The actual docks may be taken over intact or may have suffered from wholesale demolitions, as occurred so often in the last war. They may be quite inadequate or may not exist at all. This dock reconstruction or construction *ab initio* may involve very heavy engineering and is always required at a speed unheard of in peace-time. It is pre-eminently an engineering problem and, as examples of what may be required, one need only quote the American reconstruction of Naples and Cherbourg ; our own work on large numbers of smaller ports ; the work carried out in Egypt, where we built ten or twelve new full-depth berths and some five-miles-length of shallow berths, involving in all the driving of some 60,000 big piles ; and of course, last but not least, the construction of " Mulberry."

We find it convenient in the British Army for the same corps to build *and* to operate docks, just as they build and operate railways. This operation of the cranes, the cargo handling gear, the lighters and the stevedores is perhaps not strictly speaking engineering, but we find it leads to smooth running to keep it in the family, and I personally think that this is the right organization. I also think it best for us also to run (as we do) the Inland Water Transport.

Pipe-Laying

Water Supply. This has always been an important Sapper function and although we are now saved the major task of watering thirsty animals, there seems to be just as big a demand for water as there ever was. Perhaps we are cleaner or thirstier. In the Middle East we were filtering and piping around enough for a place like Birmingham or Manchester and bored twenty miles of tube wells. Water, or rather the lack of it, of course, loomed very large in desert operations, and led to the laying of the 300-mile Libyan twin pipe-line, which incidentally, was used more for thirsty locomotives than for human throats. This water line was followed by the laying of many petrol pipes in all theatres, and these have no doubt become a permanent feature of mechanized war. The thousand miles of pipes working from tankers at the Beach Head and Cherbourg, and later from Ostend, to be supplied later still from *Pluto* at Boulogne, saved the 21st Army Group L. of C. about 2,000 tons lift a day, and thus paid a handsome dividend. We shall, of course, in future improve the technique of pipe-laying, which was restricted very considerably by the type of pipes and pumps and tankage available at the time. With the far higher fuel consumption of modern fighter aircraft, there is no doubt that the pipe-lines of the future will carry both petrol and jet fuel.

I must say a word or two about the actual building of an overseas base. In these days bases are extremely dispersed for obvious reasons and it is hard to visualize their immensity. In the North-West Europe campaign, the base was in fact in England and covered a lot of it. It is when you get further afield that the problem of creating afresh arises.

Buildings and Electricity

I do not want to enter into figures, but the actual buildings involved in the Middle East Base, which grew up during 1940 to 1942, were about equivalent to the flooring and roofing of St. James's Park, Hyde Park and Kensington Gardens (say, 350 Rugger grounds). This included the depots, workshops, hospitals, personnel camps, detention barracks, factories, N.A.A.F.Is., etc., and last but not least, the headquarter offices. All this building required roads, railways, water, electric light and drainage—quite a large town ; about equivalent to $\frac{1}{20}$ of the housing accomplished by the whole building industry of Great Britain since the war. I am not prepared to assert that the quality or architecture was quite the same. We had our own shortages.

A new feature of the last war was the great use of electricity for lighting, heating, and power supply in workshops, factories, saw mills, pumping stations, etc. In all captured countries and towns its reinstatement was of prime importance, and was vital to the operations in Italy, France and Belgium. We had to do some quite big jobs in this connexion, supplementing and reconstructing power stations and, as a side line, a new grid line from Belgium to feed Holland when their only source in Limburg was still held by the enemy.

Local Production

There is just one other base activity that I should like to mention. It is the local production in the theatre of operations of all kinds of articles that cannot be obtained from home for one reason or another, or which would involve an undue quantity of shipping in their completed form. This local production was carried out on a very large scale in all theatres, either by direct employment of soldiers or, more commonly, by the adjustment or creation of local industry, controlled and supervised by the military authorities. The local production of raw materials, such as cement, bricks, bitumen and timber is fairly straightforward, but is usually on a very big scale. Modern war, however, often wants at short notice large quantities of finished articles, requiring the setting up of factories with complicated plant. For instance, in Italy, we were making complete Bailey Bridges starting from the initial smelting. In Belgium we obtained all sorts of things as soon as we got the power going. The Middle East, being almost isolated for some time, did a lot of this sort of thing. We made hundreds of big oil tanks for railway wagons and some 30,000 flit guns. We made a hundred quite good little ships, like landing craft, for working from ship to shore, and I have met them all over the world since. We made enough anti-tank mines and jerricans to reach, touching each other, from John o' Groats to Port Said. I am quite sure that this sort of thing will have to be repeated. It wants a lot of organization and a good deal of knowledge.

We now come to some activities, not strictly engineering, but in which the engineer finds a place in war—at any rate in the British Army.

Maps

First, survey—that is to say topographical survey for both the Army and Air Force. Air photography and radar have, of course, greatly simplified the making of maps. They have, so to speak, taken the drudgery out of the game by greatly quickening the mapping of topographical details, and approximate contours. On the other hand, we are still left with the bulk of the trigonometrical and mathematical parts and we find that officers with an engineer training are best for this. One ought to note that although modern technique has reduced the work of map making, modern mobility and, of course, the range of modern aircraft have enormously increased the area of the earth's surface for which maps may be required. Improvements in plotting and map reproduction have made it possible for up-to-date maps to be issued on a pretty lavish scale, and in no theatre, unless extremely close to home, is it possible to operate nowadays without a very large Map Reproduction and Distribution Service involving large numbers of big modern lithograph and printing machines.

One other activity for which the engineer cap badge is worn is Movement Control—strictly speaking, of course, a non-engineer staff function—but we find that engineer officers (and, to a certain extent, other ranks), especially with railway and docks experience, usefully fill a high proportion of Movement Control posts.

Army Postal Service

The Army Postal Service has always been manned by Royal Engineers. This dates from the days when we also ran the Signals, and our close liaison with the General Post Office is so valuable that we have retained this connexion, although in some respects it must seem a trifle illogical to those with very tidy minds.

PERSONAL

There remains one other sphere in which the Engineer finds a place in land warfare. I hope you will forgive me for mentioning this. I refer to the filling of many of the high and very high positions in the Army. It is perhaps only logical to expect that those with an engineer training should find a place in the control of an enormous organization, which is nowadays so pre-eminently mechanical. But I do not think that one would have expected a small Corps (numbering little more than a thousand regular officers in 1939) to have produced eighty Generals during the last war, holding key posts in practically every branch of the military hierarchy—Command ; Operations ; Planning ; Intelligence ; and every part of A. and Q. There was, in fact, rather a large draw off to fill non-engineer posts. Of our 1939 Majors and above, one in seven became Generals, and about half of our pre-war officers filled staff appointments. In the American Army it was rather the same.

So much for a very quick run through our jobs. Now just a few words about the problems involved in fulfilling these responsibilities. First and foremost—officers. It is quite clear that there is little scope in peace-time for carrying out more than a tiny proportion of the work that appears in war. We are therefore obviously faced with all the problems involved in a very large and very rapid expansion on mobilization.

One must remember that sappering takes a long time, and it must be started very early in a campaign if it is to bear any useful fruit. Of course, we hope to be able to draw upon the very wide body of civilian engineers, but we must remember that the Navy, Air Force, Ministry of Supply, and also all those authorities at home who are faced with big building and other work such as A.R.P. in war-time, also want engineers. We do not, therefore, have quite a free dip into the pond. I cannot omit to mention what a tremendous debt we owe to every one of the Dominions for supplying quite wonderful Sappers—both officers and men. The wide open spaces of younger lands certainly breed Sappers. Things are easier than at home, where there is hardly room to swing a bulldozer.

PLANT AND STORES

The next problem is very nearly as important : the supply of plant and material—that mass of stuff which we call Engineer Stores. Here again, it is quite obvious that no Chancellor of the Exchequer can face the financing of a stock pile in peace of stores and machinery in kind or quantity such as is required to meet our commitments. He has enough difficulty in paying for the peace-time reserves of ships, weapons, aircraft, shells and all other munitions. Moreover, most of the things we want are also wanted for the peace-time economy of the Country, and it would be an unpopular move even to try to corner stuff required to keep us all going in normal times—let alone in these days of timber, steel and machinery shortages. This question of trying to make sure that we shall not run out of materials in the first year or so of a big war presents a really major problem. It was tricky enough last time, and we had eight months of only very semi-war, in which to collect a few things together. This military engineering wants a staggering number of different items from bulldozers and bridges down to bricks and bolts, and also wants quite surprising quantities of them all and, perhaps what is the most difficult part, it may want suddenly quite different types of things, according to where and how the war goes.

In connexion with this question of supply of plant and material, one should note that just as the rest of the Army is using more and more machinery, so do we do everything we can to replace man-power by engines—we use a funny looking lot of stuff, mainly, of course, of civil origin. But it does mean that we can get the jobs done more quickly and with fewer human beings. One theatre alone had 60,000 cards in its machinery index, ranging from locomotives, dozers, graders, steam rollers and huge pile drivers through a mass of stone crushers, compressors, pumps, snow ploughs, hydraulic presses, circular saws and very big prime movers down to small electric motors and machines connected with bomb disposal—all wanting spare parts.

Do not think, however, that this machinery has entirely eliminated Man. At the base and right up the L. of C. we employ every man we can find with the skill required—and lots without it. We either employ them directly or by putting the work out to contract. In the Middle East, there were at one time close on a quarter of a million souls, including boys and women (civilians of many nations) —working for the Royal Engineers.

TRAINING

Finally, there is the training of the officers and men at home in peace-time—the nucleus, so to speak, upon which this very big expansion of war-time Sappers, and large bodies of war-time civilians has to be built. We have to train our officers to be both soldiers and engineers, and our men to be both soldiers and trades-men. It is a big job, and is becoming increasingly difficult. Not a moment passes these days, in which there is not some advance in the science of engineering and it is very hard to keep up to date in even a smattering of the many branches, and in fact many quite distinct professions, into which it is now divided.

War is indeed becoming a technical and complicated business, and I hope that I have said enough to show that the engineer has a place—an important place, and I myself think an ever increasingly important place—in it.

I have dealt perhaps at too great length on our problems in rear areas, but it is, of course, upon the front-line Sappers—the army, corps and divisional units (including airborne and armoured divisions) that other Arms really rely when carrying out their rôle of actual fighting. These are the units, more particularly, which must be really trained as soldiers—really good soldiers—and led by officers who combine military qualities with technical knowledge, quick thinking, and above all a determination to get the job done at all costs; officers with self-confidence because they know their stuff; officers who can make a plan and stick to it; officers not too proud to ask for expert advice, and not so gullible always to take it; officers who have the courage to take on something new, but also have the courage to be able to say firmly and convincingly "It can't be done, and certainly not by Tuesday"; officers who can get the very last ounce out of every hour, every machine, every brick and every man, whether he be a coolie, a soldier or a Doctor of Science. These are the officers we must have (and are getting) if we are to fill our place, our ubiquitous place (I say it again), in war on land.

DISCUSSION

CAPTAIN J. D. C. GRAHAM: When the Lecturer gave us a list of the various tasks dealt with by the Corps, he omitted to mention—I do not know whether he did so on purpose—Chemical Warfare which I believe used to come under the Royal Engineers. Could he say whether his Corps is still responsible for Chemical Warfare and research and, if that is the case, whether the decontamination of radio-active areas in future wars also comes within their responsibility?

THE LECTURER: Research is not an Army responsibility these days, and I do not know who would be responsible for the decontamination of radio-active areas. We are, of course, responsible for decontaminating gassed areas, if there were any, and I suppose the decontamination of radio-active areas would also come our way. We do not keep any gas units going in peace-time.

BRIGADIER H. A. JOLY DE LOTBINIERE: There are two points which I should like to raise. First of all, can the Lecturer tell us why the ancient and honourable term "Company" has been changed to "Squadron"? I quite realize, of course, that the term is applicable in an armoured unit which is the descendant of a cavalry division, but it strikes me that a railway squadron or a workshop squadron seems a bit odd.

Secondly, the Lecturer said that the Corps was still getting the best type of officer, and I am glad to hear it ; but I wonder whether, in view of the fact that the financial attraction when he and I joined the Corps has now been removed, and all are now getting the same, the best brains will not be attracted away from the Corps, because if they go to (say) the Infantry, the chance of securing a staff appointment is much better when compared with the one or two vacancies allowed in the Corps.

The Lecturer : With regard to this question of squadron, we had a great deal of discussion just after the war, and we came to the conclusion that the jobs done by the Sappers were bigger than before, and the unit normally required for sapper jobs these days is a whole Divisional Engineers rather than one of the companies. We wanted an organization which would put the three or four companies in a division under one command. Then the problem arose what should we call it, and it was decided that it should be called a regiment rather than a battalion, but we were informed that if we called it a regiment, the parts of it must be called squadrons. I entirely agree that some of these squadrons do sound a bit odd, but I assure you that one can get used to anything !

As to the point raised about getting the people we want, of course we are not getting anything like as many people as we *now* want, but so far we are getting the right type. It is too early to say how things will go later on. We are not monopolizing the cream at the top of the list as we did before the War, but we are getting a very good lot from Sandhurst. I know that the cutting off of the Royal Engineer pay has made a great deal of difference in the attraction to the Corps, but I do not think that in practice it has made quite so much difference as some people think. I think we Sappers have to realize that we cannot expect to take the top fifteen, or fifteen out of the top eighteen, from the list every time as we did from Woolwich before the war. It is not fair on the rest of the Army, neither is it a sound policy. Although we have the very large number of big jobs which I have run through today, other people also have big jobs and also technical problems, and I think myself that any attempt to take fifteen chaps out of the top eighteen at Sandhurst every time would not really be in the interests of the Army as a whole—much as I should like to see it happen !

Brigadier C. de L. Gaussen : I should like to support what the Lecturer has said about taking the top fifteen. Recently I protested and tried to get a limitation on the number of officers employed on the staff so that they could come back to the Corps, but I was told that the Royal Engineers officers were so clever that they could not be spared !

Captain E. Altham, R.N. : While listening to this lecture, it struck me that the Royal Engineers and the Royal Navy have a remarkable number of interests in common.

To begin with, it is the duty of both Services to keep open the lines of communication and, whether on land or sea, there is the obstruction of mines to be contended with : here they meet over the technical problem of mine detection and destruction.

Oil and its products—their grades and supply—are of great mutual interest.

The production of chart-maps should be a standing joint responsibility. Although it was an accepted principle, as the result of experience as far back as the 1914–18 war, that these were indispensable for anything in the nature of assault landings and especially for naval covering fire, it was distressing that they should have been conspicuous by their absence at the beginning of the late war : charts had reverted to one watertight compartment, maps to another, although it was soon found—once again—that the Army needs a good slice of the chart and the Navy needs quite a bit of map on these occasions.

The Lecturer also alluded to the postal service, and there I think the Royal Engineers could give the Navy an example of what such a service should be, for the Army has enjoyed one which was properly organized and which functioned well. The Navy's postal service was a mess for a great part of the war. This is a matter which closely affects morale and is, therefore, of importance.

Can we not also claim that the Royal Engineers and the Royal Navy are the parents, or at least the grandparents, of the Royal Air Force of to-day? I think it is true to say that the Royal Flying Corps was the child of the Royal Engineers, just as the Royal Naval Air Service was the child of the Navy. The two married and produced the Royal Air Force.

That brings us to the human factor in all this. It seems to me that to-day the two Services ought to be closely linked with each other and with the scientists ; there must be a great many needs common to both for which they must turn to the same scientists. At the other end of the scale there is the training of new recruits for specialist branches. I wonder how the Sappers, to use that familiar appellation, are faring with the problems which must arise in a highly technical Corps under the conditions of National Service. The Navy is becoming more and more a technical Service, and as a one-time specialist officer, I realize how very difficult it must be to give men who are only going to serve for a short time adequate training in highly technical duties ; particularly at the present time when there is such strong pressure to teach them a trade, not always with a view to it being of value to the Service, but rather so that it may be of value to the individual himself when he goes out of the Service.

Another question I want to ask the Lecturer is how the great concrete *autobahns* in Germany, made ostensibly for the pre-war tourist but in reality for strategical purposes, did in fact stand up to the war. We know that many of them were relatively new, and in the light of experience there, no doubt a great deal has been learnt about the building of heavy-traffic roads on virgin soil.

One last question: how do the gauges of the railways on the other side of the Iron Curtain compare with the gauge of the railways on this side? We know that our rolling stock can run on French railways, but does that apply in other continental countries?

THE LECTURER: With regard to our resemblance to and liaison with the Royal Navy, I have perhaps seen a lot of the back side of war, and it is very surprising how very many of our Sapper problems have to be thought out in consultation with the Navy. We Sappers must, I think, get together with the Navy very closely. It is for that reason that we are doing our utmost to foster yachting and love of water. We have done quite a lot already and want to do more, because we must know more about the sea and naval jobs. There is, for example, that five-fathom line on the naval chart. The Senior Service do not worry much about what happens within the five-fathom line; it is dry land to them, but it is not dry land to us especially when we are thinking of building docks or landing on beaches. Again there is this mine business, it is very easy to write down on a piece of paper what is a naval mine and what is an army mine, but when dealing with them in several fathoms of water it is not always clear who handles which: it calls for very close liaison between the two Services.

On the question of gauges, of course, they were a bad headache to us during the war. They were nearly as bad as volts and cycles in electricity. I think we had thirty brands of electricity in the Middle East and twelve different gauges in one place and another. I think the Russians are trying to get some of their main lines on to standard gauge, but it is a very hard job. It is, of course, easier to make gauges narrower than to make them wider. I think you might say that volts, cycles, gauges and screw threads are the curses of war!

As to the training of National Service men, there is no doubt that it is a frightful problem, and from the point of view of a technical corps it is really very difficult. It takes a great number of people to train these young men, who come to us with no trade, and who stop with us nothing like long enough to learn a trade let alone learn a trade plus other things. As soon as they have completed their National Service, they go away and there is no guarantee that they will come back to us again. As I say, from the technical corps point of view the training of National Service men is very difficult. On the other hand, we have started two big wars with only a very, very few Sapper units. Both those big wars were planned on the principle that they were going to be fought in North-West Europe, and that our Allies were going to do all the work in connexion with the ports and L. of C. That promise was made before both great wars, and in both great wars it was found that the promise could not in actual fact, with all the will in the world, be kept. So in both wars we discovered that we had to produce nearly all the technical troops *ab initio* after the war started, and it looks as though that will be largely the case the next time, because National Service does not produce enough real technical troops.

With regard to the R.A.F., it is quite true to say that before the days of the R.F.C. we had a Balloon Company which used to run balloons, kites and aircraft. They ran aircraft for a short time, but flying was one of our children who grew very fast and was thrown out of the house rather early.

As to the *autobahn*, the roads in Germany seem to be of two kinds, very good, and very bad. Hitler built his very well, and they were wonderful pieces of engineering. Of course, they were constructed regardless of cost and manpower. It was at the time when he had many unemployed for whom he wanted to find work. He did, however, build them very well indeed. They were aligned largely from the point of view of providing a nice view as one drove along, and to build roads on embankments for most of the way is none too easy. The bridges are very good too, but they have one military snag, namely, they are much too low. Some modern army vehicles on modern transporters will not go under half of these bridges.

THE CHAIRMAN

The Lecturer has put before us very forcibly the vast responsibilities of the Royal Engineers in war to-day. These responsibilities are really only a symptom of the mechanization of the Army as a whole, because if you look back and compare the situation to-day with that before the war, you find that there are great complexities. You find that all sorts of weapons such as radar, which never existed before the war, are standard pieces of equipment to-day. You find that equipment which was hardly known in this country, such as for example, bulldozers, is in everyday use in the Army, and you find that all kinds of equipment have become immensely more complicated. The modern tank has an enormous number of pieces. You find that many of the present-day weapons are largely automatic. There is the anti-aircraft gun of to-day, the laying of which is largely automatic. These things make an army much more efficient because they reduce to a certain extent the skill required of the fighting soldier, but they have enormously increased the percentage of the army which is to-day classed as "administrative troops." I do not mean to refer to the Royal Engineers as administrative troops, but a lot of their tasks are administrative tasks, and that in turn means that the actual men who carry bayonets or who man tanks are reduced in number, which is to some extent regrettable.

It is regrettable to see traditional arms go out of the Army, and it also raises, as Captain Altham pointed out, immense difficulties in recruiting technicians and in getting enough men mentally qualified to become experts, whether it be in the Royal Engineers, R.E.M.E. or any other technical Corps. I say it is regrettable, and it is in some ways, but I should not like you to gain the impression that I am belittling or disregarding the need for all the services about which the Lecturer has spoken. When I commanded a Corps in Italy in the later stages of the war, I became well aware of the fact that without my Sappers operations would have ceased. There is no question about that. An army can only exist with proper communications, roads and bridges, and had I not had any Sappers there would have been no more war there. We should have become static.

I think the lesson which we want to take away is that these tasks have come to stay and these complexities have come to stay. War has become more and more a technical business, and in peace we must give all the study we can to try to discover how we can do the jobs economically when war comes. We must find how we can reduce the number of gauges and screw threads by standardization, and simplify the tasks, because in another war there will be difficulty in finding the technical manpower for all this work, and the manpower to carry the bayonet and man the tank.

It has been to me a most interesting lecture, and on your behalf I should like to thank the Lecturer very much for having put all these things so clearly before us. (*Applause.*)

The vote of thanks to the Chairman was proposed by Commodore R. Harrison, R.N.R., and carried by acclamation.

THE MILITARY WATER PROBLEM IN THE WESTERN EGYPTIAN DESERT, 1940–1943*

By Brigadier W. G. Fryer, O.B.E.

Extracted from Volume III of the "Civil Engineer in War" by permission of the Institution of Civil Engineers (who have also kindly loaned the blocks for the plates) in extension of an article by Brigadier S. J. Armstrong, O.B.E., M.C., on the same subject in the "Royal Engineers Journal" of September, 1948.

Introduction

IN 1940, large-scale troop movement in the desert, west of the Cairo–Alexandria Line, was prohibited by lack of water. Such meagre wells as existed were scattered along the seashore at infrequent intervals, ranging from 50 to 100 miles. The frontier between Italian Cyrenaica and Egypt was a thick wire fence ; but the real barrier was the acute water shortage.

The large oases were too far from the coast for their water sources to be of any great value. Siwa, where Alexander the Great visited the shrine of Jupiter Ammon, had a copious artesian supply from Nubian sandstone. But Siwa lay deep in the desert about 160 miles from the coast. The presence of harbours and stretches of coastal road and railway, concentrated garrison effort—Italian and British—along the littoral.

Each man in the desert forces needed one gallon daily of drinkable water. Every engine radiator had to be kept full of fresh water. Every steam locomotive on the desert railway had to be given about 50 gallons of good quality water per mile.

The Western desert sources were all too saline for use in locomotive boilers, and diesel locomotives were not available till 1942. The desert railway had therefore to carry its own water from the Nile until water pipe-lines could be built westwards from Alexandria.

The Expansion of Desert Water Sources

In 1940, the Western Desert railway ran, at standard gauge, from Alexandria to Mersa Matruh. Matruh, therefore, became the forward British garrison, and held as many troops as its water sources, supplemented by water trains, would permit. The nearest large Italian garrison (and water source) was at Bardia about 140 miles west of Matruh. Between those two water sources, light outpost forces, existing on as little as half a gallon of water a day, operated. No increase to the desert garrisons was possible unless more water could be found locally, or carried forward from Alexandria by rail, road, sea, or pipe-line. Matruh is about 180 miles from Alexandria.

The development of desert sources was clearly of first importance. The possible ways of developing local water sources were :

(1) Expanding known wells.
(2) Digging or boring for new wells.
(3) Repairing the ancient Roman rainwater catchment reservoirs (known as *birs*).
(4) Improving the potability of saline sources.
(5) Educating the desert forces to drink saline supplies.
(6) Distillation from sea or saline sources.
(7) Treating desert water for locomotive boiler-feed uses.

Extraction of water in quantity from humid air was not feasible, though the heavy morning dews encouraged many experiments.

Expanding Known Wells—1940 Onwards

The most important Western Desert wells—each able to give several thousand gallons a day without becoming too saline to drink—were at Bagush and Matruh. Those wells were generally within four hundred yards of the sea, and tapped a shallow layer of fresh water, less than 2 ft. thick, lying in soft oolitic limestone directly on sea water. The fresh water came from the coastal winter rainfall. There was a continual flow of that fresh water seaward, resulting in a low level of fresh water at the start of winter. To obtain large seepage areas, long shallow galleries had to be dug or tunnelled. Collecting galleries of that kind, hundreds of feet long, with 1-ft. depth of water, cut in ancient Roman days, existed at Matruh, and were known locally as *aqueducts*. Field engineer units rapidly developed a method of digging standard test holes near coastal limestone sandhills and cutting galleries between those that gave greatest production of potable water. To get best production, the galleries were, as far as possible, sited at right angles to the probable flow direction of the fresh underground water. They were, therefore, generally parallel to the coastline.

The rate of production from the galleries (*aqueducts*) had to be controlled carefully to prevent the salinity rising. Fast production brought up the salinity sharply, and any gallery which had been overpumped was slow in recovering to a low salinity figure. Back-acting mechanical shovels were of great use in opening up galleries. There were no successful boreholes in the Western Desert littoral in 1940.

New Wells

Well-boring equipment, percussion and rotary rigs, easily capable of drilling 8-in. holes down to 500 ft. were of the greatest value in prospecting and opening up new sources. Since so much of the desert coastal formation was soft limestone, needing no casing, the conditions were ideal for percussion rigs—particularly where water was scarce. But in soft, running sand near the Nile basin, or in hard formations, rotary rigs using mud flush were better. Many hundreds of holes were bored.

An excellent team of geologists and geo-physicists was available to help in locating new well sites.

The most successful methods of discovering sites for new wells were :

(1) Boring or excavating near existing, even disused Roman, well sites.
(2) Geological forecast helped, where necessary, by geo-physicists employing electrical resistivity measurements.

It was occasionally possible, near the Nile basin, to plot salinity contours. Thus, important predictions for quality were made for well sites along the Cairo–Alexandria desert road—a road which ran close to important camps and airfields and carried a large part of the traffic to the desert forces.

Boreholes could not, of course, give any reasonable output in the coastal *aqueduct* areas, since the layer of fresh water was so thin—perhaps under 2 ft. thick. In such places, they were used for prospecting only. But, in 1941, the percussion rigs discovered important "perched" water at Fuka, capable of giving, through boreholes, more than 500 tons of water daily. That was ten times the volume of any of the important coastal sources then known ; and, as the Fuka supply lay on clay, not sea water, no change in salinity would result from heavy pumping. That welcome discovery made possible the forward water pipe-line schemes needed for the successful attack to relieve Tobruk in November 1941. Explanations of some of the new and important geo-physical methods used are in Military Engineering, Volume VI—Water Supply, Supplement No. 1, 1945, "The Location of Underground Water by Geological and Geo-physical Methods."

Birs

An extensive system of underground rainwater catchment reservoirs, dating from Roman times, existed in the desert littoral. Those reservoirs (known by the Arabs as *birs*, for example, Bir Hakim) had a capacity of many thousands of tons of water. To reduce evaporation, the natural rock roof was usually left complete except for a small manhole down which the water poured in winter rains. The large heaps of spoil at the *birs* had survived centuries of sandstorm and rain, and formed important desert landmarks. The majority of the *birs* themselves were very leaky and could not be used for forward water storage without considerable repair. They were extremely useful for outpost warfare and special attacks, but were already too large for the winter catch so that, even had it been advisable, no great improvement to supply was usually possible from that ancient system.

Improving Potability

The analysis of water from a Bardia *aqueduct*—one of the bad coastal sources—is :—

Calcium	270 parts per million
Magnesium	204 parts per million
Carbonates as CO_3	91 parts per million
Sulphate as SO_4	386 parts per million
Chloride as Cl	2,370 parts per million
Total solids	5,280 parts per million
pH value	6.9
Electrical conductivity ..	7,500

This water tastes most unpleasant. In tea it is far worse, and nearly undrinkable even by the desert-hardened. The troops drank water of that type for several months without ill effects. Limejuice, coffee, or whisky seemed to be improvements ; and improvement was certainly needed. With such a saline water there was certainly no need for a hot weather issue of salt to protect against heat-stroke. Where possible, high-salinity water was blended with a lower salinity to increase the water ration. No means of reducing salinity, other than distillation, were employed. All methods suggested seemed impractical. Where excessive sulphates, as at Jarabub, existed, some water treatment with lime was possible, and, indeed, was necessary since these waters were aperient.

The selected field-test for salinity was titration with a known silver-nitrate solution using potassium chromate as an indicator. Engineer field units were provided with sets of chemicals and burettes. Salinity figures were of such importance that some commanders of Royal Engineers carried out the tests in person. Salinity figures were scrutinized daily by senior engineer officers, since a rise in salinity might demand a reduction in outpost strength at a critical moment. No satisfactory field-test for sulphates was discovered. It took several months to set a standard of salinity which could be regarded as drinkable. At first, a salinity of 50 parts by weight of sodium chloride per 100,000 was, for medical reasons, accepted as the limit. That deadline was, however, moved by military necessity up to 350 parts during 1941, where it remained for the rest of the war. The siege of Tobruk in 1941 was successfully withstood by Commonwealth troops drinking little but local water of nearly 350 salinity.

Educating the Troops to Drink Saline Water

The least saline coastal supplies were nearest the Nile. As units came westward therefore, they met the salinity problem gradually, and slowly became accustomed to it. Veterans were able to drink water quite unsuitable for troops new to the desert.

Distillation

Some large plants of up to five effects, and capable of 100 tons of water per day, were available, but proved so vulnerable to enemy action and field maintenance conditions that they could not be considered reliable ; nor were they mobile. The Italians developed a high-efficiency mobile distillation set, using a diesel engine as the heat source. It frequently broke down.

Company cookhouses occasionally ran small single-effect stills, made from oil drums. In static conditions, especially in the 1941 siege of Tobruk, they were satisfactory and successful owing to their simplicity. In general, however, distillation was a very unsatisfactory way of providing drinking water.

Treating Desert Water for Locomotive Boiler Feed

By far the most useful method consisted of the use of tannin bricks and anti-foam compound. They were added by engine drivers to the water in the tender, when filling up at a desert water column. Some water-softening sets were installed in base areas, but the flexibility and simplicity of the tannin brick and anti-foam compound method proved best in the field. The chemicals used for a typical source near Benghazi were :—

0.2 lb. tannin extract ..	per 1,000 gallons of locomotive feed water.
1.5 lb. soda-ash	
0.2 lb. anti-foam compound ..	
(castor oil and tannin) ..	

TRANSPORTATION OF WATER

To supplement the desert supplies the following methods were possible :—

(1) Water pipe-lines.
(2) Water ships and barges.
(3) Rail tank-wagons.
(4) Canned and drummed water carried by road transport.
(5) Special water lorries.

All those methods were used. The camel water-train, so important in earlier desert wars, was no longer suitable.

Water Pipe-lines

In August 1940, a new water pipe-line leading west from Alexandria was ordered. Piping, chiefly 8-in. and 6-in., was bought from civil stocks in the Middle East. Pumps and engines were also purchased locally. As more piping and machinery were scraped together the pipe-line was extended.

By early 1941, the pipe-line had reached Dabaa, 100 miles west of Alexandria, and added 800 tons a day to the available carry of the Western Desert railway. In July 1941, the Germans and Italians were besieging Tobruk with a powerful force, and the garrison was hard-pressed. The enemy had little difficulty in beating back the attacks of the relieving force. It was clear that if Tobruk was to be relieved, a large-scale attack, with greatly improved lines of communications west of Alexandria, was needed. It was decided to extend, at utmost speed, the water pipe-line and the railway. The Eighth Army was formed in September 1941 and at once began the new pipe-line, pumping, and reservoir schemes. In short, before the attack, and in advance of the main garrisons, the military engineers had to construct 145 miles of mixed 8-in., 6-in., and 4-in. pipe-lines, seven pumping stations, and ten large reservoirs to give a total storage of 8,200 tons. All work had to be hidden and each of the seven pumping stations duplicated.

In addition, large new works and pipe-lines between the pipe source and the existing pipe head at Dabaa were needed, because supply to Dabaa had to be trebled. A new 10-in. steel pipe-line to Dabaa, 80 miles long, fed from new filtration plant on the Nile at Nubariya, was started as part of that development.

Plate 2 shows the main military water pipe-lines built by 1942.

The special difficulties connected with the building of the new pipe-lines to Dabaa were :—

(1) The forward pipe-lines had to be in full working order within two months of the day it was decided to build.

(2) Little but low-grade Arab labour, its effort braked by Ramadan, was available in the rear areas.

(3) The irregular and unpredictable U-boat and aircraft toll on arrivals of stores in Middle East.

General Specifications

Main Pipe-lines

(1) Steel pipes were buried $2\frac{1}{2}$ ft. deep where the ground permitted.

(2) Operation had to be continuous.

(3) Water pumping pressures varied from 300 to 850 ft. depending upon the pumping sets available in base stores.

(4) Pipe-lines on rocky desert were laid on the surface and vehicle crossing ramps were made every $\frac{1}{4}$ mile.

(5) Pump-houses and reservoirs had to be hidden from enemy observation.

(6) No boosting was done in the new lines.

(7) Each main pumping station was given a reservoir equal to at least 10 hours' pumping in order to allow continuous delivery if one pumping link broke down. These reservoirs also helped to clear the water and make early deliveries of water from the pipe-line drinkable. An average pumping leg was about 25 miles long between pump-houses.

(8) No cast-iron pipes were used.

(9) No special expansion joints were used.

In all pipe-line design great use was made of nomograms. Plate 3 shows a useful nomogram designed to cover pipe-lines liable to carry different fluids. For example, the oil pipe-lines from Suez to Port Said and from Suez to Cairo both carried, at various times, water, petrol, aviation spirit, and kerosene.

Pipe Joints

(1) *Buried Sections.*—In buried sections joints were of three types: lead (for pressure-heads up to 300 ft.), Victaulic, and Johnson or Dresser-type collar couplings. For speedy field use the latter were the most satisfactory, and when the supply of rubber rings failed, joints were made with tarred hemp in the couplings. The kind of rough handling which seriously damaged Victaulic pipe lengths, did little damage to the plain-ended pipe lengths of the collar-coupled systems. Rough handling was difficult to avoid and there were far more leaks in the victaulic sections, than in the collar-coupled sections.

(2) *Surface Sections.*—Joints in surface sections were either victaulic or screwed. If special obstacles were available to keep away traffic, then collar couplings were used. Welding plant was scarce, and so welded joints were used only where other joints were lacking or unsuitable. Plain-ended pipe was best suited for welding, as the lengths had chamfered ends. Moreover, welded plain pipe-lines could be worked at higher pressures than victaulic grooved piping of similar thickness.

Use of Mechanical Equipment

A mixed fleet of trench diggers, end- or side-boom tractors, rooters, graders, bulldozers, welding plant, compressors, mixers, and wellboring rigs supported the engineer effort, and performed tasks of Hercules himself. No pipe-jointing trailer was ever put into use since the conditions did not favour the use of such a trailer. About 600 miles of track cutting was necessary. For example, on one stretch of desert the pipe-carrying lorries destroyed the graded track daily, and a new twenty-five mile stretch of track had to be cut out of virgin hummocky desert ready for their consumption each morning.

Reservoirs

To suit the waterless sandy conditions, many reservoirs were built by bulldozing the desert sand into retaining walls. Linings were of asphalt or concrete, or asphalt on rabbit wire, or tarpaulin. The simplest, quickest design held 90 tons of water and was made from two tarpaulins lying directly on the sand. Those designs lent themselves to camouflage. A typical design of reservoir is illustrated in Plate 1. Main pump-houses were hidden below ground.

Miscellaneous Installations

Air valves were, in the dry desert, tempting to the thirsty, and otherwise unsatisfactory. Their use at summits was often omitted, for those reasons. As a rule no foundation holding-down bolts were employed with self-contained pumping sets. That saved time and gave less likelihood of damage during installation ; it was invariably a success in hundreds of instances. In general, makers' drawings of foundations for self-contained pumping sets seemed far too massive. In many desert installations large skid-mounted pumping sets worked for years lying unbolted on sleepers, in spite of the fact that the makers had recommended bolting down to a 2 ft. 6 in. thickness of concrete.

Radiators of the "suck-in" type were the least useful, as they made the underground engine rooms unbearably hot. Heat exchangers, working off the pipe-line, were best of all, the next best being radiators of the "blow out" type.

Sabotage

From time to time, plugs were inserted in the line after dark during the construction period. The partial blocks held up progress, as no satisfactory go-devils were immediately available. A go-devil which was audible with certainty when stuck in a buried section was needed.

Some Pipe-line Figures

Our troops attacking Tobruk in November 1941 drew 600 tons of water on D-day from the pipe-head, 270 miles west of Alexandria. D-day was two months after deciding to extend the pipe-line to 145 miles west of Matruh ; 8,000 tons of piping and pumps were drawn from base stores in Egypt during this period. Most of that lift was in 40-ft. long pipes which were too long for the standard railway trucks and army lorries.

PLATE 1.

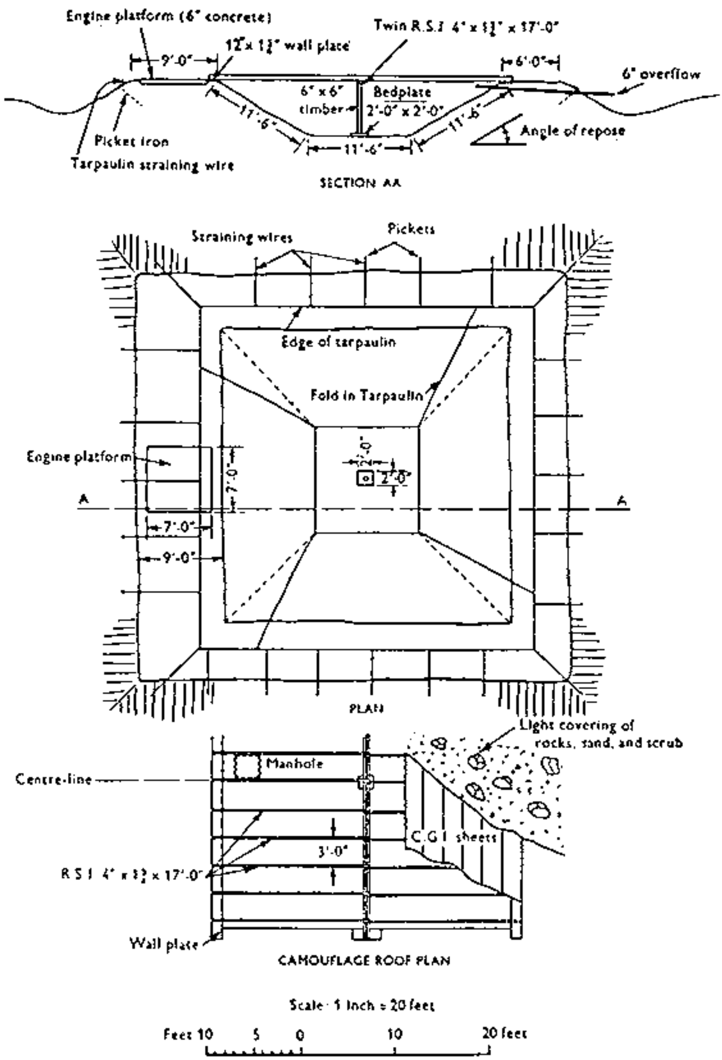
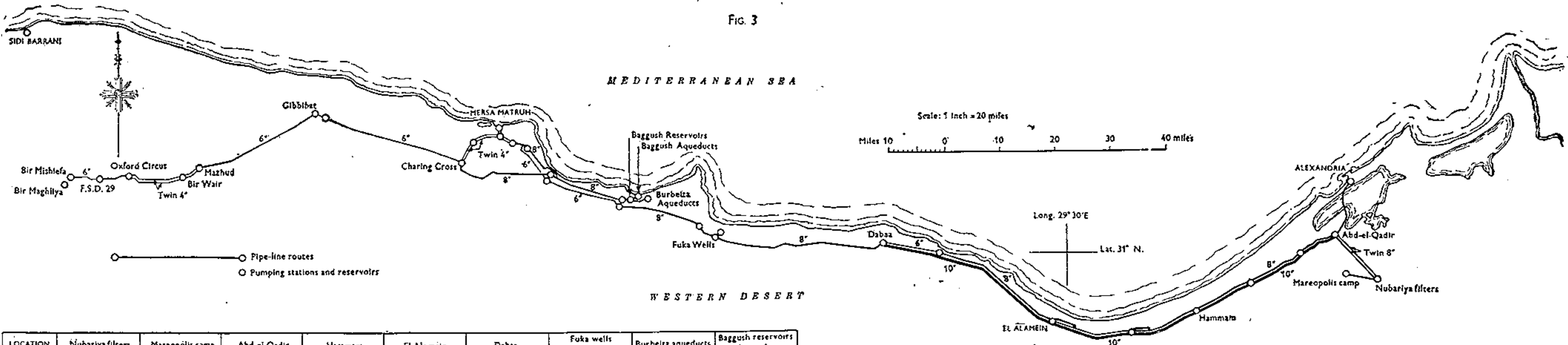

Engine platform (6" concrete)
Twin R.S.J. 4" x 1¾" x 17'-0"
12" x 1½" wall plate
9'-0"
6'-0"
6" overflow
6" x 6" timber
Bedplate 2'-0" x 2'-0"
11'-6"
Angle of repose
Picket iron
Tarpaulin straining wire
SECTION AA
Straining wires
Pickets
Edge of tarpaulin
Fold in Tarpaulin
Engine platform
7'-0"
2'-0"
A
9'-0"
PLAN
Light covering of rocks, sand, and scrub
Manhole
Centre-line
3'-0"
C.G.I. sheets
R.S.J. 4" x 1¾" x 17'-0"
Wall plate
CAMOUFLAGE ROOF PLAN
Scale: 1 inch = 20 feet
Feet 10 5 0 10 20 feet

PLATE 2.

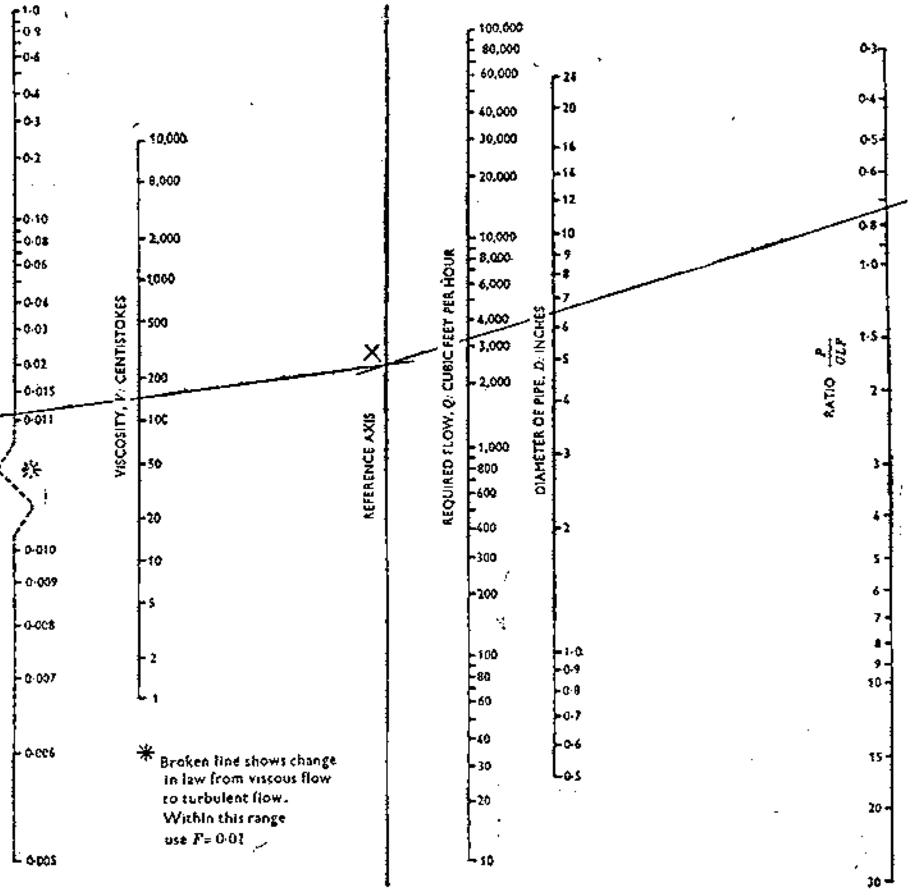
FIG. 3



LOCATION	Nubariya filters	Mareopolis camp	Abd-el-Qadir	Hammam	El Alamein	Dabaa	Fuka wells pumping station	Burbeita aqueducts	Baggush reservoirs and aqueducts
STORAGE CAPACITY	1,500 tons	—	3,245 tons	—	4,490 tons [1]	3,150 tons	165 tons	350 tons	900 tons
LOCATION	Mersa Matruh	Charing Cross	Gibbibat	Mazhud	Bir Wair	Oxford Circus	F.S.D. 29	Bir Mishiefa	Bir Maghliya
STORAGE CAPACITY	8,510 tons	95 tons	300 tons	300 tons	260 tons	180 tons	360 tons	1,200 tons	600/700 tons

WESTERN DESERT MAIN WATER PIPE-LINES

PLATE 3.



NOMENCLATURE AND EXAMPLE TO ILLUSTRATE THE USE OF THE NOMOGRAM

Basic equation for flow in level pipes is :

$$Q = 34{\cdot}5\sqrt{\frac{D^5P}{GLF}}$$

Where Q denotes flow in cubic feet per hour,
D denotes internal diameter of pipe in inches,
P denotes friction pressure drop in lb. per square inch,
G denotes fluid density (water = 1.0),
L denotes length of pipe-line in feet,
F denotes Fanning friction factor,
and V denotes viscosity in centistokes.

Example

Fuel oil of density 0.9 and viscosity 150 centistokes is pumped at 20,000 gallons per hour along a 10-mile length of pipe of 6½ inches internal diameter. What is the pressure needed to overcome friction ?

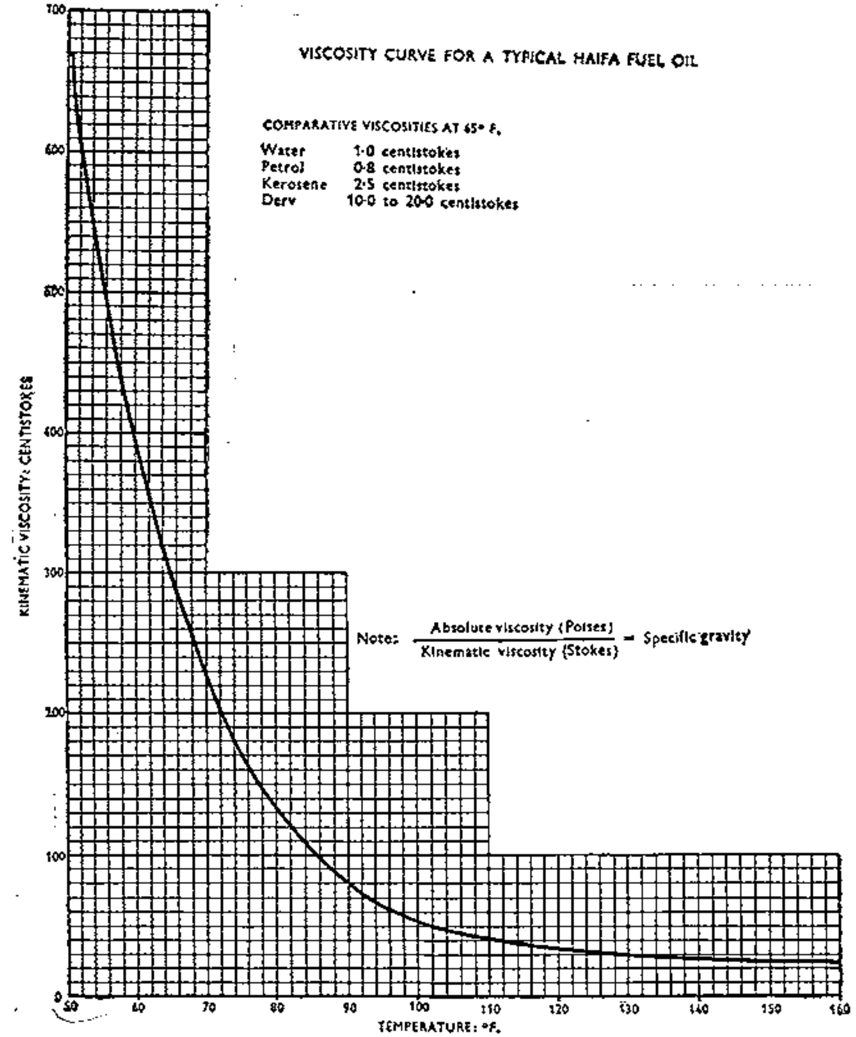
(*a*) Join 3,200 cubic feet per hour (= 20,000 gallons per hour) on the Q-line to 6½ inches on the D-line and produce to cut the reference axis at X and the $\frac{P}{GLF}$- line at 0.73

(*b*) Join X to 150 on the V-line and produce to cut the F-line at 0.012.

(*c*) From (*a*) $P = 0.73\ GLF$.
From (*b*) $F = 0.012$.
$\therefore$ $P = 0.73 \times 0.9 \times 52000 \times 0.012$
$= 416$ lb. per square inch.

(*d*) Add 10 per cent for rough pipe.
Pressure to overcome friction = 460 lb. per square inch.

NOMOGRAM FOR DESIGN OF PIPELINES TO CARRY DIFFERENT FLUIDS

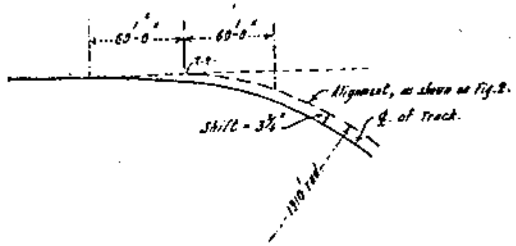


IRAQ — BAGHDAD RAILWAY BRIDGE

FIG. 2. — ALIGNMENT PLAN.

FIG. 4.

DIAGRAM OF TRANSITION CURVES.



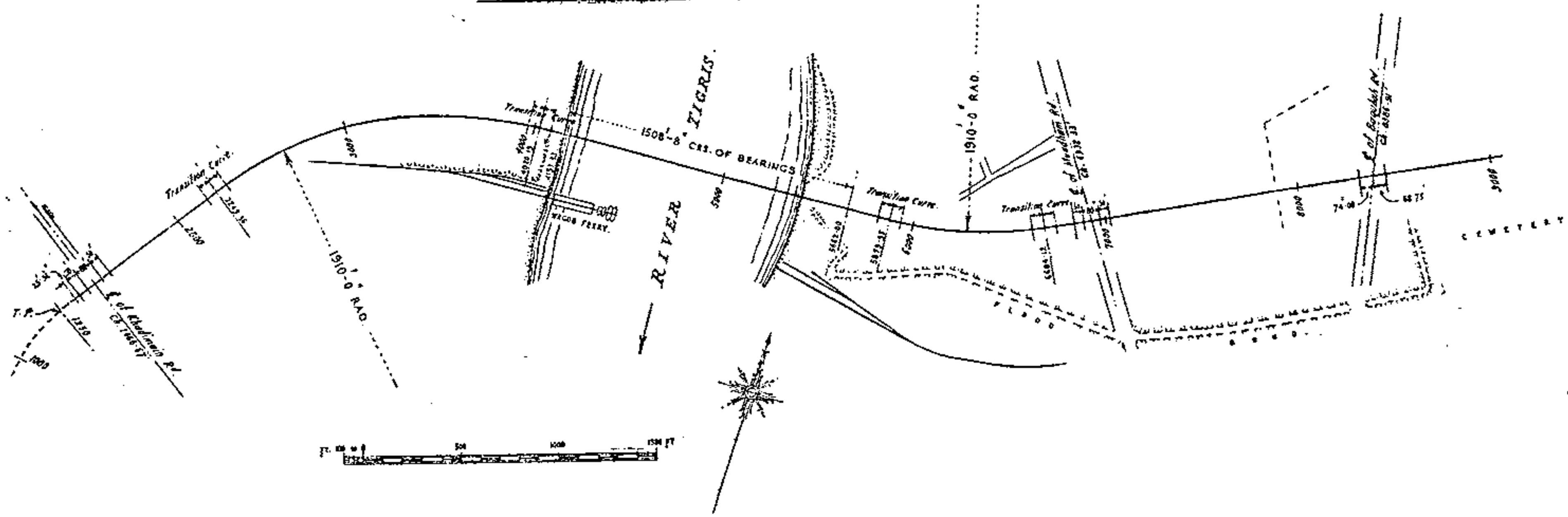
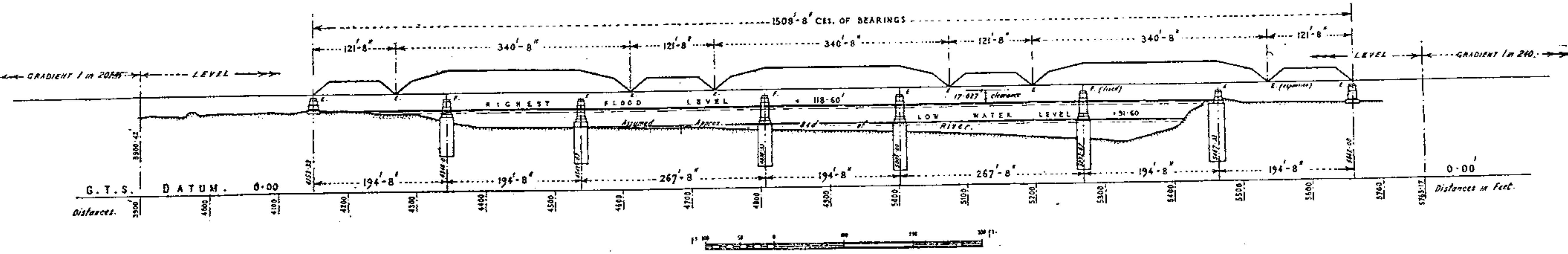
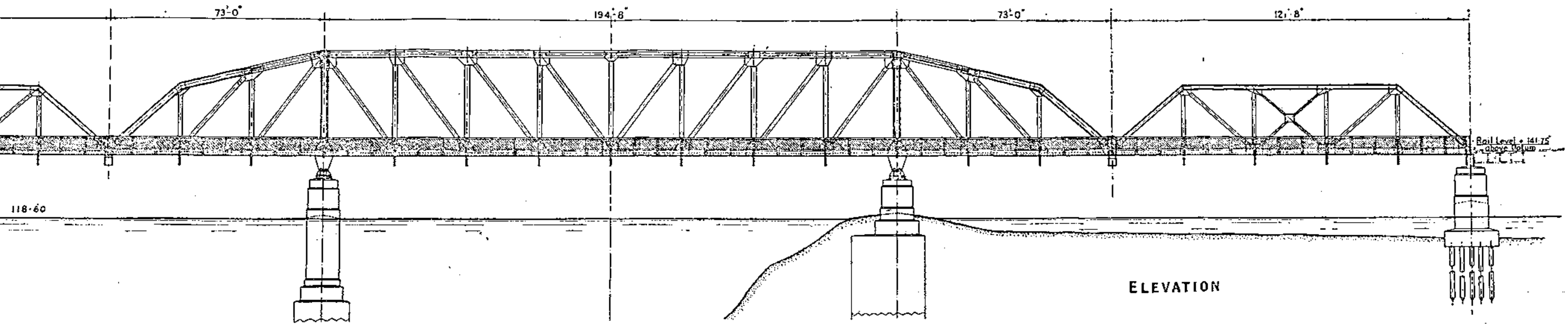
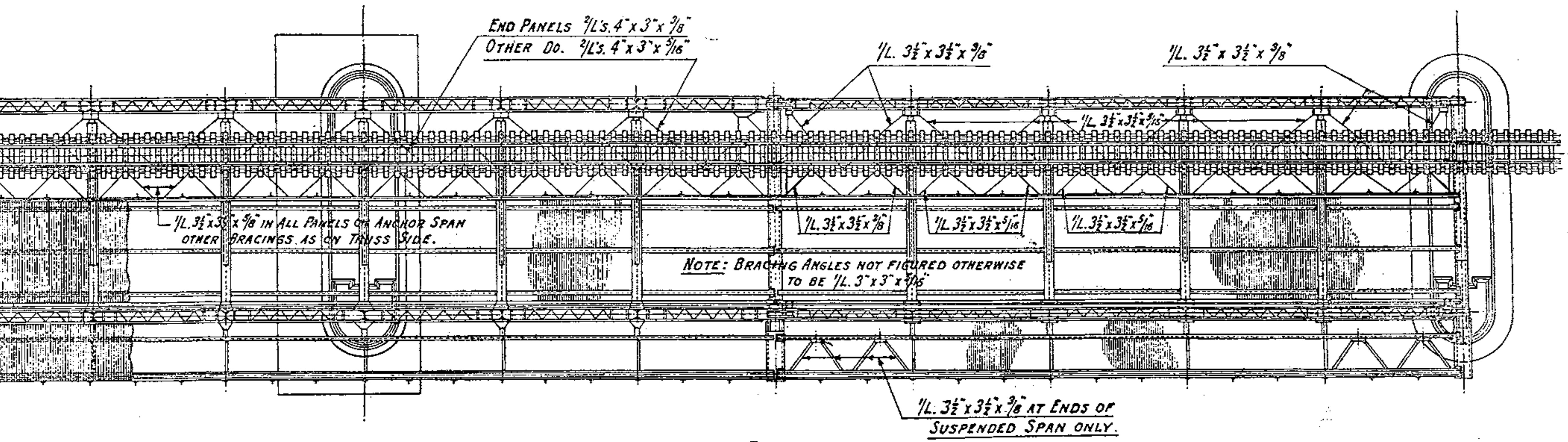


FIG. 3. — ELEVATION OF MAIN SPANS.





ELEVATION



PLAN OF RAIL TRACK, ROADWAY AND FOOTWAY.

A month or two later, at Deolali South, the unit fired their mortars on the ranges. They used weapons that so far they had not seen—the 4.2 in.—six of them. No gunner ever fondled his piece with greater pride or anticipation. Drill had to start all over again to suit the heavier weapon. A limited amount of ammunition was available and by careful salvage and the use of sand filled bombs it was possible to extend its use to last for short daily practices for two months. For demonstrations to visitors ammonal took the place of sand and the Platoon would really let itself go. Lack of knowledge of Urdu by the average Madrassi presented a great problem, and instruction in it became one of the main daily features. A break in mortar training was made by a Company march to and from Trimback, a round trip of 110 miles in 5 days. This was done as a full tactical exercise with rations and stores delivered daily. Wireless training was a nightmare. Daily all stations would net in the M.T. lines before moving off, renet a mile from camp, and then, with regular monotony, would never be heard of again.

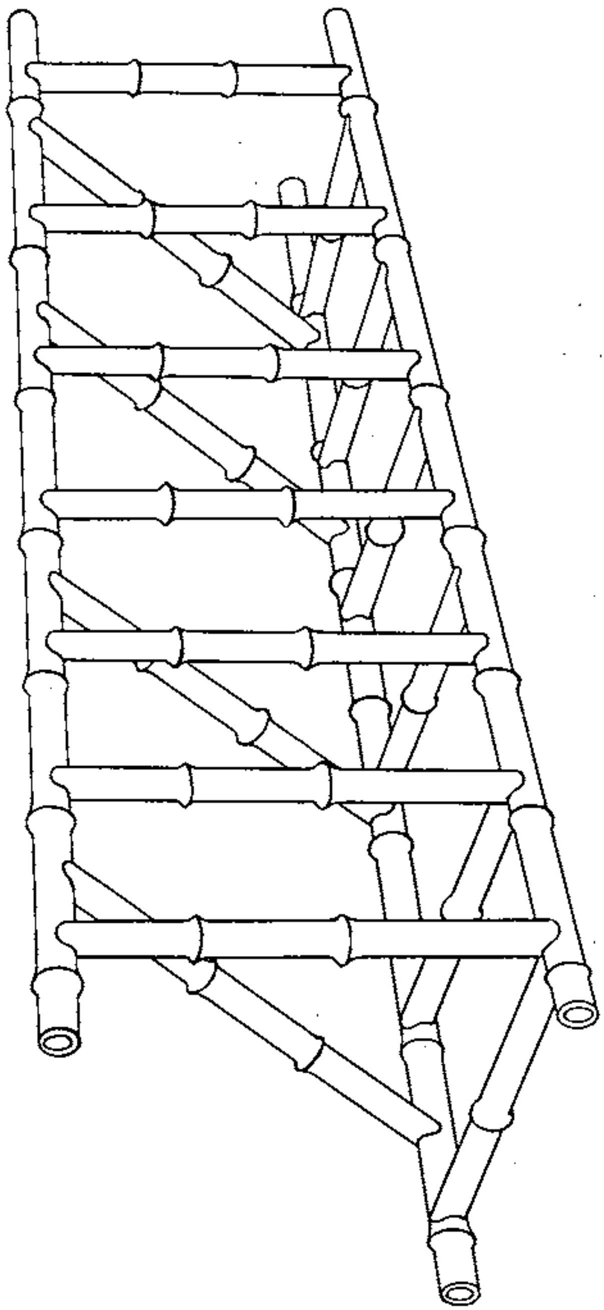
At this stage the unit joined its formation, the 1st Indian C.W. Group, made up of the three units then range firing at Deolali. There was little of interest in the formation, except perhaps the C.O's. little Black Book, "kept to protect himself from the gross inefficiency and crass stupidity of his subordinates." It was at this time, however, that the Company got its first real engineering job—one that showed each officer what he could expect from his men when they were given a hard job of work. A contractor was building a reinforced concrete bridge across the Darna River and completely failed when trying to excavate for his two central piers. The Company took on the job, built a huge sandbag coffer dam, excavated 15,000 cu. ft. of sand down to rock and poured 7,000 cu. ft. concrete, all in five days and nights.

Shortages of ammunition, and none expected from U.K. until April at the earliest, caused a cessation of all range practice. So it was arranged with the Royal Bombay Sappers and Miners that the unit should go to Kirkee for three weeks for a Bridging Refresher, and have the use of their resources. This was a splendid gesture. Each platoon did the Bailey, entirely new to them, the pontoon and F.B.E. and built and launched an Inglis with derrick and preventer, and the whole Company constructed a Class 30 timber trestle bridge over 140 ft. gap. This was first class training that was later to stand them in good stead. Meanwhile most of their transport arrived and an intensive drive was made to give drivers the maximum experience possible and to train 100 per cent spare. Convoys were run day and night on the roads, over the Ghats, and across country, until all were brimful of confidence. The O.C's orders were that each driver would spend every available minute of the day and night at the steering wheel. In this way 100 per cent spare drivers were trained and excellent drivers they became.

Then in May, 1943, 362 Field Company was posted to Forward Airfield Engineers. It entrained and commenced a fifteen-day journey that proved to be one continuous tale of amazing inefficiency.

The men entrained at Deolali South and the vehicles further up the line. Insufficient "flats" were laid on and several lorries could not be loaded, so the personnel sat in the train at the platform for 24 hours. They started next day and within 30 miles of Deolali the engine broke down and they remained stationary for another 8 hours, waiting for a relief. Meal halts of about 3 hours were arranged one for each day at certain stops. Invariably the train would stop a mile or two outside the station and wait anything up to 4 hours. Neither guard nor engine driver could ever say how long the halt would be so no one was allowed to leave the train. Then it would pull into the station and the "official" meal halt would commence! At Calcutta the train had to be turned round and the engine put at the other end. The guard wanted his van changed as well, although it was only for 5 miles, and he and the driver sat beside the track arguing for 1½ hours. In the end the driver walked to the nearest signal box and obtained a special shunting order. Other highlights included the receipt of no less than three telegrams from G.H.Q. during the journey, changing the unit's destination; the failure to lay on rations; and the setting on fire of the transport by sparks from the engine. Finally, on 14th June, the train stopped in N.E. Assam and the men detrained, under command of G.R.E.F.—the General Reserve Engineering Force that was, in effect, an Engineer Division complete with its own "A" and "Q" staff. All will remember with pride their association with this highly efficient organization. Their task was the construction of the airfield at Dergaon.

The initial job was to construct the runway of 2,600 yds. × 50 yds., 5,000 ft. taxi strip and forty-five hard standings of pressed steel plank (P.S.P.). I say initial because it soon became necessary to detach a platoon from the main task to help with roads and construct culverts, or the job would never have got under way. The P.S.P., now familiar to all, was delivered in sixteen trains, each of 400-500 tons, to a station 8 miles away. A train came each day and had to be cleared in 8 hours. To do this the G.E. had Pioneer labour and thirty-two 3 tonners. Of these 30 per cent were invariably out of action. The situation was nothing short of ludicrous. With a 16 mile turn round over the most appalling road it just could not be done. The Company's transport was mobilized, all tailboards stiffened and men and vehicles put on to the job—day and night.



BRINDLEY'S REVERSIBLE SHUTTERING FOR CULVERTS.

The rains had started, but very fortunately for the fate of the whole project, three days' fine weather ensued, during which it was possible to unload the plank on the edge of the runway formation. Thereafter the plank had to be unloaded at the roadside on the airfield boundary, and carried by hand to the strip. When about one-third of the P.S.P. had been delivered and the Mech. Equip. Platoon had got sufficient lead on grading the runway, it was decided to start the laying task.

P.S.P. at this time was unknown in India and this was the first job on which it was used. Captain Gregory of the U.S. Corps of Engineers, who had laid the Dakar Strip, was brought in to advise. He explained the Dakar job had been done by Pennsylvanian Miners who were " purty tough and mighty mean." He took one look at the little Madrassis and thought it was hopeless. They would never reach the production rate expected. Within a week they had beaten him to a frazzle. The very monotony that had undermined the American effort suited them perfectly. A little competitive team work and the rest was easy.

Culverts were quite a big task. They had to take Class 70, have a large outfall and were in some cases very deep. Brindley, one of the Platoon officers, produced an excellent idea for shuttering which simplified the problem immensely. It is shown on page 153. The shuttering was used with C.I. Sheets or similar lining. After the floor had been poured and set the shuttering and lining were fixed as shown and one wall poured. When that was set the shuttering was turned over and the second wall and the roof were poured in one operation.

It was here also that the Company personnel met their first mechanical equipment. During training at the Depot, none had been available, and no one was experienced in crushers, rollers or mixers. However, the sapper quickly proved how adaptable he can be. The task was completed in just over three months and was then in constant use. Transports, medium bombers and fighters continually operated from it.

During the train journey from India, with little anti-malarial discipline, the unit became ineffective. Within a fortnight of their arrival at Dergaon forty-two men were in hospital with malaria. The O.C. went to see the Senior Medical Officer at the hospital who said that with rigid discipline he could stamp it out of the unit. Back at the unit he published an Anti-Malarial Order—" The Ten Commandments "—that were read out on roll call parade each evening for a week. Then he got up one morning at 2 a.m. and toured the lines and caught seventeen offenders. At a " Russian " trial the next morning he gave them all the maximum. By the end of September casualties due to malaria were down to one man and never were there more throughout the whole march through Assam and Burma, during the next two years.

On 3rd October the unit received orders to be away in 12 hours, with their destination Khongkhang on the Palel–Tamu Road. They arrived on the 6th, after a 450 mile march to a desolate and depressing scene. It was raining as only it can rain in the Manipur Hills, with mud and water everywhere. The road there bifurcated. The Down, or Lower Road, to Lokchao, 6 miles long, was badly cut up and practically impassable, and the Top Road, or Up Road, Diversion 7, was being made by 16 Engineer Battalion. The Company's task was in three phases :—

(i) To keep the Lower Road open to let the division through.
(ii) To take over D.7 from 16 Engineer Battalion and complete it to one way "all weather."
(iii) To make the Lower Road one way "all weather."

The target date for D.7 was given as 1st February, but subsequently became 1st March. D.7 was 4½ miles long. The Lower Road for a fortnight was a nightmare, but on 17th October the monsoon ended and the task became simple. A grader over the surface, about once a week, kept it constantly open and allowed the unit to concentrate all its effort on D.7. Two companies of pioneers were put under command and one platoon of 362 Company was detached to work under the G.E. on D.6—the next section behind. It was a very interesting project. The work included the development of what must have become one of the largest quarries in Assam, the running of crushers, rollers, concrete mixers, and a 1,200 gallon tar distributor. As usual, labour and equipment were very inadequate and it became a race against time. 1200 Indian Tea Association coolies were brought in, the General Purpose Transport Section produced three drivers per vehicle, and quarrying and delivery of soling and metal went on for 24 hours a day, 7 days a week in eight shifts. The Chief Engineer had established a Pioneer Crusher in a quarry lower down the road to produce 50 tons per hour. The apparent problem was how to cope with such an output with the transport available and the limited turn round possible on a one-way road. There was in fact no problem. The crusher proved to be the white elephant of the campaign and never averaged more than 1,000 cu. ft. per day. The road was finally completed and opened to traffic on 1st March, 1944.

Everything was then switched to the Lower Road with the firm intention of completing it by 1st June. At this stage it is necessary to turn to the tactical situation. There had already been something of a flap in December, when all work on forward roads ceased under the threat of a Japanese attack and non-combatant labour had withdrawn towards Palel. After a week the situation returned to normal and they returned, but from the lessons learnt a new scheme was evolved for their evacuation in the event of a further scare. It was in three phases—A, B, and C, and in " C " all combatant engineer units were to " drop everything," dig and wire themselves in, and prepare to stay to the last round. In February we knew that the Jap was concentrating and outnumbered us by about three to one. Then on 17th March at about 1100 hrs., the unit received the code-word for Phase " C "—never having heard of " A " or " B." The Jap had crossed the Chindwin and was already in Laiching, only 17 miles east. The scenes that followed were reminiscent of France in 1940. The I.T.A. were just told to get out. No transport was available. 362 Company dug in and wired their perimeter and took a 25 pdr. battery and a mountain battery under their wing. They came under command 80 Brigade of 20 Indian Division, who established themselves on the next hill about 600 yards away. 32 Brigade were forward in Tamu and Moreh.

Two nights later the first Jap patrol came in. They were about thirty strong, and some of them sat about 900 yards away and steadily fired red tracer into the camp. Others tried windlassing the perimeter wire open and some tried to scale the cliff from the road, using bamboo ladders. This was too much for the sappers, and in fact for the defence platoon of 80 Brigade, who opened up with everything they had. In spite of orders that no weapons would use automatic fire by night one Bren gunner very efficiently sprayed Brigade Hill. The B.M. got one through his pillow. The battle went on through most of the night. Altogether over 2,000 rounds were fired, and as far as is known there were no Jap casualties. The Company lost two men killed and two wounded. Next morning it sat up and licked its wounds, took stock of the situation, assumed an air of the veteran campaigner, and settled down to become " P.B.I." For this they were but ill equipped and poorly trained, and the lessons learnt were from bitter experience. The Signallers, who by this time had become very proficient, were loaned to 20 Division and to the Patiala Regiment and put up a grand show.

By now pressure was increasing all round. The Jap had cut in behind Nippon Hill ; was pushing up the Mombi track and the Sita track, and was hammering at Tamu. 32 Brigade began to evacuate.

The Jap very accurately located the 25 pdr. Battery and the Mountain Battery and commenced counter battery fire morning and evening. 362 Company lines were continually peppered. When 32 Brigade commenced its withdrawal they switched on to the road and it was then that the Company lost its Platoon Commander, Wright, who was hit when trying to clear a stationary lorry blocking the road. On about 2nd April, 80 Brigade commenced to withdraw and 362 Company pulled out and marched to Shenam. From Nippon Hill No. 3 Platoon were heavily fired on and had to run the gauntlet.

At Shenam they moved by transport to Kanglatongbi where all the unit's stores had been moved in anticipation. There they found a sorry state of affairs. The Jap was sitting in the hills 5 miles away and few appeared to appreciate the situation. Fortunately, or unfortunately, the Company was ordered to Bishenpur the next morning, and two days later Kanglatongbi was overrun.

From Bishenpur they were sent down the Bishenpur–Silchar Track —the " great highway " made by " Chapforce." A short description of it will not be out of place. It was a mule track, 109 miles long, between Bishenpur and Lakhipur, that was kept open to jeeps by constant maintenance. It crossed five mountain ranges, four of them between 5,000 and 6,000 ft. at Miles 27, 38, 62 and 78. It made five river crossings, four of them over suspension bridges well over 300 ft. long, at an average height of 150 ft. above sea level, and which could just take a jeep. Between each river and the next hill feature the road zigzagged round hair-pin bends and in April, 1944, there were ninety-seven that needed cutting back to get a jeep round without reversing. Between Miles 59 and 62 there were thirty-two bends, of which twenty-eight were not passable in one. The vegetation was dense miscellaneous jungle and was the densest to be found in this theatre.

The Company was sent down the road with two others to make it passable to 15-cwt. lorries in three weeks! A Platoon of the Baluch Regiment were at Mile 36. The Company moved off and had been at it for a few days when an order was received to send a platoon to protect the bridge at Mile 51. No. 3 Platoon went at once and dug in. The next day a further order came to " drop everything " and move the whole Company there. A party of sixty Japs were on their way to blow the bridge. The river passed through a gorge and was crossed by a 330 ft. suspension bridge. So close were the pillars of the bridge to the cliff face that a jeep had to reverse twice at either end to get on to the bridge. The jungle in the area was particularly dense. It was " Duffers Drift " all over again. Dispositions were made and a platoon dug into the cliff at each end of the bridge. Sentries were put under the bridge abutments.

A report came in that a patrol from the Baluchis had found the Japs and had killed an Indian National Army officer. The Japs were in a nullah leading up from the river about half a mile downstream. A platoon of the Mahindra Dal Regiment stationed at Nungba, Mile 62, arrived to see them off. After combing the nullah they came in at about 1600 hrs. having seen nothing. They returned to Nungba leaving behind a Bren team and a 2-in. mortar. That night three I.N.A. men ran away from the Jap party and found their way to Nungba. There one of them saw the platoon officer and said he had seen him before. When asked where, he replied that he was the officer that had brought his patrol that morning right through the Jap position and back again and the Japanese officer had decided not to fire! During that night there were several false alarms and the unit stood to many times. The next morning 362 Company sent out two platoons and combed the area again. They saw nothing and heard nothing. At 0800 hrs. twelve Jap planes dive bombed the bridge and the lines. One very near miss cratered the road badly. One sapper was wounded. Meanwhile other personnel were busy booby-trapping the area, but they were forbidden to trap the road or bridge approaches. Making a further appreciation that evening, it was decided that as the men were such untrained rifle shots it would be better to rely on the grenade. So the sentries from under the bridge were withdrawn to enable the posts at the bridge end to use grenades without hindrance. At about 2130 hrs. that night there was a short sharp burst of fire followed almost immediately by a devastating roar and the bridge was down. Two or three Japs had crept on to the bridge, dumped a pressure charge and ran for it. One had jumped overboard 80 ft. into the water below. And the sappers had had drummed into them—" Don't shoot until you see the whites of their eyes."

The next day the O.C. had the unpleasant task of reporting his failure to the C.R.E. back at Bishenpur. It was a bitter moment. After he returned the road was completely cut behind him at Mile 27 and three Fd. Coys. and an Infantry Platoon were cut off from their H.Q. O.C. 362 Company assumed local command of the force and informed 4 Corps by wireless. An airdrop was arranged and the Infantry Platoon left to try to reach its H.Q. in Bishenpur. The three Companies went on to half rations and maintenance and communication was eventually established with 3 S.S. Brigade in Silchar. 362 Company built a Class 5 timber trestle bridge until they could obtain stores to repair the suspension bridge. Immediately the Japanese came in again. This time they were caught, and two were killed and two wounded. At dawn when our patrol moved to the perimeter there was another bang as a wounded Jap committed suicide with a grenade. This attack definitely confirmed that the Jap party was sitting up above the Company, 4,000 ft. high, watching everything, and slipping down into the gorge as and when they wished. A further combing of the area took place and at last a patrol discovered a way up and walked right into the Jap lines, flushing them right, left, and centre. They slipped into the jungle and were later followed by the Gurkhas from Nungba for a week, but could never be brought to battle. Constant patrolling was maintained to the line of the Jap L. of C. to Imphal and valuable information passed on. In all 17 I.N.A. were brought in, but all attempts to find the Japs in suitable parties with which to do battle failed. On each occasion they had left just before the arrival of the fighting patrol. And, as each patrol meant a round average trip of about twenty-five miles through appalling country, it became very disappointing and discouraging work. The two other Companies were withdrawn and 362 Company remained to repair the Suspension Bridge. The promised stores did not arrive, so they went into the jungle and dismantled an old disused bridge, spliced in lengths of cable, straightened and repaired the damaged slings and had the bridge open to traffic on 10th June. Improvisation was of a very high order. They made their own charcoal, their own forge, and a drilling machine. On 15th June they commenced their march out to Silchar, 120 miles down the track, wondering what the next task was to be.

In Silchar they found their rear and M.T. parties, that had been left behind in Bishenpur. It was flown out from Imphal, via Jorhat, to join them. But they had lost all their vehicles and most of their stores, including all the sports gear and other amenities, which were not allowed to leave Imphal, and were given to other units. The Company had a week's rest in Silchar and then went to Kohima to join 33 Corps in their advance down the Imphal road. Water points and bridging became the order of the day. The bridging consisted of replacing Bailey and the like with stock spans. At Mile 78, No. 2 Platoon were fortunate. The men had just broken off for a meal and only two Naiks and the V.C.O. were actually on the site when a 250 lb. bomb, apparently set in the centre arch, as a mine, exploded. The two Naiks were killed and the V.C.O. badly wounded. Stock spans were also put in at Mile 108 and 112.

From there the unit moved back to its old hunting ground on the Palel–Tamu road, putting quarries into operation at Mile 35, 52 and 69. By now leave was in full swing and 40 per cent of the Company was absent. The Japanese had put all the crushers out of action and a search was made up and down the country for spares. Gradually quarry after quarry went into production and sufficient metal was produced to enable the road surface to be maintained until the monsoon ended. At Mile 52 the Company moved into its old lines at Khonghang. Whilst there great demands were made on them for mine lifting. Some 200 mines in all were detected and picked up in the course of a month. They were mostly our own, and many were booby-trapped and fitted with anti-lifting devices. No charts or records were to hand and an officer and five others were lost during one week. For this work a Naik was awarded the M.M.

In September, 1944, when the quarry at Mile 69 was completed, the Company was in Moreh. It was offered the opportunity of coming out and going into rest and refitting. The decision to go on was unanimous. It remained in Moreh until December erecting water points, converting the Bailey into Triple Triple and buttressing the abutments, and erecting Corps H.Q. Camp. Then it pushed down the Kabaw Valley on road work, more water points and a camp for Fourteenth Army at Indaingyyi, arriving in Kalewa on the 12th January.

The task there was to construct the "Falls" Bridge across the Chindwin. The selection of the unit for this special job was considered a terrific "Shabash." Much has been and will be said of this bridge. It was the longest floating bridge of its day and was 1,260 ft. long. It can hardly be classed as a great engineering feat. It was plain hard slogging work. It was a well conceived bridge, with steel pontoons in three sections, each weighing 2½ tons. Unfortunately little consideration appeared to have been given to auxiliary equipment, and as no crane was available, everything had to be manhandled. Those who saw the soft banks of the Chindwin will appreciate what that meant. The monsoon rise of the river at that point was no less than 42 ft. ! and the approaches presented a pretty problem. Three ramps were cut at different levels—a high, medium, and a low, and two shore bays were used. As the river reached the peak of its low limit, the medium level bay was launched, and the lower one dismantled and rebuilt on the high level ready to launch at the next rise. The reverse took place as the river fell. The far bank was a sand bank over 1,000 ft. wide, on which a temporary track was laid. The pontoons were designed to act as piers and the bridge was to have been extended and completed ready for the monsoon rise. It would then have been 2,500 ft. long. Unfortunately this was never done because the pontoons had to be borrowed to make rafts to replace the wooden Eastern Army boats that sank in profusion. There were a few difficulties that called for snap decisions in the organizing of the project. The biggest and by far the most serious one centred around bridge stores and their delivery. Many of the items were unusual and special, and personnel in the E.S.D's further back were unfamiliar with them. If the job was to be finished on time they had to be got to the bridge site by hook or by crook. A platoon officer was detailed as bridge stores officer, given personnel, transport and *carte blanche* and told to go to it. He was somewhat peeved at being withdrawn from the construction job but he did a fine job of work and got all that was wanted WHEN it was wanted. Thanks to his efforts the bridge was completed and opened to traffic 24 hours ahead of time.

From Kalewa they went on again through Ye-U to Chaung-U, 20 miles east of Monywa. A recce to the Irrawaddy at Sameikkon was carried out by C.A.G.R.E. and the O.C., covered by a platoon of the Madras Regiment, and the unit followed two days later, on 18th March, to construct and operate a ferry across the river to take 400 vehicles a day. There were Japs in considerable numbers 10 miles south and on the other side of the river. Whilst waiting for the equipment to arrive the Company dug itself in, pushed out patrols across the river, and lifted Japanese booby traps in local villages. A Japanese officer was taken when trying to cross the river above the village, and a patrol took a Japanese Warrant Officer, who was hiding in a Burmese village a day or so later. Very amicable relations were established with the local Burmese, who seemed very pleased to see our troops again—once they had decided we had come to stay. Bailey pontoons, and outboard motors arrived and five rafts were constructed and ferrying went on day and night. The unit was there sixteen days and during that time 5,000 vehicles were put across.

They were relieved on 18th April and pushed on to Meiktila. There, to quote the Operation Order, " To follow the advance to Rangoon and undertake intensive bridging." The O.C. was given a free hand to follow hard on the heels of the division, bridging where necessary. At Meiktila they had a well earned three days' rest and then moved to Mile 272 to cut out and clear the debris of a damaged bridge and to launch a 110 ft. D. D. Bailey. Whilst there they received information of Japs in a village 5 miles off and sent out a patrol that brought in three men.

The next task was the Pyinmana Bridge, 380 ft. span. They blew the old trusses, that were still in position, into small pieces that could be dragged out by a recovery vehicle. The demolition was completed in one, using 970 lb. of " 808 " and was most effective. They built three Bailey crib piers on the existing foundations and over these they launched a continuous bridge of Triple Single Bailey to take Class 40 loads. This was the first of its kind in this theatre and a fine-looking job.

From there the Company moved to Rangoon arriving on 21st May, 1945, virtually at the end of the Burma Campaign, having spent two years doing all that Sappers can do towards the common weal. Its personnel collected two M.B.Es., two M.Ms., and several " Mentions " and left its mark with pride wherever it went.

THE BAGHDAD RAILWAY BRIDGE

By " Pooh "

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General Background

THE bulk of the commerce of Iraq has to pass through the port of Basra at the head of the Persian Gulf. Much of her exports both mineral and agricultural, originate in the Kirkuk area and the southern foothills of the Caucasus mountains, and similarly a large proportion of her imports find their way to the same area.

Kirkuk is connected to Basra by a metre-gauge railway system. North of Baghdad the line runs on the East of the Tigris. From Baghdad to Basra the railway is on the west side of the river (see Fig. 1). Up to the present, the only connexion between the two systems has been a goods-waggon ferry across the Tigris to the north of Baghdad. Although this ancient improvisation—it was originally installed by the Sappers shortly after the 1914–18 war—handles a surprising tonnage with commendable regularity, the need for a Railway Bridge across the Tigris at Baghdad has long been evident.

The design of the bridge which is now being built was prepared in 1939, but the war prevented any possibility of early construction. Immediately after the war, however, the plans were rapidly resurrected. Messrs. Holloway Bros. (London) Ltd., a firm with great experience of Public Works, particularly in the Middle East, were the successful tenderers.

Main Bridge Superstructure

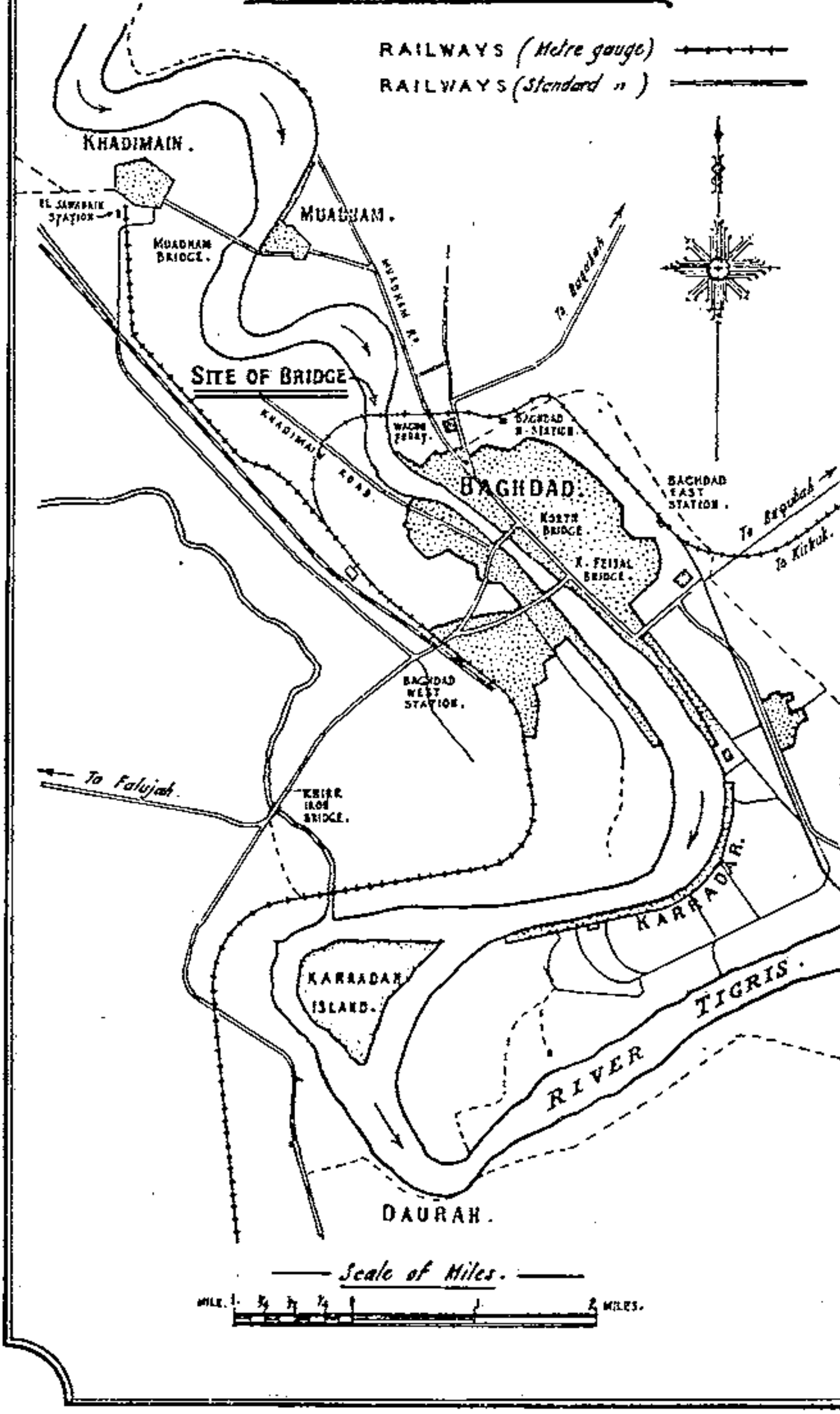
The main river crossing is a steel girder " through " bridge (see Photo No. 1) running east and west, carrying a single line railway inside the north trusses, an 18-ft. roadway alongside it and a 10-ft. footway cantilevered outside the south trusses (see Folding Plates Nos. 1 and 2). There are six river piers. Three large " Anchor " spans rest each over two piers and extend 73 ft. beyond them. Supported on these cantilevered ends are four small " suspended " spans, the short ends of the outside ones resting on abutment piers. The total length of the bridge between abutments is 1,508 ft.

The loads which the bridge is designed to carry are, for the railway, British Standard 19-ton Unit Loading, and for the road the British Ministry of Transport maximum two-way loading.

The bridge, although being built for metre-gauge railway, is also designed to enable conversion to standard gauge to be simply and rapidly effected should such a change become desirable in the future, and to take the increased loads.

FIG. I

SITE PLAN



All the structural steelwork both of the main spans and approaches was fabricated and drilled in England and shipped out ready for site assembly and riveting. The main span structural steelwork is all high-tensile steel and all structural joints are made with high-tensile steel rivets.

Prestressing

An interesting feature of the main spans is that, in order to minimize secondary stresses, components of the anchor spans are prestressed so that the trusses reach a condition of geometric perfection when the span is under full load. To achieve this, individual members are manufactured to a length slightly different from the theoretical, and gusset plates are precisely drilled so that the angles between members at the joints shall be held rigidly geometrically correct. Thus at loads less than full load, the members are in a state of both longitudinal strain and lateral distortion.

During construction, external forces to produce this state have to be applied to each member completing a triangle (see Photo No. 2) and the distortion must be exactly maintained by generous drifting and bolting during riveting.

This design calls for great precision and a high standard of workmanship in fabrication, as there are minute differences between members which would normally be, and do appear to be, identical. It is greatly to the credit of the sub-contractors for the Main Span steelwork—the Cleveland Bridge and Engineering Co. of Middlesbrough, England—that no rivet hole had to be reamered, nor resort to heavy drifting taken.

Main Span Sub-Structure—Pneumatic Caissons

In the Baghdad area, foundations in general present the usual problems met with in alluvial ground. No positive founding stratum exists at practicable depths and, in the river, scour is an ever-present danger. Both for bearing capacity and as a precaution against scour, therefore, the foundations of the bridge and abutment piers had to be carried well down to the firm sand-and-gravel subsoils.

All the eight piers were founded on pneumatic caissons, and except for one pier in the east bund, all the caissons were identical in plan-section, being 56 ft. 6 in. long over all and 19 ft. wide, with semi-circular ends, giving a bearing area of 1,000 sq. ft. each.

The odd caisson in the east bund had an additional overturning moment to withstand due to the high earth bank on the one side and a steeply shelving river bed on the other. So this caisson was designed rectangular in plan-section, 62 ft. 6in. × 25 ft., and the pier on top of it was slightly offset to counteract the overturning moment.

Caissons were sunk to a minimum of 45 ft. below river bed level, the deepest being 75 ft. below low water level. The maximum pressure reached was 38 lb. per sq. in. and at the higher pressures some cases

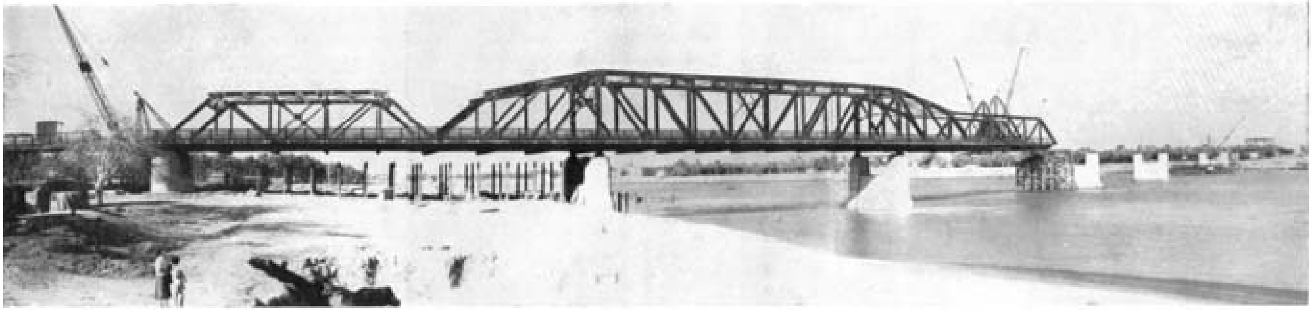


Photo 1.—General view of bridge under construction.

The Baghdad Railway Bridge 1

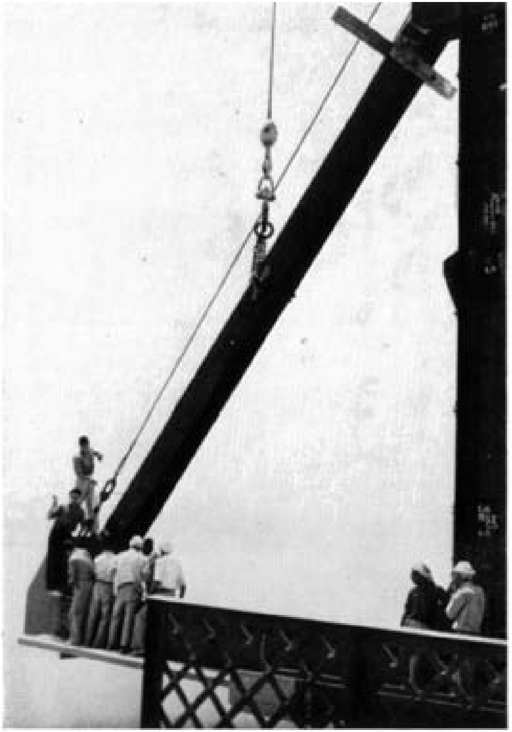


Photo 2.—Applying external prestressing forces by S.W.R. and turnbuckles to close one triangle of an Anchor Span.

Photo 3.—West railway approach viaduct.

The Baghdad Railway Bridge 2,3

of caisson disease occurred, mostly to the tough Kurdish excavators who would take a mischievous pride in evading decompression discipline.

The caissons consisted of ¼-in. mild steel skin plating well braced internally with steel angles. They were filled with concrete as sinking proceeded. The cutting edge was ⅜-in. mild steel plate. The working chamber gave 8 ft. headroom above the cutting edge level and was served by two airshafts accommodating buckets of 1 cu. yd. capacity. Apparent skin friction during sinking varied from 2.9 to 4.1 cwt. per sq. ft.

The process of sinking comprised three operations—excavating, adding skin-plates and pouring concrete. Roughly speaking each operation could be balanced into one 8-hour shift and in these circumstances an average of 2 ft. per day was comfortably maintained in the sands and sandy-clays under the river. With the large caisson, the average was of course, about half that figure.

On reaching designed founding level, the stratum was examined and probed and if suitable, the bottom was carefully levelled and cleaned and the working chamber sealed solid with concrete. Air pressure was maintained for 48 hours after sealing was complete. In no case has any subsequent settlement been detected.

Pier Shafts

Mass concrete pier shafts were constructed on top of the caissons by the use of climbing steel shuttering which gave a good finish to the above-water part of the structure (see Photo No. 4).

Inside the three piers in the deepest water, three steel-lined chambers were left, in which pumping machinery is to be installed. This is to satisfy the increased demand for water which will be created by the completion of the Iraqi State Railways scheme for the development of the area on the west bank near the bridge.

Each pump chamber is provided with dual suction systems at different levels. The lower inlet, which is the one to be used at normal and low river levels, is supplemented by one at a higher level for use when the river is in flood and carrying a high proportion of silt.

Driven by electric motors, the pumps will discharge into two 16-in. mains which are carried to the bank under the cantilevered footway.

Approach Viaducts

Road and rail level on the main spans was governed by the minimum specified shipping headroom of 18 ft. at high flood.

A ruling gradient of 1 in 25 was laid down for the road approaches, and this entailed a viaduct of 450 ft. on each bank to bring the road down to a convenient level for an earth embankment. These roadway viaducts are carried on H-shaped trestles at 25 ft. 3½ in. centres with high tensile steel stringers supporting the troughing. The central trestle of each viaduct is braced longitudinally, the expansion on either side of it being transmitted to expansion joints at the main bridge abutment on the one hand and the viaduct abutment on the other, by allowing the unbraced trestles to flex.

The lengths and gradients of the railway viaducts were regulated by the necessity to carry the railway over main roads in the vicinity of the bridge. On the west bank the Baghdad–Kadhimain Road lies exactly half a mile back from the bridge, and the main road to Baquba is the same distance away on the east bank. These roads are spanned by steel joist overbridges, and from them the railway approach is carried to the main bridge on double high-tensile steel stringers supported by A-shaped mild steel trestles 16–22 ft. tall at 25 ft. 3½ in. centres (see Photo 3). Like the railway side of the main bridge, the approaches are designed for easy conversion to standard gauge if necessary.

On both banks the railway approach viaducts incorporate circular curves of 1,900 ft. radius, that on the east bank being 800 ft. in length, and that on the west, 1,800 ft. The trestles are set vertical and the superelevation of the permanent way is imposed by raising the outside stringer and tilting both stringers: 120-ft. transition curves introduce the straight to the curve at each tangent point.

Dictated by the land available and the contiguous railway layout, these long, high, curved approaches make a graceful and impressive run-up through the date palms to the bridge (see Photo No. 3), which gave much consolation to the engineers for all the difficulties in fabrication, setting-out and erection, which attended this interpolation of curves into structural steelwork.

Every seventh trestle of the railway viaducts is braced longitudinally, the stringers being carried through solid to the next braced trestle before being broken for an expansion joint (see Photo No. 6). Expansion of the stringers causes the unbraced trestles to flex and in order to prevent this movement transmitting angular strain to the stringers a special rocker connexion is incorporated in the joint holding the stringers down to the tops of the trestles.

Viaduct Foundations

It was originally intended to found the viaducts on *cast-in-situ* piles, but soil analyses revealed a high proportion of sulphates in the subsoil and subsoil-water.

Some salinity was to be expected: for hundreds of years the land lying back from the river banks has been irrigated from the river. The impracticability of having a drainage system back into the river, a very low rainfall, a high rate of evaporation and a sluggish water table, all combine to make the accumulation of salts inevitable. Most of the saline content in these circumstances is common salt

Photo 4.—River pier under construction showing climbing steel shuttering.

Photo 5.—Reinforced concrete rafts for approach viaduct foundations.

The Baghdad Railway Bridge 4,5

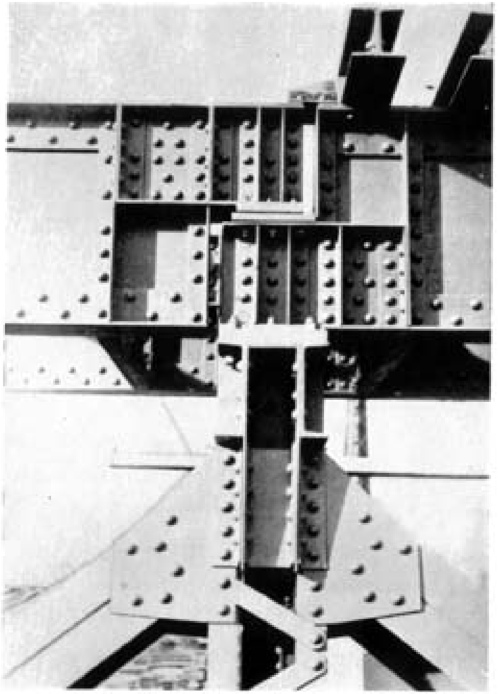


Photo 6.—Details of an expansion joint in the stringers over a longitudinally braced trestle of the railway viaduct.

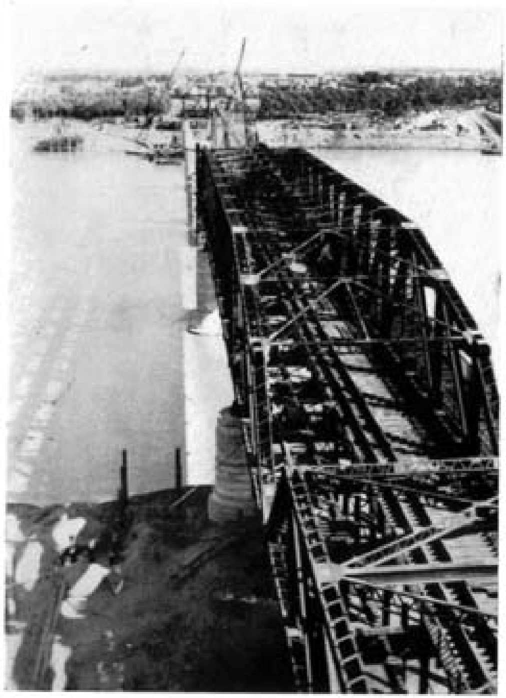


Photo 7.—Overhead view of bridge, showing stringers on left ready to take railway; roadway in centre with temporary rail track for construction purposes; and footpath on right.

The Baghdad Railway Bridge 6,7

which is not in itself a menace to concrete, and the corrosive sulphates in the Baghdad area, although enough to cause anxiety and necessitate vigilance, are not generally in alarming concentration.

At the bridge site, however, it was found that there were the remains of an old Baghdad—probably that of Haroun-al-Rashid of *The Thousand-and-One Nights*—in the form of a stratum of brickbats between 6 and 20 ft. below ground level. These bricks had been set in gypsum mortar, with the result that the subsoil water had a very dangerously high sulphate content. As much as 6,000 parts of sulphation per 100,000 parts of water has been recorded, and 9 per cent of the subsoil itself has been found in places to be solid sulphate.

Thus *cast-in-situ* piles were out of the question. It was therefore decided to form the viaducts on a continuous reinforced concrete raft (see Photo No. 5) above the general level of the water table. Tests showed that the alluvial soil of the area could not be relied on to take more than 0.7 tons per sq. ft. and the raft was designed to this figure.

Slight settlement, even during construction, could not be accepted in a steel structure of this sort, so as an additional precaution, 14 × 14 in. pre-cast reinforced concrete piles were driven under the raft.

Close control was kept on the concrete of both raft and piles, a rich mix with a special cement, low in potential tri-calcium-aluminate, being used, and due care being taken to obtain a dense, impermeable concrete. The piles were finally waterproofed by being dipped in a bath of 6 per cent sodium silicate solution.

Labour

It may not take three generations to make a civil engineer, but Iraq is scarcely one generation out from under the heel of the old Turkish Sultanate. At this stage of the country's development, Western supervision is essential in heavy Public Works. The climate of Baghdad is particularly searching on the Western constitution, and it was not easy for the contractors to find supervisory staff with the technical ability, the physical fitness and the moral stamina to serve away from home in a somewhat thankless atmosphere.

The contractors with some years of civil engineering continuity in the country, have a few loyal Iraqi craftsmen, but the majority of their local labour had to be trained. When trained, it could not always be relied on to repay the trouble, either by conscientious workmanship or fidelity. Heavy work and work in compressed air is done by Kurds from the mountainous country in the north. These men are remarkably strong and it is quite a common sight, for instance, to see a string of them comfortably unloading cement all day, each carrying three 1-cwt. bags. Jobs requiring manual skill and technical ability seem best filled by Armenians and Assyrians.

Clerical work and accounting fall to the Jews. The Baghdadi Arabs—a heterogeneous race including Caucasian, Semitic and Negroid types and all grades between—provide the general labour.

Iraqi labour is not psychologically adjusted for political organization—99 per cent of it is illiterate. The politician, whether senator or student, is essentially literate, and thus traditionally an object of suspicion to the illiterate. Furthermore, political organization of illiterate workers requires on the part of the organizer considerable physical vigour, a characteristic conspicuous in the Iraqi agitator by its absence.

Nevertheless the workman gets a fair enough deal, partly due to a set of sound Labour Laws and partly by his own efforts. Objective enough to know his own value to a farthing, shrewd enough to demand, and get, several times that value and independent and dignified enough to refuse less, he naturally regards anything resembling a trades union as another redundant official method of milking him of " baksheesh."

Relations between employer and workman on the bridge have been equable. There was one short strike in spring 1948, but this was externally inspired.

Finance

The bridge is a £1 million lump sum contract. It is only part of an ambitious and far-sighted scheme of development which includes other railway works, large irrigation schemes, town planning improvements and extension of highways.

Iraq is a country with a large economic potential—both its agricultural and its mineral outputs are capable of manifold increase. At the moment it lacks capital, as any underdeveloped country lacks capital. The speed with which its potential is converted to actual productivity bears a direct relation to the amount of external capital available.

The present is an unpropitious period for the Arab section of the world, but it may be expected that the world will soon enough be in need of what Iraq has to offer and will be prepared to invest capital to get it. The mile and a half of steel over the Tigris at Baghdad will help to facilitate the exchange.

Dramatis Personae

Owners.—The Board of Management, Iraqi State Railways. Chief Engineer : A. D. M. Brown.

Consulting Engineers.—Messrs. Coode, Vaughan-Lee, Frank & Gwyther, London (by whose kind permission the drawings are reproduced). Resident Engineer : H. Mattick.

Contractors.—Messrs. Holloway Bros. (London) Ltd. General Manager, Middle East : A. E. Reid.

"IDEALS"

By "METHUSELAH"

IN England there has always been a popular suspicion that the soldier's training makes him narrow-minded, callous, and materialistic—in fact of the earth, earthy. Especially now, while we have National Service men to train, and while the nation is threatened by the worst of totalitarian precepts, we might consider to what star we have hitched the sapper wagon.

This old country has gone through all the social evolutionary stages of family, clan, and nation, to Commonwealth. With each stage we have sought a better way of life, and whenever the search has led to a conflict of irreconcilable ideals, the inevitable final act has been battle. War, however, "consisteth not in battle only, or in the act of fighting ; but in a tract of time wherein the will to contend by battle is sufficiently known" This is just such a tract of time. The next logical step must be the welding of the white peoples into one group with one way of life. But the search for this has brought us to two opposing ideas, democracy as understood by the West, and communism as understood by the East.

Some may think that, once again, battle is the only way out. But the West looks upon battle as a last and evil resort, since modern battle may well destroy all that it seeks to gain. Some pin their faith to a counter-attack of ideas, spreading truths and allaying fears ; but ideologies develop their full influence very slowly. Our present conflict of ideals may force us into unwanted battle, before any ideological counter-attack can gain its aims. It would therefore seem sound to train the fighting forces for both aims at once, the long term victory of ideas, and the short term victory in battle.

We rely for our security on the free sea movement of trade. The two threats to the commonwealth are, invasion or destruction of the British Isles, and the cutting of the seaways without which we can neither live in peace nor sustain battle. The forces to meet these threats must be joint forces. They can only carry out their tasks by the joint action of all three services and the civilian population. Even if the time has not yet come for the establishment of these joint forces under single command, trained and equipped in peace for joint action in battle, still training can at least be on joint principles, which all three Services and the civilian population can follow.

The truest lesson of battle is a simple one, that the essential quality of any good fighting force is the mutual confidence within it. This is a quality entirely distinct from the fanatical enthusiasm of a mob. It depends on sound technique, which includes skilful organization, expert training, and approved leadership, and also on a reasoned purpose common to all ranks. These factors need continuity. Each man must have acquired confidence in the good faith and intelligence of his leaders, the integrity and skill of his equals, and the loyalty and courage of his followers. Unfortunately, for reasons beyond its own control, the Army cannot yet maintain any continuity in either its organization or its leadership ; but it can maintain continuity in both its training and its purpose. As a joint partner in far greater forces it can be a fitting instrument both for possible future battle, and for the current war of ideas.

As Sappers, we have unusual chances of practising joint action. We exist only to assist any other arm of any service to fight in battle, and occasionally take a direct part in fighting the battles ourselves. Our work puts us in the closest touch with other members of the fighting forces, and with scientists, research workers, and civilian industry. Our recreations bring us companions, both civil and service, from among all those who ride, or sail, fly or glide, mountaineer or play games. Sapper training should fit very easily into the common purpose, in the war of ideas, as well as in the technique for battle.

The ugliest features of totalitarianism are its denial of the privileges and responsibilities of the individual, and its control of the masses by terror.

All our training should stress the opposites. In battle an officer needs courage and the ability to dominate others ; in peace he should acquire professional knowledge, and learn to understand others. The excellent training devised for the Sapper officer in peace ensures him every opportunity of learning the technique. Does it sufficiently bring out the spirit ?

Perhaps one ideal should be to teach that everything each one of us does will affect someone else, in another arm, another Service, another country, or another walk of life—someone with a purpose very like our own. Perhaps another should be to insist most strongly that the individual is an end in himself, and not just a means ; to grant him full personal privileges, and ensure that he accepts full personal responsibilities. Perhaps a third should be to oppose any lack of faith in Government and higher authority, any intolerance of alien beliefs, any class antagonism or mistrust of allies, and every single tenet of materialism wherever found.

These ideals are pretty well covered by an old trilogy—faith, hope, and charity ; faith in the common purpose, hope for unity in that purpose, and charity towards all others with the same hope. The aim seems quite clear ; it is to build up mutual confidence within this Corps, as part of the joint Services of the nation, the Western Union, and the Atlantic Pact Powers. We are already engaged in a war of ideals, and may be engaged in battle—together.

C.R.E., NOBODY'S SAPPERS

By COLONEL A. CRICHTON MITCHELL, O.B.E.

THESE articles are a brief personal account of the Seventh Armoured Divisional Engineers in the first year of their existence, from their formation in April, 1940, until the capture of so many of them in Libya by General Rommel's Afrika Korps in April, 1941.

During that year they never joined their division, but they were not idle. The summer of 1940 saw them, newly formed, on an anti-invasion rôle in Kent and they did not reach Middle East until November, too late to be absorbed in their division before it played its part in General Wavell's first great desert offensive. They followed up that offensive, however, doing odd jobs, learning much, but still nobody's children in particular. Then they were sent on short loan to another armoured division: it would not be for long, they were told, but three weeks sufficed. For in that time Rommel struck back and swept the weak British forces out of Libya.

It was a difficult year—of tensions, crises and great contrasts. Suckled to Mr. Churchill's "blood and tears and toil and sweat," the unit had to learn its job and take its shape as best it could and to suffer its first blooding in the stress of a major withdrawal. Yet that year had its great moments and the Sappers did not let down any side they played for. The story may add little to history but its telling now, after a lapse of years, may not be without interest.

ENGLAND—SUMMER, 1940

I had had just four days of my first leave since 1937 when I was ordered to Chatham on 26th April to form and command the Seventh Armoured Divisional Engineers. I arrived to find a few of the unit already there—Major P. A. Clauson, M.B.E., to command 4 Field Squadron; Captain S. T. A. Radcliffe to command 143 Field Park Troop; Captain J. Constant to be Adjutant; together with a handful of N.C.Os. and men from First Armoured Divisional Engineers. But more officers and men, mostly newly fledged, arrived within the next few days; and by the beginning of May we were practically up to strength for a Headquarters, one Field Squadron and one Field Park Troop, which at that time comprised the war establishment of an Armoured Divisional Engineers.

The S.M.E. of those days was largely a "sausage machine," forming new units as rapidly as possible and turning them out into a hard, cold world to fend for themselves. We might be there for three weeks, then move to the New Forest to train alongside First Armoured Divisional Engineers before joining our own division in Egypt. Our early days were busy and not without difficulties. We started with nothing—not even a telephone—and had everything to get and to do. With our division already overseas we had no real "parents": we were at first unknown and few would admit our existence. But we got about and got known: we invaded everybody, and in the end folks found life quieter if they gave us what we wanted. And gradually we got things—a telephone, vehicles of sorts, some stores and equipment, a beginning of training and a few men on courses.

The German Blitzkrieg began on 10th May and at once we were detailed to certain local defence tasks—a reconnaissance of the Medway bridges at Rochester and Aylesford for demolition (with Clauson almost arrested by the police whilst exploring Rochester bridge); certain tank stops in the Brompton area; a troop of the squadron as mobile reserve for Sheppey. I did not like this vague, dispersed rôle, particularly detaching a troop to Sheppey: we were not yet a unit in any sense and control and concentration were essential. But a good deal of confusion reigned and on one particular day we received three different sets of orders: perhaps a training establishment was not quickly adaptable to practical soldiering. I went to Sheppey on 12th May and came back worried. O.C. Troops there had a motley collection of soldiers, sailors and airmen for local defence, but how they were to function and what my troop would do were far from clear. I put up a scheme for Sheppey defence: by the 14th we had taken over from the detachment at Kingsferry Bridge and on the 20th the whole unit moved into camp there. Sheppey might be dull but at least we would be concentrated and on a definite job.

Kingsferry Bridge was the vital road and rail link between Sheppey and the mainland, and our task was to make and man its all-round defence, besides preparing the bridge itself for demolition. To that was quickly added the construction and manning of all-round defence for Fletcher (9.2 in.) Battery on the north coast of the island. In both places the problem was to combine adequate depth with economy of manpower. If we went well forward at Kingsferry our digging quickly struck water, so we had to build our posts closer in on the sea-walls and railway embankment: but we were able to flood a considerable area in front of them by letting in the sea. As to bridge demolition, we were far from satisfied with the preparations we found on arrival and Haines got busy on a more comprehensive scheme, anxiously watched by engineers from the Southern Railway. Could we move certain charges a little to one side so as not to break the windows of the hut housing the lifting mechanism? "When these charges go off," replied Haines, "there will be no bridge and no hut," and the job went on.

Work progressed slowly at first. Stores and material were hard to come by and some of our suppliers forgot this was war and no longer peace-time stores procedure. Many of our hired vehicles were in a shocking state mechanically. Most officers and N.C.Os. were inexperienced and the entire responsibility for getting things done at first fell on the few with pre-war experience. Even so, much of the work was necessarily makeshift and in one case a roadblock was largely contrived from several brass bedsteads we had found. But we had quickly established good relations with General Goschen and his staff at Chatham Area Headquarters and by this means achieved much that might have otherwise been impossible. Gradually our defences developed. At first the squadron held the long island sector of the Kingsferry perimeter, with Bond's troop in M.T. as mobile reserve for the whole island. The Field Park Troop held the mainland sector, but with some sixty men detached to Fletcher Battery. We had to man as well as make our defences, with full-strength garrisons for dawn and dusk "Stand To" and quarter garrisons by night. There were several sideshow jobs as well, such as planning pier demolitions at Sheerness, Queenborough and Port Victoria; together with such nuisances as traffic control, the check of all persons passing over the bridge and the receipt of stupid security messages such as "Suspicious-looking dark-haired gent with young blonde last seen proceeding through Oxford in green motor car number so-and-so." It was therefore a most strenuous period, but across the Channel the great withdrawal was in progress and we felt our work had purpose as a small part of England's desperately hurried defence. And it was far, far better training for war than anything we could have got elsewhere. They were great days really: we were frantically busy but we were on our toes, stopped by nothing and quickly acquiring that intangible "something" that makes a unit. And there were lighter moments as, for example, when a very tired Sapper returning to camp was hailed by a local lovely. "Garn," he grunted, "digging and dames just don't go." General Goschen paid us numerous visits and was most helpful. General Sir Guy Williams, G.O.C.-in-C. Eastern Command, came twice, explained the east coast defence set-up and let us infer that, as we were far in front of the line England would fight to retain, our whitened bones might ultimately be revenged, but we need expect no reinforcement.

On 30th May, Chatham Area Headquarters rang up to ask if I knew anything about anti-tank gunnery. Of course I didn't, but would I go along to Chatham Dockyard to help the Navy with a small problem? I arrived and was shown straight into the Dockyard cinema and an audience of about six hundred matelots. Vaguely I gathered that the Navy were mounting guns on lorry chassis and wanted to know how to use them in a mobile rôle, how we soldiers played the game of gun *versus* tank. I gave a preliminary talk helped out by minor situations on the blackboard. Then, during a break, I dashed to a toyshop in the High Street and bought it out of toy cars, lorries and the like. With these we continued the game on our knees on the cinema stage, and I found it hard to get these sailors to stop once they had grasped the idea: they were terrifically keen. They had certainly done themselves excellently in the way of equipment. There were four 8-gun batteries: the lorries carried armour plate: each troop of two guns had its accompanying shell lorries, each battery its command vehicles with wireless, plus personnel lorries with light automatics and rifles for local protection. In the Army we had seen nothing like it. The following Sunday we decided to give the whole circus, close on a hundred large vehicles, a day in the country. We first caused a major traffic jam at Chatham Town Hall and by the time we had reached Short's works on the Maidstone Road we had most of Kent in our wake. We first tried out our drill by numbers: every Maidstone bus was a Boche tank against which those big guns swung into action: it was altogether too much for some of the bus drivers and their passengers. In the afternoon we let the batteries roam the countryside, practising driving, coming into action and fighting each other if they met. A good time was enjoyed by all in one of the most strenuous days I've had. About the same time General Goschen turned the S.M.E. on to the problem of extemporized armoured cars. Lorry chassis might be available and the Navy might supply light armour plate. I was bidden to the S.M.E. Workshops to help design the first mock-up, and we got the first three of these "Corporation Dustcarts" for John Bond's mobile column.

On 17th June, the day France asked for an armistice, I was made Commander, Land Defences, Sheppey, in addition to my existing duties as C.R.E. It was a new appointment under O.C. Troops, Sheppey, and designed to free the latter for his coast defence rôle. I moved into Sheerness to be in closer touch with O.C. Troops and the Navy: I was given a staff officer, a F.A.N.Y. driver, a car and a share of the Garrison Adjutant's three clerks—for control of a force which I found was about the strength of an infantry brigade. It was not long therefore before I brought in my Adjutant and his Headquarters staff from Kingsferry to help with the work.

Sheppey tactics are easily explained. The island's coast defences covered the Thames and Medway approaches and the two naval dockyards at Sheerness and Chatham. Other vital points were Eastchurch aerodrome and another secondary landing ground, besides several possible areas for glider landings ; the heavy coastal batteries at Fletcher and Shellness, the Minster ridge and the Kingsferry road/rail link with the mainland. But these were widely separated and difficult to knit into a comprehensive defence, whilst Minster ridge, the tactical key to the whole island, was not held at all. The first essential was to find out what my "army" consisted of and what defences it had. I inspected everything and everyone, but found nothing to my liking : I was appalled in fact. Apart from my own Sappers I had no properly constituted unit at my disposal ; nothing but such spare men as might be available at any given moment from the local Gunners, Navy or R.A.F., together with part of a L.D.V. unit, commanded by a local draper. These "squads" were each supposed to defend their own doorstep, but were constantly changing in strength and personnel. There was no comprehensive plan of defence ; no idea of defeating the enemy, merely of haphazardly resisting him. Near the Dockyard were a few sandbag posts standing up like Aunt Sallys. On the Canal at the south end of the town were some light concrete pillboxes with loopholes nearly big enough to get a grand piano through and built, I was told, to the design of a Dockyard civilian clerk of works. The enormous perimeter of Eastchurch aerodrome had a few widely separated lengths of trench whose purpose it was hard to discern. Kingsferry Bridge and Fletcher Battery now had complete perimeter defences but Shellness, possible landing beaches like Warden Bay and the important Minster ridge had nothing, whilst no attempt had been made to put possible landing grounds out of action. There was no central control or reserve, little intercommunication and no plan to deal with parachutists landing in areas distant from these few fixed defences. Transport was lacking and troops were largely immobilized in often badly sited and constructed defences. At first I doubted if I could ever get things right. One needed so much—materials, time, trained troops—and all were precious in that critical summer of 1940. England had been caught almost unprepared and there had not yet been time or means to do all that had to be done. The last man had left Dunkirk only a fortnight before and England stood as Hitler's only enemy. He had called us decadent : he had vast resources, flushed with success and would surely come. And it did not look as if he would long delay, for we had Boche aircraft over us on 18th June, again on 19th, 21st and 22nd—the first skirmishes of the Battle of Britain.

Again our days were busy. A comprehensive plan had first to be worked out ; defences made or remade ; commanders and garrisons trained. The responsibilities of my own unit were extended ; with only 4 Field Squadron holding Kingsferry and finding a troop in mobile reserve ; whilst 143 Field Park Troop was responsible for Fletcher Battery, Warden Beach and Shellness. Gunners held the Dockyard moat ; the Navy manned the Canal posts and found another small mobile reserve ; R.A.F. personnel held the Eastchurch aerodrome defences. But more troops were essential if we were to hold Minster ridge and be capable of any major mopping up on the island. With limited resources I saw that our only hope of success lay in dealing with initial landings before these could be consolidated, and for this I had to have something mobile and hard-hitting. As soon as plans took shape I ordered all commanders on a conducted tour of the island and painted a possible picture for them at each point so that each might know the general plan, his own part and how he might best co-operate. From that we went on to have " battles," with some of Clauson's squadron as enemy parachutists scattered over the island to be rounded up by Bond or the Navy.

My appeal for more troops quickly bore fruit and early in July the 2/6th Queens Regiment, under Lieut.-Colonel Bolton, was detached to Sheppey from its brigade on the mainland. Most of the men were little past the recruit stage, but Bolton worked like a beaver and proved of great value : moreover, this was a *unit* with all the advantages and frills of organization which a unit had. But though under my tactical command the regiment remained administered by its brigade and this dual control led to some confusion : on Sheppey we sometimes found it difficult to serve both God and Mammon. I placed the regiment round Eastchurch village, where it could support certain defended localities and also deny the high ground. My " army " now amounted to about 2,800 men—Sappers, Infantry, Gunners, Navy, R.A.F. and a L.D.V. unit—but numbers were liable to vary without warning. Few men were fully trained ; much equipment and transport were still lacking ; and if the Boche came we were at best a village eleven trying to take on the champion county. Life was not quite all work, however, once things got going. " The Bull " at Sittingbourne was a favourite rendezvous for a bath and a meal, and I taught its staff how to concoct a " Hammy, eggy, cheesey topside." I even managed to play two rounds of golf that summer.

Boche bombers were frequently over us, and between 18th June and 7th August we had twenty-nine different alarms, though only six of these resulted in local bombing. Combined with bombing was the possibility of air- or sea-borne invasion, and for this we watched certain moon and high-tide periods. Invasion craft would probably come under cover of darkness. They could not start undetected before dusk and would aim to have their men ashore in England by first light and to make these shelving beaches on top of a high tide. The peak danger periods were therefore those with high tide between about midnight and 0300 hrs. Such invasion might be preceded or supported by parachute or glider-borne landings. For these the code signal was " Cromwell " and the first we got was at 0200 hrs. on 3rd July, right at the start of one of the critical high-tide periods. From the Control Centre at Admiralty House I sent out action orders by telephone and after a short interval started to go round the various posts by car to see that all was well. Amongst my orders had been one to H.M.S. *Wildfire* (Sheerness Dockyard) for its mobile reserve to move to Cowstead Farm, ready to round up parachutists in the marshes. But at Cowstead I could find no sailors and not for some hours did I learn why: *Wildfire* had borrowed the men as a boarding party for two French naval craft then in harbour, part of an Admiralty scheme whereby all French vessels in British ports were suddenly taken over. In Sheerness there had been some minor Gallic excitement but no real trouble. Later, over gin, the Navy were suitably apologetic: they had had no other men available and had not counted on a " Cromwell " that night. Fortunately, " Cromwell " proved to be a false alarm.

During all this time we had not forgotten that our ultimate rôle lay in Middle East. These weeks on Sheppey had been of great value, but they had not covered all the engineer training we required. Towards the end of July, therefore, with Sheppey defence as complete as existing resources were likely to get it, our thoughts turned to moving overseas. We badgered " S.D." at the War Office and found them sympathetic: it had been agreed in principle to bring the Seventh Armoured Division up to strength, but many troops were still needed for Home Defence and something like a tug of war had started between the War Office and Home Forces for ownership of the British Army in England. But on 1st August we were transferred from Home Forces to War Office control and were to move to Aldershot to mobilize. I slightly modified the Sheppey defence plan and handed over to Bolton: we got the first batch of men away on embarkation leave. A final bombing raid on Fletcher Battery, a last game of golf, a cheerful dinner at " The Bull," and on 8th August we entrained for Aldershot.

These three months had held a curious mixture of activities—of much devilish hard work, of cursing at delays and inefficiency, of worry and a good deal of strain. But we had got on our toes at the start and stayed there; we had done our stuff, I believe; and had seized with both hands such moments of fun and thrill as had come to us. The experience had been invaluable to us all and we had quite definitely changed from a motley crowd of " bodies " into a unit: we were in fair fettle for the next stage, whatever it was.

General Goschen sent me a farewell letter, of which the following is an extract :

" I want to thank you and your men of all ranks for the good work they have done on the Isle of Sheppey. They have been employed on a great variety of duties, all of which they have carried out with great skill and determination. Your 7th Armoured Divisional R.E. have transformed Sheppey into a formidable fortress and I only wish you had been there to deliver the welcome to the Boche, which I am sure they would have received without much pleasure had they attempted to land on the island.

" During the whole time you have been on the island your formation has inspired me with confidence that they would give a jolly good account of themselves under all circumstances. Anyhow, your good work will remain for the benefit of your successors and our country.

" I wish you Godspeed wherever you may go and I am quite sure that your arrival at your final destination will be welcomed by everybody serving alongside with you."

In my turn, I could as sincerely thank all those in Sheppey and Chatham who had helped us—sailors, airmen and soldiers, staffs, clerks and a gallant F.A.N.Y. driver.

At Aldershot mobilization proved almost as exasperating as Sheppey defence : equipment was short ; we still lacked parents and were insufficiently known. But again we got about and got known, and we put in a fair amount of engineer training. First Armoured Divisional Engineers, back from France, were not far off so we made liaison and picked up ideas. Major-General G. H. Addison, Inspector of Royal Engineers, and Major-General E. L. Morris, D.S.D, visited us and were helpful. Mobilization equipment at last began to come in fairly well and our chief remaining worry was over officers' pay and allowances. But a long, blistering telegram from us, plus, I believe, a word from either General Addison or General Morris got things moving just in time before we sailed. Air raids became more frequent as Aldershot seemed to be on the enemy's " bus route " from Northern France to the Midlands. There was little local bombing but hardly a night without the dismal siren warning and " noises off." Farnborough and certain establishments in the Aldershot area were, of course, important targets but, apart from a certain gallant Engineer officer crawling under his camp bed for cover, we had little incident. The famous " Battle of Britain " Sunday gave us plenty of thrills. There was a second " Cromwell " when church bells were rung, but that, too, proved a false alarm.

Many dates in succession were given for our departure, starting early in September. Delay was understandable, but after a time rather tiresome : leave was stopped and training interfered with, But at last we got a firm date to entrain on the night 4th/5th October. and the R.E. Mess dined us out in great style. We had already prepared a detailed entraining programme with the railway authorities, but little of it happened. The train was an hour late: a local air raid began and an excited member of the R.T.O. staff shouted to the men "Scram in anyhow." In the pitch darkness it took some moments to locate him and get him out of the way, but we all got in somehow and left nothing behind. On the 5th we detrained at Liverpool and at once embarked on H.T. *Orontes*—a total strength of 14 Officers, 2 Warrant Officers, and 481 N.C.Os. and men. Embarkation arrangements were poor and at first there was a good deal of confusion. We pulled out into the stream next day and sailed on the 7th in company with two other big ships and an escort of two destroyers.

Egypt—1940

Clearing the Mersey, we quickly ran into dirty weather and there followed four days of terrific Atlantic storm. Our destroyers had to turn back; we were late at the rendezvous with a Clyde convoy and ocean escort; and, until we caught them up on the 12th, were quite unescorted. We had no Ship's Standing Orders for the first two days and early attempts at Boat Stations were chaos. But at least we missed the bombing the Clyde convoy got from a Boche flying boat. Then came better and warmer weather and by 18th October we reached Freetown. Troops did not get ashore but there was a vigorous bumboat trade, with clothing swapped for fruit after money ran out. "You'll be charged for that cardigan on next kit inspection," Bill Haines told a Sapper, "and then you'll think it plain stupid to pay about a shilling per banana in a place where they grow."

We reached Cape Town on 28th October—the day before Italy attacked Greece—and troops were allowed ashore. We had first warned them as to behaviour, as a recent Australian convoy had beaten up the place and we felt Cape Town might be rather off licentious soldiery. But the welcome was truly magnificent. A South African in a car pulled up beside two Sappers. "Can either of you drive? Well, here's my car and my daughter as guide. Take yourselves around." Another Sapper was hailed with: "I'm an old Sapper myself and it's good to see the badge again. I'm going into the country on a job today. Come for the drive and see it." Clauson and I walked into an Information Bureau to change money. "No, we can't change money, I'm afraid," said a very attractive young woman behind the desk, "but would you both care to dine with me tonight? I'll get a friend." She also borrowed a car and after dinner took us up Table Mountain. To stand there in the dark and see the myriad of lights below us that was Cape Town was a sight for sair 'een after England's blackout. And so it went on for two days and the men behaved excellently. Cape Town would certainly take a lot of forgetting and in letters to its Press and City Authorities we later tried to show our gratitude. In the Indian Ocean we overhauled another convoy and now totalled a dozen ships. Off Aden we increased our escort to four vessels as we had to run the gauntlet of Italian Eritrea. Everyone was expectant as the setting sun and then a full moon gave perfect conditions for attack, and it seemed unbelievable that the Italians should not have a crack at such a large armada. But nothing happened and with a sense of anticlimax we continued northwards. We reached Suez on 16th November but remained two more days on board, suffering the almost emetic smells from the oil plant and Suez sewage, whilst some amongst us had their first, rather despondent, look at a desert. We landed on the 18th, entrained and about midnight that night arrived at Abbassia, to be told by an excited young R.T.O. that an air raid was in progress. We had not been lucky over R.T.Os. since leaving Aldershot, for there was not the sound of a gun or bomb. But we apologized for our lack of appreciation and explained that we had just come from England where it was not considered cricket to call anything an air raid unless one heard the actual whistle of the bombs. Cairo seemed so very far from the Battle of Britain. We moved by M.T. to Almaza Camp, a few miles north-east of Cairo, and found it merely a patch of desert with a fence round it. Luckily there was a good moon to help us sort kits and blankets; whilst 292 Field Company, already in the camp, were most helpful. After forty-six days in transit over some fourteen thousand miles we had reached our theatre and the men were in good shape. A new chapter opened for us in which we would have much to learn.

At G.H.Q. next morning I met Major-General H. B. W. Hughes, the Engineer-in-Chief, and some of his staff, and learnt to my surprise that as we had not carried out the full official training programme in England someone in M.T. at the War Office had written to say we were untrained. I explained all we had done, but the "untrained" impression had got in first and was hard to eradicate. The Seventh Armoured Division had already borrowed two Sapper units from the Cavalry Division in Palestine, with Farewell as C.R.E. and they had been working well. There was no question of us joining the division at once: we must first train. Up to a point I accepted this but it was disheartening. Later, I learnt that there was a plot to keep the Cavalry Division Sappers with Seventh Armoured Division and switch us to Palestine: that I was determined to resist, but none of it gave us a very happy start.

I had numerous other visits to G.H.Q. and H.Q., B.T.E. in the ensuing weeks, trying to get vehicles and equipment, asking to move out to the desert for training. But everything seemed to be in short supply except rather inefficient staff officers with a "couldn't care less" outlook on the war. Of course there were workers half killing themselves with the extra load they carried, but there were far too many others who regarded the war—the Middle East brand of it—as a heaven-sent opportunity for comfort, good pay, a degree of prestige and *cachet* they had never known before, and, of course, a lovely armband. By some I was regarded as a fool to live in a tent at Almaza when I might get on the lodging list and take a flat in Cairo—"so much more amusing," I was told and could believe it. After Churchill's "toil and sweat" it all seemed a crime: after what I had hammered into my officers and men about doing their damnedest I felt let down.

We had arrived with ten Regular officers out of fourteen and it was not long before the rape began. By the end of November Clauson had gone off as a C.R.E. Works, and Haines to be an Instructor at the S.M.E. in Moascar. I was sorry to lose them as they had done excellent work, but their moves gave them promotion. In their places we got Bill Loring and Peter Moore, both Regulars and splendid acquisitions. Radcliffe took over Clauson's squadron, with Moore as second-in-command; whilst Loring took over the Field Park Troop. We also got young Geoffrey Reed who soon showed he could pull his weight. We managed to get rid of all our bridging gear to Moascar—there were no rivers to bridge in the desert—and we turned the men of the Field Park's Bridging Section into an extra but unofficial Field Troop under Tony Weir: it proved very useful on normal duties. We started a little desert training. We were inspected by the Engineer-in-Chief and Chief Engineer, B.T.E.: both said they were satisfied and we hoped that our "untrained" reputation would die. But I knew we could make little progress till we had all our vehicles and equipment, and got out to the desert, nearer our division and the war.

The E.-in-C. had promised me an early trip to the Western Desert to see conditions and contact Seventh Armoured Division. So on 3rd December, Radcliffe and I set off with Farewell who had been back in Cairo for a few days. A long, monotonous road, good as far as the outskirts of Alexandria but shocking in parts along the coast, took us to Bagush by afternoon. There, at Force Headquarters, I met Brigadier H. P. W. Hutson, the Chief Engineer, and discussed things with him. He wanted us to lend two subalterns to 2 Field Squadron, with Seventh Armoured Division, so I signalled back for Grant and Bond to come up at once: the experience would do them good. Next morning we drove on to Mersa Matruh, an ugly, depressing hole, surprisingly little damaged considering the number of bombs the Italians had thrown at it, and now cluttered with defences which, by home standards, would not have kept out an enterprising Baby Austin. From there we turned south and climbed the scarp to Charing Cross, where one road turned west to Sidi Barrani and the Italians but it was blocked by mines. The other continued south to Siwa and this we followed as far as Bir Hakuma where we found Seventh Armoured Divisional Advanced Headquarters. Great dispersion, little water or comfort ; no tents and people lived under lorry covers or in bivvy shelters over a scrape in the sand and thought it overcrowding if the next man was within a hundred yards. General Creagh, the Divisional Commander, was temporarily away sick but I met some of his staff. The fighting efficiency of this division was quickly to show itself as magnificent and to continue so, but I felt that that headquarters was not a happy family at that time, and had evidently little conception of the real purpose of a C.R.E. We went round part of the area that afternoon and met 2 Field Squadron, where I left Radcliffe for the night. Next afternoon we returned to Bagush where I told the Chief Engineer (and next morning the Corps Commander, General O'Connor) that I was none too happy about things, particularly about the strong initial prejudice I felt certain we would meet. As far as Force Headquarters was concerned, I was told, we would go to the division, but there could be no question of this at the moment : we were not yet ready and the first big desert offensive was due to start in a few days. Back to Cairo on the 6th, rather heavy of heart, and I told the E.-in-C. all I had said at Bagush. More than ever we must get vehicles and get out to the desert.

General Wavell's desert offensive opened on 8th December and came as Middle East's Christmas present to the Empire. It was a grand victory, and coupled with the valiant Greek efforts, a crushing blow to Italian prestige. As T. S. M. Cumper remarked, the problem was not how to chase Italians but how to overtake them. Except for Bond and Grant we took no part unfortunately, but these two youngsters did very well according to reports, though Brian Grant got a slight splinter wound in the hand—our first battle casualty.

Christmas found us still at Almaza, so we were able to organize a grand Christmas dinner for the men. Perhaps the best part of it was that, through the Adjutant's efforts, many of the men got their first mail from England with their dinners. Postal delays at that time were shocking : most letters from England took two months or more but there were also tremendous local delays. One letter from a Cairo bank took eleven days to reach me in Almaza, ten miles away. A cable from England which was marked as reaching Cairo in two days took another three weeks for local delivery. In our case matters were made worse by the fact that there were now two " Seventh Armoured Divisional Engineers " in the theatre and many of our letters first went out to Farewell in the desert.

Our constant pestering had not been without result and December saw a steady increase in our vehicles. As soon as we were nearly mobile I renewed my offensive to get out to the desert and the " Olympians " finally agreed. We would first go to Daba and from there work westwards, training, learning the desert, doing various jobs until we overtook the war and could be absorbed in our division. But we were altogether seven impatient weeks in Almaza before we moved early in January.

(To be continued)

THE GURKHA SAPPER

By MAJOR D. E. M. INGRAM, R.E.

NOW that Gurkhas are being trained as engineers to take their place in field units of British Gurkha formations, it is thought that readers may be interested to learn something of these soldiers of a foreign land who have given such loyal service to our country for so many years. Firstly, it is intended to give some information about the Gurkhas' home, of the classes from which sappers are being recruited, and the method of enlistment into the British Army. Then a brief outline will be given of their training as engineers, both individually and collectively.

The Gurkha soldier comes from the independent kingdom of Nepal, which is situated on the north-eastern frontier of India, and it extends from that frontier to the main axis of the Himalayas, which forms the boundary of Nepal with Tibet. Roads and railways, other than short lengths extending just over the Indian frontier, do not exist ; all movement is by foot on hill tracks.

The government of the country is not exercised by the King, who is merely a titular head, rarely moving from his palace in Kathmandu, the capital, but by the Maharajah, Prime Minister, and Supreme Commander-in-Chief of Nepal, whose power is absolute.

The entry of Europeans into Nepal is severely restricted but H.B.M. is represented in the country by a Minister and Nepal is similarly represented in London. The country is Hindu but with customs and ceremonies peculiar to itself. These are very much bound up with family life, and the clans and kindreds are the feature of that life. The division of the classes or tribes into clans and kindreds can be compared with Scots clans and septs. Gurkhas have always had a tradition of military service and the bearing of arms is exemplified in the wearing of the national weapon, a curved knife called the Kukri. Service in the Gurkha Regiments, in the British Army now the Brigade of Gurkhas, has shown what a fine disciplined soldier he makes.

The ability, however, of the Gurkha to become an engineer was, and still is, unknown. He is not often a tradesman in his native land, in fact certain trades which are required in an R.E. unit are considered as low caste. It is hoped, by presenting in the proper manner the sappers' task of helping the " teeth " troops to fight, that these prejudices will be overcome. Success in this direction is more likely in view of the fact that a Gurkha becomes " unclean " by going overseas and has to perform the Pani Patiya ceremony on returning to Nepal to regain caste. The performance of this ceremony apparently covers other acts of " uncleanliness."

The Classes from which Gurkha sappers were to be recruited were, therefore, decided on the basis of soldierly qualities rather than by looking for artisans, and the following are being recruited: Limbus, Rais, Magars, Gurungs, and a small proportion of Thakurs and Newars. The first two years' intake was to be from trained soldiers who had taken their release on the reduction of the war-time Indian Army. This was necessary in order to save time in training and to get a higher and more varied age structure in the R.E. units. It would obviously have been desirable to obtain a rifle battalion for conversion *en bloc*, as had been done for R.A. units, but that was not possible. The decision to recruit from mixed classes is a new departure ; up to now each Rifle Regiment has recruited from one class. However, it is likely that in future all units of the Brigade of Gurkhas will be made up of mixed classes.

The Limbus and Rais come from Eastern Nepal, and although two separate clans, they intermarry, and for all practical purposes can be considered as one. Pre-war they were enlisted into the 7th and 10th Gurkha Rifles and are considered to be slightly more intelligent than the average Gurkha, whilst retaining the characteristic cheerfulness and generosity. In appearance they are very Mongolian, with fair colouring and are slightly bigger than Magars and Gurungs. Originally they were Buddhist, but they accept the supremacy of the Brahman.

The Magars, often said to be the typical Gurkha, provide the largest number of men for the army. They come from Central and Western Nepal, are the main agricultural class, and the clans within the class are very numerous. There appears to be no doubt that Magars have been influenced in their past by considerable contact with Hindus from India during the latter's invasions; this is reflected in their greater orthodoxy in religion.

The real hill classes, the Gurungs, come from the north of Nepal, but they are very like the Magar in appearance. They wear the rup, a thread necklace of nine strands for men and seven for women, with nine and seven knots respectively. As is to be expected of hill people, they are mainly shepherds. There are many divisions of the class, and some clans and kindreds consider themselves far superior to the rest. The Gurungs are Hindus but employ Buddhist priests for some of their more important religious festivals, as originally they were of that faith.

The Thakurs are the educated class and occupy a high social position in their native country. This class provides a large number of Gurkha officers. They are Mongolian in appearance, being very like Magars and Gurungs.

The Newars are the shopkeepers, artisans and farmers of the country, of which they form the bulk of the population. Formerly they were a very important section of the country, but after being conquered by the more martial races they were held very much in a state of subjugation and turned to the simpler pursuits. They are, therefore, not found so much in the army. Their craftsmanship has reached an extraordinarily high standard although, of course, their methods are most elementary and mass production is unknown. The influence of India can be observed in the appearance of the Newar who is perhaps a little taller than, and not so dark skinned as, the average Gurkha.

In his customs, the Gurkha is bound by orthodox Hindu caste laws and failure to observe them means loss of caste. These laws, of course, cover the eating of food, both in its preparation and type. For example it must be prepared by one of higher or equal caste and no Gurkha will eat female goats or sheep. They have no restrictions as to alcoholic drinks, particularly rum, as many British officers have discovered to their cost when being entertained by Gurkha officers.

Clothing in Nepal varies from a kilt-like cloth worn over a loin cloth to European type garments. The women are remarkable for the amount of clothes they wear, even when they go overseas to a warmer climate like that of Malaya. Their dress consists of a bodice wound several times around the waist, a shawl worn on head and shoulders, and a white cloth is wound several times around the stomach. Most articles are brightly coloured and jewellery is worn profusely. The baby is carried on the mother's back, being tied in position with a cloth.

The Gurkha is permitted a second wife, who may or may not have the same status as the first one. Only one wife, however, is allowed in the married lines. Divorce is allowed and remarriage possible.

There are many Hindu festivals which are observed as holidays in the army, totalling some twenty-eight days in a year. The longest, ten days, and most important, is Dashera in September or October. This is the warriors' festival and dedicated to the god of war and the goddess of victory. It is a time of merrymaking and dancing, culminating in an all night celebration to which are invited the British officers and their wives, and, finally, in the sacrifice of chopping off the heads of bullocks, goats and other animals. The head must be severed by the Konra, a heavy curved weapon, with one blow. The young Gurkha graduates to the final sacrifice by commencing on chickens with a kukri.

A Gurkha is either cremated or buried at death. A sick man who is unlikely to get well is sent home from overseas in order that he may regain his caste, lost by going overseas, before dying.

The writer had the good fortune to be able to travel to India for last year's recruiting and before outlining the recruiting procedure, a picture of the route over which the Gurkha travels from his home in Nepal to Malaya where he is at present serving, will be given.

The prospective recruit usually arrives at the terminals of the L. of C. by rail from Nepal. These terminals are the two recruiting depots, situated on the Indian side of the border, in the United Provinces. The main recruiting depot is near Gorakphur, and serves Central and Western Nepal; a depot at Ghoom serves Eastern Nepal. The original Central Recruiting Depot at Kunraghat, three miles from the town of Gorakphur, was handed over to India when she became self-governing, and a temporary tented camp in the vicinity has been used by the British Gurkhas up to the present. A permanent British Recruiting Depot is planned to be built on a site, not yet fixed, in the same area.

Movement between the recruiting depots and Calcutta, the port of embarkation, is by rail, usually in special trains chartered by H.Q. British Gurkhas. The journey takes about twenty-four hours and on arrival in Calcutta the Gurkha soldier is sent by road transport to a transit camp ; there he waits until arrangements have been completed for his onward transportation. A small British Staff is stationed in Calcutta to administer the transit camp and arrange movement.

The ports of disembarkation in Malaya are either Penang or Singapore depending on the location of the Training Centre or

Rifle Battalion to which the recruit has been posted. The sea journey from Calcutta to these ports takes about a week or ten days and may either be on a troopship or an ordinary civilian boat, according to the numbers being sent. To the new recruit and families this provides their first sight of the sea.

The recruiting season starts immediately after the Dashera festival, and within a few days of its termination parties of recruits begin to arrive. But first it should be explained how the recruits are brought to the depot.

The Chief Recruiting Officer appoints Gurkha pensioners and other ex-soldiers as Paid Recruiters and these are given instructions as to the district they will recruit from (invariably that in which they normally live), type of recruit required, e.g., class, if ex-soldier acceptable, age, etc., and an authority to recruit. These recruiters spend the summer collecting their quota of recruits so that by the time the recruiting season approaches they can conduct them down from the hills to the railway station on the Nepal side of the border. There they are given tickets by a re-employed pensioned Gurkha officer who is employed for the purpose ; they are then dispatched on the train to the depot.

The beginning of the recruiting season at Kunraghat coincides with the end of the monsoon and cooler weather is noticeable, particularly shortly after dawn when the first step is taken in enrolling the prospective Gurkha soldier. The scene is a flat grass parade ground area, somewhat larger than a football pitch, for which purpose it is used in off-duty times, with the office tents of the Headquarters, British Gurkhas in India, at one end, and living tents, etc., at one side and at the other end. The prospective recruit, who has been given a meal and a much needed bath, forms up on the parade ground with other recruits in parties under their recruiters, and a Gurkha clerk, under the direction of a Gurkha officer, takes down their names, addresses, and recruiter's name. This is a long and involved business as their names and classes, etc., have to be checked against the Gurkha Handbook, which is a complete list of classes, clans, and kindreds with the districts from which each comes. Few of the Gurkhas have much idea of what their full clan names are and these have mostly to be deduced from answers to questions. One good clue is the area in which they pay their taxes ; most seem to know this !

A few impressions of the prospective recruit as they struck the writer at this stage may be interesting. Physically he is often a fine specimen, although some show signs of undernourishment and disease. He is not very tall and has a swarthy appearance. His facial expression does not lead one to expect a high degree of intelligence, and he is very nervous and shy. The latter is no doubt largely due to the strangeness of the surroundings and many new things which he is seeing for the first time ; a party walking up from the station to the recruiting depot were seen to take cover in road-side drains at the approach of a motor car. His clothing conforms to national custom and he wears plenty of it ; his personal belongings are carried in a small cloth wrapped bundle. Generally he has the appearance of a rather wild and uncivilized creature and not very promising material for training as a soldier. Obviously appearances, at any rate to the inexperienced eye, are deceptive.

When the recruit's particulars have been recorded he strips down to his loin-cloth—an odd pile his clothing makes—and he is inspected by a Gurkha officer who records his weight, height, age and chest measurements, and then looks for obvious physical defects by making him run, bend, stretch, etc. Afterwards the prospective recruits are formed up in single file facing front and are inspected by the British Assistant Recruiting Officer, who is usually a representative of his Regiment or Corps and anxious to get the best possible recruits for his unit. He is guided in his assessment by certain specified physical standards. If a recruit is considered fit he is marked on his chest with a Roman I ; if below standard for any reason, even appearance, he is marked II.

On the next day the Chief Recruiting Officer holds his parade. The present holder of this appointment possesses a considerable knowledge of the Gurkha, gained over many years' service with these troops ; he is able to tell at a glance to what class and often clan a man belongs and what his mental and physical capacity is. The recruits are formed up in two ranks, with those graded II by the Assistant Recruiting Officer in the rear rank and with the recruiters who brought them standing behind. The Chief Recruiting Officer is accompanied by the Assistant Recruiting Officer and Gurkha Officer who originally inspected and graded them, whilst he walks first down the line of those graded I ; any recruit who is not considered up to standard by the C.R.O. falls out. In the recruitment of Sappers it is necessary at this stage to ask for volunteers because of course there is no traditional and clan association with R.E. The enthusiasm for enlistment in R.E. was good in the first year, due largely to the reputation of the Indian Sappers and Miners, who were well known to all Gurkha ex-soldiers.

Then those graded II are inspected by the C.R.O. to confirm that they are not suitable. If any are considered to be up to standard by the C.R.O. in light of his greater experience they are promoted to the front rank ; the remainder go off parade. This inspection continues party by party until all recruits graded on the previous day are disposed of. Rejected recruits are given a meal and return to their homes under the charge of the recruiter who brought them, who must bring back a receipt from the head man of the rejected recruit's village in due course.

Later in the morning, after the recruits have been either accepted or rejected, the C.R.O. holds a parade of the recruiters to assess the reward to be paid to them. The recruiters form up in front of the C.R.O., who is seated at a table with the nominal roll of accepted recruits in front of him, and are called up individually. After consulting the roll upon which has been marked the proposed rewards, the maximum being ten rupees, the C.R.O. announces his award. Hard words are spoken to recruiters who do not bring a reasonable number of accepted men and the C.R.O. can and does cancel the recruiter's authority for the next season and/or cancel part or the whole of his pay.

It will be observed that up to now the selection has been based purely on the recruiting staff's knowledge and experience and it is on this basis that the recruiter is rewarded. The recruit, however, can be rejected as a result of his medical examination by R.A.M.C. officers and this is the next hurdle the prospective recruit has to surmount. If he fails, he returns to Nepal with the rest of the rejected recruits at the end of the day. Those who are finally passed are issued with certain articles of clothing on the next day, then complete their attestation papers and take the oath of loyalty before a British officer. An advance of pay completes the formalities and the recruits are dispatched as soon as possible to Calcutta on the first stage of their journey to Malaya to commence training.

The procedure of selection as described ensures that every care is exercised in the selection of the recruit and it is rare that a bad one gets through the net, although the keenness of the Gurkha to enlist is such that he frequently departs from the truth in his answers to questions ; the combined experience of the recruiting staff, however, usually finds him out.

Experience with Gurkha troops is something we have not yet got, of course, in the R.E. and every opportunity has to be taken to learn from others who have. A visit to, or service with, the depot during the recruiting season provides a lot of experience in a short time.

Officers for service with Gurkhas are being selected by the War Office from volunteers, and arrive in Malaya after having been given any specialized training which it is considered necessary for them to have in order to fit them as unit instructors. The British officer is a vital factor in the formation of the Gurkha Engineers, as upon him falls the entire technical responsibility of his unit for some time to come.

The R.E. officer first of all spends a period of three months with a Rifle Battalion or Gurkha Training Centre, learning the language and the Gurkha way of life, before joining the Engineer Training

Centre, Far East, which has a special training wing for the Gurkhas. It will be appreciated that three months gives little time to attain a degree of skill in the language sufficient for instruction. One of the first problems, therefore, was to provide suitable instructors for the Gurkha cadres of instructors, obtained from volunteers from rifle battalions already serving in Malaya, who themselves would in due course be instructing the recruits in field engineering.

It was found that nearly all these N.C.Os., having served in the Indian Army, had a knowledge of Hindustani, consequently application was made through the War Office to the Indian Government for the loan of some Indian Sappers and Miners. Army Headquarters in New Delhi was most co-operative and the services of a Jemadar and two Havildars from the Madras Sappers and Miners were obtained on loan ; these arrived at the Engineer Training Centre towards the end of last year.

As yet there is no primary training centre for Gurkha recruits in Malaya, as is the ultimate intention, so at present all Regiments and Corps have to be responsible for the basic training of their own recruits. This commitment is also being undertaken by the Engineer Training Centre who have attached to them instructors on temporary loan from their battalions. The programme of training of the Gurkha sapper is laid down to cover a period of one year, during the first four months of which he receives his basic training. As has already been mentioned, the initial two intakes are from ex-soldiers and for the present this period is more in the nature of refresher training. Several of the re-enlisted men are potential N.C.Os. right from the start, some having held ranks up to that of Sergeant on their previous engagements in the Indian Army. It has been possible, therefore, to achieve almost from the outset a remarkably high standard of drill and bearing, and more than one senior R.E. officer has been very impressed by the Gurkha sapper on parade. Whilst basic training is proceeding the N.C.Os. forming the fieldworks instructors cadres are receiving the necessary instruction to fit them for their rôle. Results to date are quite promising, considering the difficulties—language, lack of textbooks and diagrams in the vernacular, etc. The instruction consequently is essentially practical in character and they spend much of their time in the Centre's fieldworks ground, a disused quarry set in some typical Malayan jungle. Here they build jeep tracks, carry out improvised bridging, construct culverts, lay and set off demolition charges, and all under the guidance of their officers and the Madras Sappers and Miners, they learn the hundred and one things that will make them trained field engineers. They show considerable enthusiasm to learn and the Indians are doing a fine job in teaching them.

On the completion of the recruits' initial four months basic military training, they commence field engineering under their own instructors. The training is based on that of the British sapper and the standard aimed at is the same. The provision of Gurkha instructors during the first few years will present difficulties, as practically the only ones available will be those drawn from the initial cadres of N.C.Os., who have had to learn all they know about field engineering in a shorter period than is scheduled for the recruit. The present training syllabus is given as an Appendix ; this will no doubt be amended in light of experience gained.

The Gurkha units form up at the end of the year as squadrons, being by that time skilled soldiers and field engineers, able to give limited engineer support in the division. Full support will not, however, be possible during the first year with formed units, as this period will be devoted to the training of tradesmen. Every trade on the establishment of the British Field Engineer Regiment will be taught to the Gurkhas, who are being formed into units with establishments very similar to those of British ones. All ranks, other than officers, will be Gurkha, although it is the intention in years to come that there will be Gurkha commissioned officers. Selected boys are being educated up to the standard for entrance to Sandhurst and no doubt some will subsequently be trained as engineers and take their place in Gurkha engineer units. But this is looking rather far into the future ; meanwhile the object is to train Gurkha tradesmen to fill every vacancy on the establishments. Some will take much more than the year allotted, as they demand a fairly high educational standard before the commencement of practical training. Until such time as they are available, the Gurkha units will be made fit for their rôle by the attachment of training and administrative Increments of British Other Ranks to make good the deficiencies in tradesmen and unit instructors. During their first year, as formed squadrons, and concurrently with trade training, the Gurkha engineer units will carry out collective training with the other arms of their formations.

The Gurkha engineers will be organized on a divisional basis and will form part of the Gurkha formations in the British Army, who will without doubt live up to their glorious traditions earned in the Indian Army. The Gurkha sapper has yet to make his mark, but with the R.E. badge on his headdress and the sign of the crossed kukris on his shoulder he has plenty of tradition behind him and should become a worthy heir to the throne left vacant in the British Army by the Indian Sappers and Miners.

SYNOPSIS OF INSTRUCTION

Serial	Course	Object	Duration	Subjects	Periods of ¾ hrs.
1	Basic Military Training	To train Gurkhas as Soldiers of the British Army	4 months	Drill P.T. including battle course Weapon Training Application of Fire Fieldcraft Bomb disposal Education Interior Economy Hygiene and Sanitation	75 100 150 20 55 30 140 20 18 608
2	Corps Training (Cadres)	To train Gurkha N.C.Os. as instructors in Corps training for recruits	5 months (concurrently with Serial 1)	All field engineering subjects (as Serial 3, but on reduced time table)	
3	Corps Training	To train Gurkha soldiers as sappers	8 months	Field Engineering (i) Field Engineering (ii) Camp and Water Supply Roads and Tracks Bridging—General Bridging—Dry Bailey Bridging—Wet Bailey Bridging and Watermanship Demolitions, mines, and booby traps Further Military training, Education and P.T.	132 88 88 88 44 66 66 88 480 1,140
4	Trade Training	To train selected Gurkha sappers as tradesmen	Variable	All trades on establishment of field engineer regiment	

FLUSHING STREAMS AS AN ANTI-MALARIA MEASURE UNDER WAR CONDITIONS

By MAJOR W. E. C. PETTMAN, R.E.

THE Sappers' part in an anti-malaria campaign was described in the *R.E. Journal* in December, 1948, and although chemical researches continue to add weapons against this scourge, engineering measures will still be necessary in some theatres of war to neutralize the breeding places of certain species of mosquito. One of these measures is the flushing of streams by means of dams, so as to kill the embryo malaria carriers in their early stages, i.e., the eggs, larvae, and pupae which float helplessly in pools along the banks. These may either be washed on to the surrounding ground and left stranded there, or they may be drowned by a disturbance of the water. This work much resembles the mud-larking, about which our parents were so unreasonable in our youth, but its technique depends on knowledge of the enemy—the local malaria carrier or " vector " —and on engineering economy—£ s. d. = " Lorries, Labour, Stores, and Days." This article describes that technique as learnt in the backwaters of the Fourteenth Army in the last war, and includes some new data obtained in the process.

DAMS

Simple earth dams were used, not more than 3 or 4 ft. high. Any greater head of water causes too much pressure for convenience under service conditions. The resultant waves are only an inch or two high, but they serve their purpose provided that the dams are not too far apart. The sluices are easily made from salvaged petrol or oil drums, and the gates from planks, with no hinges since the water pressure keeps them firmly in place—sometimes too firmly for convenience in opening. Fig. 1 shows the sort of dam required, and Fig. 2 shows a petrol or oil drum sluice. The gate consists of the base cut away from the drum. This suffices for dams up to about 4 ft. high, after which some stronger or more elaborate device is necessary. Automatic syphon sluices are often used for this purpose, but were shunned by the Sappers in Assam for fear of elaborate construction, intricate adjustments, and the uncertainty of monsoon conditions in jungle. They are therefore not described here.

It was found that the sectional area of the sluices in a dam should total about 30 per cent of the vertical face area of the dam. A higher

Fig. 1

TYPICAL SLUICE for 3 FT. HEAD LOOKING UPSTREAM

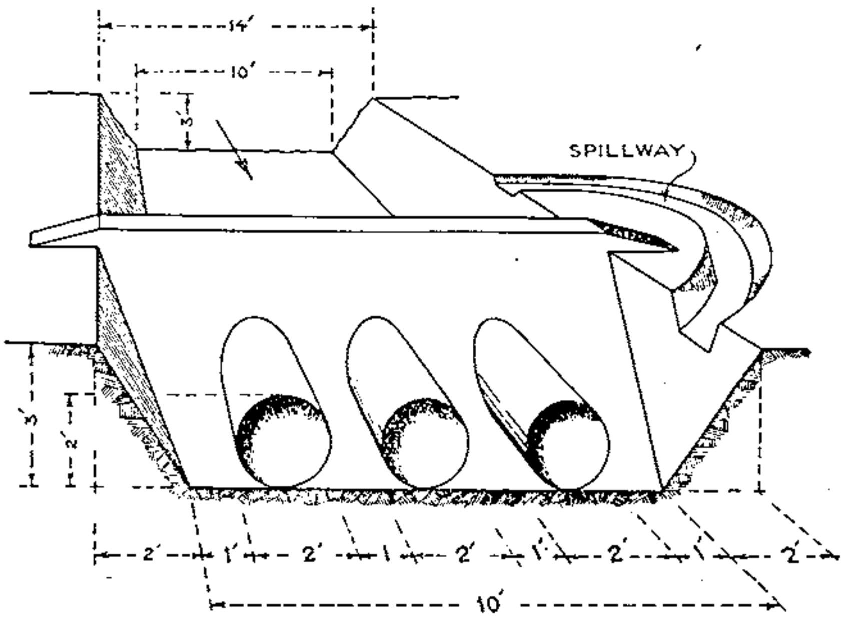
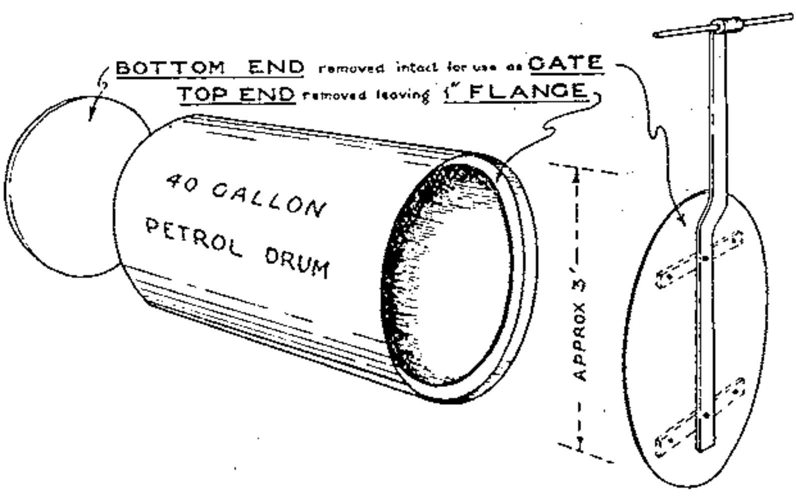


Fig. 2

SIMPLE GATE from SALVAGED MATERIALS



ratio than this is difficult to obtain and adds little to the efficiency of the wave. The drums should be at least 1 ft. clear apart, otherwise it is difficult to pack the earth between them, especially if boulders are mixed with the earth.

A by-pass must be dug round the dam, just below its top, to prevent scour over the top.

These dams leak so much that constant maintenance and occasional rebuilding are necessary. These however, are quite simple.

Dams should be sited so as to impound as much water as possible, since this greatly improves the effect of the wave. A narrow neck, just below a widening of the stream, is worth seeking, but the siting of dams is affected by other considerations, as we shall now see.

Distance Between Dams

" How far apart must such dams be ? " To this question no answer was available in the field, so the Sappers who asked the question in Assam made their own attempt to answer it. Their conclusions, which include some new work on this subject, were published in India,* but the theory propounded then has since been improved by investigations in U.K., and this article describes the revised theory. It transpires that the conclusions reached herein are generally consistent with field observations elsewhere.

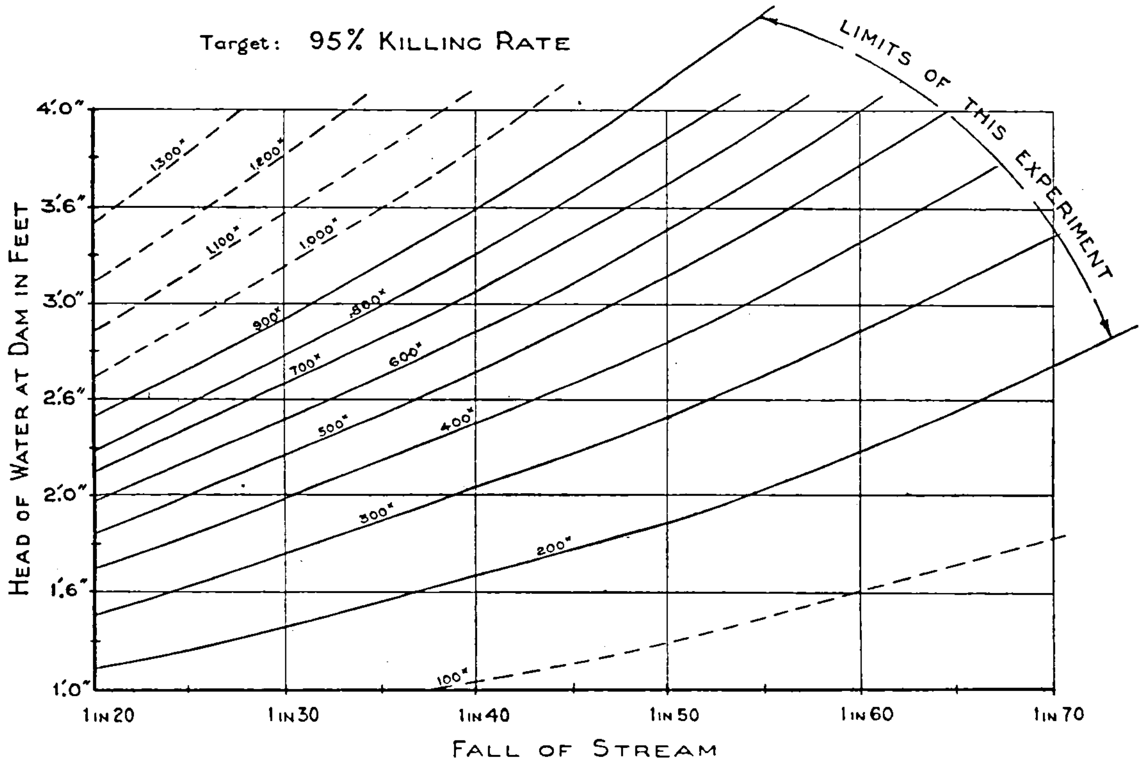
Malariologists stated that 95 per cent of the larvae, etc., must be killed if malaria was to be controlled. (This assessment depends on local conditions and the nature of the " vector.") They also stated that the larvicidal value of a wave depends on its height and on its speed. Experimental waves in several streams revealed a linear relation between the *head* of water at a dam and the *height* of the resulting wave, and also a smooth curve connecting *fall* of stream with *speed* of wave. These two relationships were found to be independent of each other, i.e., *head* does not effect *speed*, nor does *fall* affect *height* of wave. A further factor—*roughness* of stream bed—was disregarded, partly because of the difficulty of measuring and allowing for it and partly because it was assumed to be fairly constant among malarious streams. Knowing, then, how the larvicidal characteristics of a wave depend on the *head* and *fall* respectively, it seemed simple to calculate the lethal effect of any wave within reasonable limits *if only the effect of one given wave were known.*

To find this out, skilled larva catchers, borrowed from an Anti-Malaria Unit, counted the density of larvae in several pools before and after the passage of a particular wave, which was then taken as a " Standard Wave " and used as a basis for the subsequent calculations.

**Indian Journal of Malariology. 1. 4th December, 1947.*

Fig. 3

EFFECTIVE LARVICIDAL RANGES OF DAMS IN MALARIOUS STREAMS



As a result of this experiment a rough guide to the effective killing range of a wave, depending on the height of the dam and the fall of the stream, was obtained. This is shown in Fig. 3 and seems to give a fair guide within the limits shown.

Auxiliary Aids

It is sometimes suggested that flushing would be more effective if some form of insecticide were added to the water impounded by the dam, but this idea should be treated with caution. The impounded water does not travel on the wave but soon becomes a part of the stream, and pools remote from the main current would receive little if any of the poison intended for them.

Another measure supplementary to flushing is the trimming of the banks. Trimming so thorough as to smooth out all malarious pools and backwaters would render flushing unnecessary, but is extravagant of labour and time. Usually, however, only a little labour is required to improve greatly the effect of the wave, and this work is the proper accompaniment of flushing It calls for some knowledge of the local vector's breeding habits, but this is easily acquired, and is expected of anyone engaging in anti-malaria work. Even without a special training in the subject, enough can be learned by consulting the malariologists and entomologists who naturally direct any anti-malaria campaign.

The effect of trimming cannot be measured exactly, and would be difficult even for an expert to assess. It cannot, therefore, be used as a known factor in calculations, and may well be regarded as an uncertain, and highly desirable, Factor of Safety.

Interpretation of Data

Since this study of flushing is new, and because the very nature of the subject is incompatible with exact measurements, one must explain how the Rough Rule emerged from the ideas already mentioned.

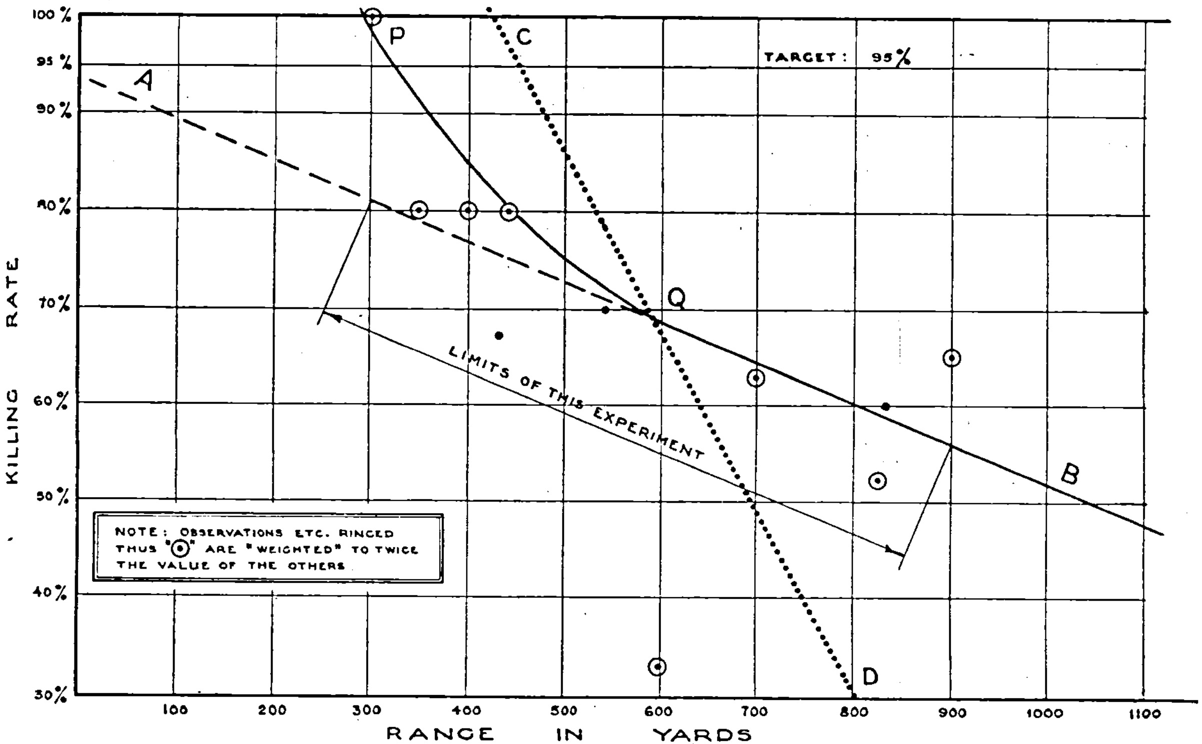
It would, in fact, be rash to use the Rule without knowing something of its origin and limitations.

The chief problem was to measure the larvicidal effect of the standard wave. Several experiments were made, but subsequent examination of the results led to the rejection of all except one. Much, therefore, depends on the interpretation of the meagre data obtained.

The larva catchers counted the larvae in several scoops made in each of the selected pools, both before and after the passage of the wave. From these figures the density of larvae after flushing was compared with the density before flushing. This ratio was called the " Killing Rate." Unfortunately, larvae were so scarce that some

Fig. 4

GRAPH shewing KILLING RATE at VARIOUS RANGES



of the counts were too small to be reliable, so greater importance was attached to results obtained either from a larger number of scoops or from a higher density of larvae. Table I shows how these figures were recorded in the field and which of them were selected by inspection as being the more reliable. These are " ticked " in the appropriate column, and their resulting percentages are " ringed," both in Table I and in Fig. 4, which shows them plotted. In the subsequent calculations these figures were " weighted " by counting them twice. The reliability of these readings may be questioned, but statistical calculations show that their correlation is just close enough to signify a connexion between Range and Killing Rate. We may therefore accept them as an indication of what happens, though they should not be regarded as accurate.

TABLE I

EFFECTIVE RANGE: ACTUAL OBSERVATIONS

Table of catches, giving Killing Rate

Head 2 ft. 6 in. Opening 29 per cent | Flow 1.1 ft./sec.
Fall of stream 1 in 50 | Mean speed of wave 0.8 m.p.h.

Pool number	Range in yds.	DENSITY OF LARVAE				PERCENTAGE OF		REMARKS
		BEFORE FLUSHING		AFTER FLUSHING				
		Catches	Average per scoop	Catches	Average per scoop	Survivors	Killed	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	300	15 in 10	1.5	*Nil* in 10	0.0	0	100	
2	350	16 in 10	1.6	3 in 10 ✓	0.3	19	80	
3	400	20/10	2.0	4/10 ✓	0.4	20	80	
4	430	3/5	0.6	1/5	0.2	33	67	
5	440	10 in 10	1.0	2 in 10 ✓	0.2	20	80	
6	500	*Nil* in 5	0.0	*Nil* in 5	0.0	..	..	Inconclusive
7	540	10/5	2.0	3 in 5	0.6	30	70	
8	560	*Nil*/5	0.0	*Nil* in 5	0.0	..	..	Inconclusive
9	600	12/5	2.4	8/5 ✓	1.6	67	33	Sheltered pool
10	700	40 in 5	8.0	15/5 ✓	3.0	37	63	

Note.—Promising results are " ticked " in column 5 before averages are worked out, so as to select them without bias.

The first impulse was to draw the best possible line by eye through the plotted points, and from this was deduced the Rough Rule originally published in India. The line was assumed to be straight because no reason appeared for supposing otherwise, and because the height of the wave had been found to decrease, after the first 200 yards or so, fairly regularly with the distance.

Later, however, the Theory of Statistics showed the fallacy of this arbitrary fixing of the line. It can be calculated, and the calculation gives two alternative lines according to which of the two variables is known and which is uncertain. In this case the Range is known and the Killing Rate is uncertain. These lines, assumed for the moment to be straight, are shown in Fig. 4 as A–B and C–D respectively. A–B is for use when Range is known and Killing Rate is uncertain, as in this experiment, and this is the line used in the present work. It is called by statisticians the "Regression of Killing Rate on Range." The other line, C–D, is the Regression of Range on Killing Rate, and would have been used if the Killing Rate had been known and the Range uncertain. The line originally drawn by inspection is a sort of average line bisecting A–B and C–D, and has no meaning at all. It is greatly to be regretted that the Rough Rule published in India was based on this meaningless line and is therefore wrong. It is hoped that this digression into the Theory of Statistics may prevent other explorers from falling into the same error.

The line need not necessarily be straight, and it would seem unnatural for it to be so. If the observations had been more numerous and more consistent it might have been possible to calculate its true shape, and even to deduce something about influences other than Speed and Height. As it is, however, a certain amount can be inferred from what we do know.

Speed is uniform as long as the fall of the stream is constant—that is if we are justified in neglecting roughness. Therefore Speed makes a linear contribution to the Killing Rate curve.

Height, however, does not decrease uniformly. It subsides quickly on leaving the dam, but after 200 or 300 yds. begins to diminish more gradually. After 400 or 500 yds. its rate of diminution is nearly linear, though of course not quite, because the wave never quite disappears. Our experiment extended from 300 to 900 yds., the mean range being near 600 yds. Therefore the straight Regression line was adopted for ranges longer than 600 yds., giving a slight error on the safe side at long range. Nearer the dam a freehand curve was superimposed on it, resembling the shapes of curves (not printed here) of the rate of diminution of several waves. The resulting curve, shown in the firm line P–Q–B in Fig. 4, was used to find the Rough Rule.

Correction Factors

The results of the Standard Wave were easily applied to other waves in other streams by using two Correction Factors, one for Head at dam (i.e., for height of wave) and the other for Fall of Stream (i.e., for Speed of Wave). Readings not plotted here showed that Height of Wave depends directly on Head at dam, and since the Standard dam was 2 ft. 6 in. high the formula for other dams is :

$$\text{Corrected Killing Rate} = \text{Standard K.R.} \times \frac{H}{2\frac{1}{2}}$$

$$= \text{S.K.R.} \times 0.4\ H, \text{ where H is in feet.}$$

The correction for fall is less simple, since the relation between Speed of Wave and Fall of Stream is not linear ; in fact, it closely resembles an hyperbola, whose formula is too complicated for use here. Therefore the Correction Factor for any particular Fall was found by measurement from a suitable scale drawn on the " Fall–Speed " graph (not reproduced here). Both Correction Factors are tabulated in Table II, which also shows their products, which are the combined Correction Factors (C.C.F.) for various combinations of Head and Fall.

TABLE II

Combined Correction Factor for Head and Fall

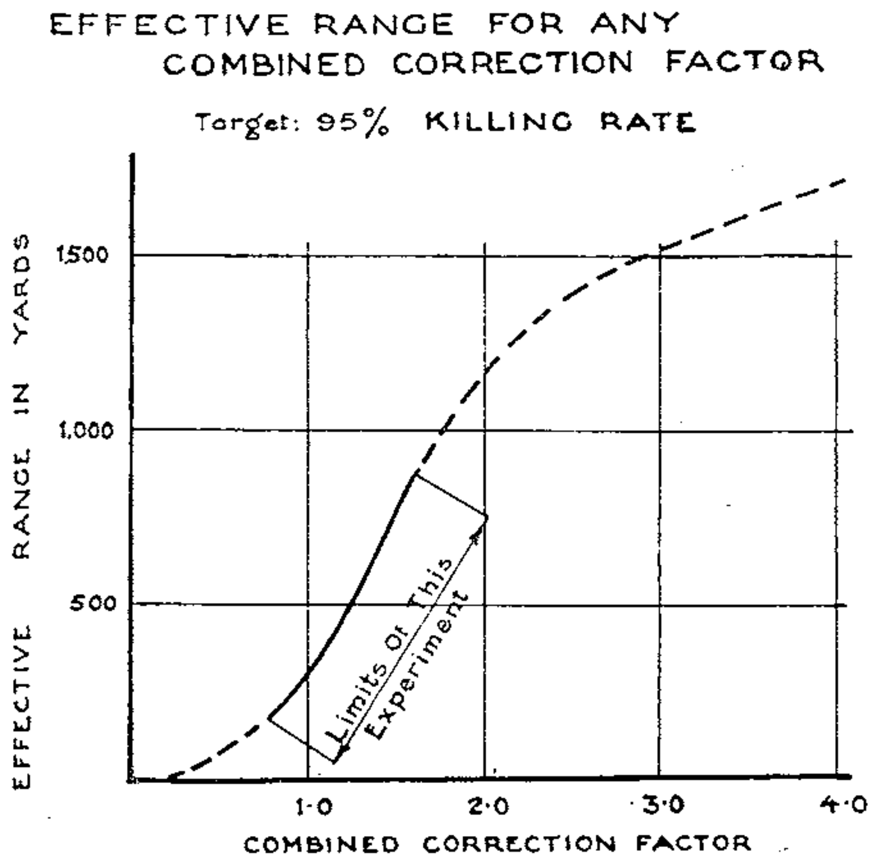
FALL :— FACTOR FOR FALL :—		1/20 1.72	1/30 1.40	1/40 1.18	1/50 1.00	1/60 0.85	1/70 0.70
Head	Factor for Head	Combined Correction Factor					
4 ft.	1.6	2.75	2.24	1.89	1.60	1.36	1.12
3½ ft.	1.4	2.41	1.96	1.65	1.40	1.19	0.98
3 ft.	1.2	2.06	1.68	1.42	1.20	1.02	0.84
2½ ft.	1.0	1.72	1.40	1.18	1.00	0.85	
2 ft.	0.8	1.38	1.12	0.94	0.80		

The rest follows simply from what we have now obtained. Each of the C.C.Fs. in Table II is applied in turn to the Killing Rate curve as drawn in Fig. 4, and the " Effective Range " corresponding to each, i.e., the range at which the Killing Rate = 95 per cent, is plotted in Fig. 5. This contains the information we want, but it is set out in a more convenient form in Fig. 3 above, which is the Rough Rule we wanted.

Review of Findings

Now then, how does all this theory compare with reasonable expectations ? Fig. 5 can be translated into terms of real life. The curve is steepest within the limits of the experiment. The dotted lines extended beyond this suggest that damming is practically useless unless a C.C.F. of at least about 0·8 can be obtained. In a sluggish stream falling at, say 1 in 70, a 3-ft. dam is only effective

Fig 5



for 250 yds., and a 4-ft. dam for 400 yds. Dams higher than 4 ft. would usually be expensive of engineer effort. On the other hand, in a swift stream, say one falling at 1 in 20, a 3 ft. 6 in. dam gives an effective range of ¾ mile. Slow moving streams therefore appear to be unfavourable for flushing. Unfortunately, however, they may contain more malarious pools than rapid streams, but since they will probably occur in flat country these pools will probably be susceptible to flushing. Deep pools with steep edges, such as those found among tree roots, are practically impervious to flushing.

The curve in Fig. 5 seems to flatten out towards the top, so that it seems pointless to increase the C.C.F. beyond about 0.4 ; i.e., not only are big dams uneconomical of engineer effort, but they are not much more effective than small ones. A C.C.F. of about 2·0 seems the optimum, and is given in a 1 in 20 stream by a 3-ft. dam. In a 1 in 60 or 1 in 70 stream it is hardly obtainable.

Thus the fall of the stream, being the most persistent factor, seems more important than the height of the dam, whose effect may not always extend far enough to justify the effort of construction. "Little and often" seems to be a guiding principle.

Not only has the roughness of the stream bed been disregarded, for reasons already explained, but also Depth of Water and Speed of Stream, both of which may affect the wave and its effects, though probably not very much. In shallow water the wave is more noticeable, but its stranding effect depends not so much on this as on the nature of the banks. Over flat banks it will spread further, and therefore be more useful than over steep banks. Speed of stream varies with rainfall. The speeds noted here occurred in dry weather; monsoon torrents produce spates too heavy for breeding. Early monsoon and post monsoon conditions must be watched. These are the most dangerous times, but too unpredictable for inclusion in these rough calculations.

Another larvicidal device, which may sometimes rival flushing, is the splashing of a jet of water into the pools. A small portable pump and some hose are all the apparatus needed, but the nozzle must be directed wisely. This method kills by swamping, whereas a wave does it in a slow stream by stranding, and only by swamping when the turbulence is considerable, i.e., in a steep stream, or just after leaving the dam. Perhaps the hose may be preferable in sluggish streams in flat open country, and flushing in steep swift streams, where a hose party cannot so easily move.

Conclusion

Finally it should be remembered that larvicidal work cannot succeed without expert guidance from malariologists, though it is easy to learn from them enough of the subject to use their advice intelligently. The Rule propounded above should be a useful guide to the spacing of dams, but it should only be applied with deference to the breeding propensities of the local vector, as expounded by "those who know."

Thanks are due to Professor G. Macdonald, Director of the Ross Institute of Tropical Hygiene, for encouragement and advice, and to Dr. D. J. Finney, Lecturer in the Design and Analysis of Scientific Experiment at Oxford, for help in statistical inquiries. The author also thanks the Editor, *Indian Journal of Malariology*, for publishing the original theory, and regrets that this revision of it should have been found necessary.

HE WANTED TO BE A SOLDIER

By Captain J. I. G. Capadose, R.E.

ONCE upon a time there was a little boy, who wanted to be a soldier. The moment that he had first climbed from his cradle, he was at the window watching the parade in the barracks near by and it was then that his ambition was born.

Each birthday and every Christmas, he was given a set of lead soldiers and by the time he was seven, his nursery put the battlefields of history to shame. There were soldiers in busbies and soldiers without busbies; soldiers in kilts and soldiers without kilts—that is, with trews, rather; there were soldiers on horses and soldiers on motor bikes; everywhere there were soldiers. And equipment too —where there was personnel, there was also *matériel*; many a kind aunt had entered the house bristling with warlike stores; many a peace-loving spinster had crossed the threshold with guns, tanks, and such things as searchlights concealed about her person.

Then the little boy grew up and he had to set aside his arrows of desire and to start considering those of outrageous fortune and take up arms against a sea of troubles. He went to school, in fact. Before very long, he discovered that under certain circumstances $a + b = c$ —very illuminating! But it wasn't quite the same thing as playing with his multi-coloured militia. Every day he was informed about more and more weird and wonderful things and a short while after he learnt that in certain cases, $a^2 + b^2 = c^2$.

Many, many, months passed by and numerous blackboards had been filled with the most obscure hieroglyphics in front of his eyes; this was all most disconcerting, of course, to his working out plans for leaden campaigns, the draft of which could generally be found on his blotter.

Five long years went by and the little boy had gained much knowledge from his exacting pedagogues who still hampered in no inconsiderable way his military activities; they had even taught him that $a^2 = b^2 + c^2 - 2bc \operatorname{Cos} A$. But a great thing now happened; he donned a uniform and strutted out on to a parade ground, one mass of puttees. A soldier at last? No, but he was in the O.T.C. which was indeed no small step in the right direction.

However, the Mind Mathematick had no intention of losing his services so soon and after a brief afternoon's glory, he was seized and told that the integral of $2a$ was a^2 plus a constant—a most disturbing thought.

For four years more they tortured him with figures and had impressed upon his mind things quite beyond the scope of this printing press. They even sent him to Cambridge for six months where he was advised of things so complicated that they entered the realms of fantasy and the supernatural. The only redeeming feature there being that he was allowed to parade twice a week with the S.T.C. How he revelled in those khaki-clad afternoons !

But all horrors come to an end, and the little boy, now no longer a little boy, at last achieved the wish he had formulated when he hopped out of his cot for the first time. He was a soldier. He marched fast and furiously through his primary training and his Corps training—oh what joy ! a mere speck in time and that was over. He learned how to clean a bayonet scabbard and a pair of boots and after this arduous but enthralling instruction, he was deemed fit to command men, and was commissioned.

How he loved this soldiering. It seemed that no time at all had passed from the day that he had boarded a ship and sailed into his paradise—an outpost of the Empire—to the day when he considered he was really dug in with all the amenities that the life military could afford him. Now he could really claim with dignity and pride, " I say unto one 'come,' and he cometh ; to another 'do this' and he doeth it ; and to yet another 'here's to you' and he here-ith to me." This was it ! And how he enjoyed it. Many moons rose and set over the warm twinkling waters which peeped through the gracefully swaying palm trees—all was bliss.

But then the terrible thing happened. He had gone down to the club for a Saturday lunch-time round of gin ; that had been great fun. He had his lunch and as was his wont, he selected a large low armchair in which to snooze away the afternoon and the gin. Having floated off into oblivion, a most ghastly dream came to him. It was all confused as dreams generally are but he was back at school and was being taught that $a + b = c$ and $a^2 + b^2 = c^2$ and $a^2 = b^2 + c^2 - 2bc\mathrm{Cos}A$ and even that the integral of $2a$ was a^2 plus a constant and all the frightful things that now hung vaguely from the shelves of his memory like spiders' webs. He saw interminable rows of blackboards, but in the middle of slumber, the schoolmaster's writing on them looked like soldiers that he had met somewhere and his schoolmates looked like more of them and they all seemed to be armed with funny little short canes. How soul-shattering, the endless nightmare was.

All this might not have been so terrible, but the true horror revealed itself when he came to and discovered that it wasn't a dream at all but that he was on a Supplementary Course at Chatham.

PAULIN-LINED RESERVOIRS

By LIEUT.-COLONEL E. H. IEVERS, R.E.

(Owing to lack of a better word, "paulin" is used to denote a closely woven canvas sheet either tarred, rubberized, or otherwise treated or untreated.)

INTRODUCTION

MY first experience of a paulin-lined dug reservoir was when ordered to provide one in a large field between Aldershot and Salisbury Plain in readiness for watering men and horses of a brigade group which was to stage there. The only water supply available came through a long length of $\frac{3}{4}$-in. tubing to a cattle trough, and it was decided to start filling a dug reservoir four days before the brigade group was due, in order to be able to supply the sudden heavy demand expected.

I was told that a 30 × 30 ft. tarpaulin would be available and I asked for advice on the dimensions of the reservoir. I received some such reply as "I don't really know, but I suggest you make it about 3 ft. deep."

My next experience with dug reservoirs was on the North West Frontier of what was then India. A two-company post was to be established and it was hoped to obtain its water supply from a tube well to be sunk to a water bearing stratum about 400 ft. below. During the drilling of the well, all water required would have to be brought in tanks, placed in lorries, from a source over five miles away and stored at the post in paulin-lined reservoirs (see photos opposite). I was issued with two 30 × 30 ft. waterproofed sheets and told to construct two reservoirs as soon as the perimeter of the post was complete.

I again repeated my request for advice on dug reservoirs and I received an answer like the previous one. The reservoirs were made 3 ft. deep and taken into use at once, part of the 3 ft. depth being in excavation and the remainder being the height of the banks formed by the excavated earth.

When I had done a lot of tedious calculations, I found that the two reservoirs, which were used in that particular post for several months, were both wasteful of valuable ground space within the perimeter, and if they had been correctly designed they would have held more water in a reduced area.

Lorry convoy discharging 400-gallon loads into a paulin-lined reservoir.

Water lorry just emptied into a paulin-lined reservoir.

Paulin is anchored to angle-iron pickets, which carry barbed wire surrounding the reservoir.

Paulin-Lined Reservoirs

RESEARCH

When I first met this problem, I consulted M.E. Vol. VI (1922) and was pleased to find a section on "Dug reservoirs." My hopes fell when I found that this contained nothing more useful to me than the remarks "tarred sailcloth sheets with an earth backing will stand a head of five feet of water for months," and "the sides are made with a slope, which will depend on the natural angle of the soil." Plates at the end of the book included one of a 40 × 20 ft. sailcloth, sheet storage reservoir only 2 ft. 6 in. deep, and one of a sunken tank formed from a waterproof sheet in an excavation with vertical sides. These discredited both the extracts quoted from the section on the subject. I thought it was a pity that adequate information on the design and preparation of paulin-lined storage reservoirs was not readily available for R.E. Officers.

After I had spent much time on the problem and produced what I considered to be a useful simple rule covering all cases, I initiated a recommendation through the correct military channel that the result of my labour should be included in an appropriate R.E. Manual. This did not get very far; presumably because the busy military channel would have become strained if it had tried to pass the original researches of a subaltern, which included many pages to prove the simple resulting answer.

I then hoped in due course to elaborate my results into an article including notes on methods of construction with time and labour figures. But each time I tried to collect the practical results I wanted, the work got interrupted.

M.E. Vol. VI (1936) included a new table (Table XII) giving "Capacities of canvas-lined reservoirs" formed from 30 × 30 ft. paulins. This table, if studied, makes apparent the great waste of available storage capacity when such reservoirs are made too shallow, or with incorrect slope of sides.

R.E. Supplementary Pocket Book No. 6, 1946, reproduces this somewhat elaborate table under a new title "Capacity of Tarpaulin Dishes."

INFORMATION REQUIRED

One wants to know how to obtain easily the dimensions of a reservoir to provide maximum storage capacity from the given paulin with which it is to be lined. Many people when presented with this problem will say at once "you will obviously get maximum capacity if you make the sides vertical," but they are wrong. If a flat canvas paulin is used to line a reservoir dug with vertical sides, there is a very large " pig's ear " of spare canvas wasted at each corner. On the other hand, if the sides are sloped, the amount of canvas spare in each corner is less and the capacity of the reservoir is greater, unless it is made shallow like a dish.

Any shape and size of paulin may be used to line a dug reservoir, but in detailed calculations, 30 × 30 ft. paulins have been assumed. This is the largest size listed in the Vocabulary of Ordnance Stores, and is the one most commonly used for this purpose. Moreover, reservoirs lined with paulins more than 30 ft. wide, of the theoretically best depth, would be getting too deep.

In any particular case, the unknowns are the depth, and the length of the sides of the top and floor of the reservoir, which are inter-dependent on the slope of the sides. These can be determined by calculation, but there are of course practical considerations besides the mathematical ones.

Determination of Dimensions for Maximum Capacity

If we assume a square paulin lining a reservoir with sloping sides, the volume of the reservoir will be the difference between the volumes of two pyramids. We can calculate what any one dimension should be, in terms of the angle of slope of the sides, for maximum volume. See Fig. 1, on page 210, and the results noted below it.

If you find yourself alone in a restaurant where the service is slow, on the back of two menus you may obtain these results.

From these results we can deduce the dimensions which will make the volume of a reservoir a maximum for any particular angle of slope of the sides, and calculate the volume. (I do not recommend this in restaurants !)

For practical reasons L must be taken as the effective length rather than the total length of side of the paulin. Paulins usually have eyelet holes along each edge and when these are attached by cords to pickets, sandbags or stones, there is a sag in the edge of the paulin between the attachments. Besides it is not practical to have a reservoir brim full. Hence maximum practical storage capacity cannot reach more than up to within a foot of each extreme edge of the paulin measured on the sloping sides. The *effective length* of side of a square paulin should therefore be taken as the total length of side less 2 ft., or less whatever allowance may be decided upon.

Table 1, on page 209, shows results worked out for reservoirs formed from 30 × 30 ft. paulins taking L as 28 ft., with different angles of slope of their sides.

TABLE 1

Values of z, x, in Fig. 1, and the maximum capacities of reservoirs formed from square paulins, for different angles of slope of the sides, when L = 28 ft.

Slope	Angle of Slope	z	x	Capacity in gallons
	22°	10′ 8″	4′ 0″	6,530
	30°	9′ 4″	4′ 8″	9,460
3/4	36° 52′	8′ 6″	5′ 1″	10,560
1/1	45°	7′ 7″	5′ 5″	11,410
4/3	53° 8′	6′ 11″	5′ 6″	11,760
3/2	56° 19′	6′ 8″	5′ 6″	11,820
	57°	6′ 7″	5′ 6″	11,820
	58°	6′ 6″	5′ 6″	11,820
	60°	6′ 4″	5′ 6″	11,820
2/1	62° 26′	6′ 1″	5′ 5″	11,760
Vertical	90°	4′ 8″	4′ 8″	10,130

Graph 1, on page 211, shows how the maximum capacity of any such reservoir varies with the slope of sides.

From these results it is seen that the maximum capacity of a square paulin-lined reservoir is obtained when the slope of the sides is between 4/3 and 2/1 and that between these limits the variation is negligible.

Graph 2, on page 212, shows how the depth for optimum capacity varies with the slope of the sides. It may be noted that the depth should exceed 4 ft. in all cases where the slope of sides exceeds 22 deg. (approx. 1 in $2\frac{1}{2}$).

Practical Formulae for use with Square Paulin

Now it is desirable (*i*) to have the sides of the reservoir sloping at the minimum angle of slope which gives approximately maximum capacity, (*ii*) to have simple practical formulae from which the best dimensions for a reservoir from any size of paulin can be easily determined, or better still, (*iii*) to have a simple rule which can be remembered and from which the required dimensions can be worked out, (*iv*) to adopt a slope which is one of those marked on the Field Level (Levels, F.S.Mk. IV—4 ft. with spirit level), so that this can be used conveniently to check the slope of the sides of the excavation.

Most fortunately, all the above desiderata are satisfied when the sides slope at 4/3. Using the symbols shown in Fig. 1, Table 2, on page 213, shows in the same terms the dimensions for maximum capacity of a reservoir whose slope of sides is 4/3.

RESERVOIR USING A SQUARE PAULIN, LENGTH OF SIDE L FEET

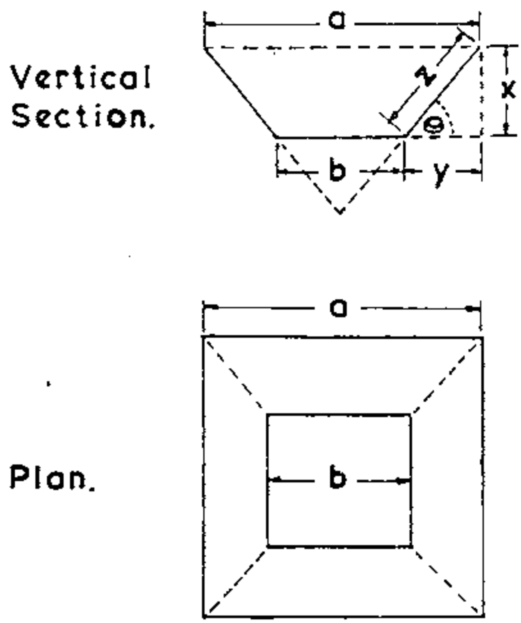


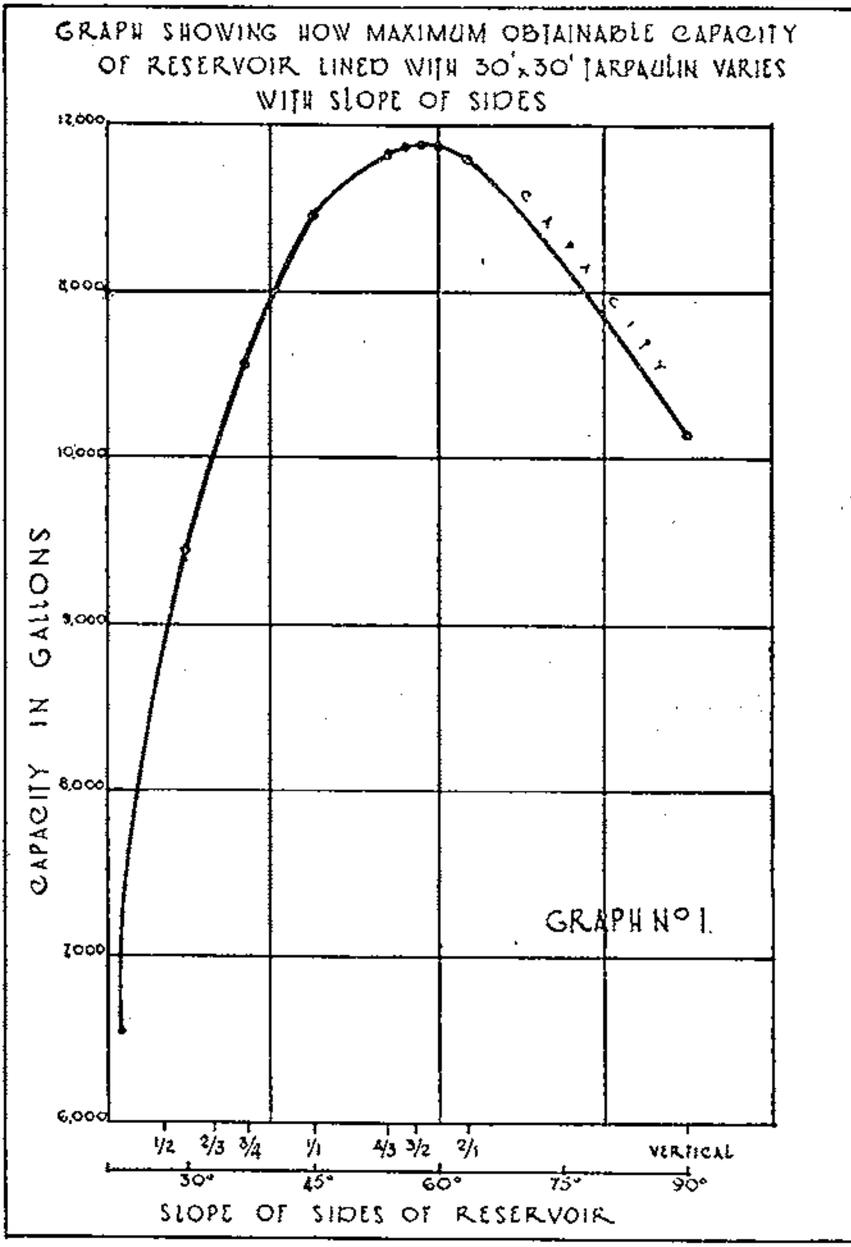
Fig. 1.

$b + 2z = L$ [a. b. x. y. z. L. in feet]

Volume of reservoir $\frac{\tan\theta}{6}\left(a^3 - b^3\right)$ cu. ft.

For maximum volume:—

$$z = \frac{L\left(2 - \cos\theta - \sqrt{1 - \cos\theta}\right)}{2\left(3 - 3\cos\theta + \cos^2\theta\right)}$$


GRAPH SHOWING HOW MAXIMUM OBTAINABLE CAPACITY OF RESERVOIR LINED WITH 30'x30' TARPAULIN VARIES WITH SLOPE OF SIDES
12,000
11,000
10,000
9,000
8,000
7000
6,000
CAPACITY IN GALLONS
CAPACITY
GRAPH N° 1.
1/2
2/3
3/4
1/1
4/3
3/2
2/1
VERTICAL
30°
45°
60°
75°
90°
SLOPE OF SIDES OF RESERVOIR

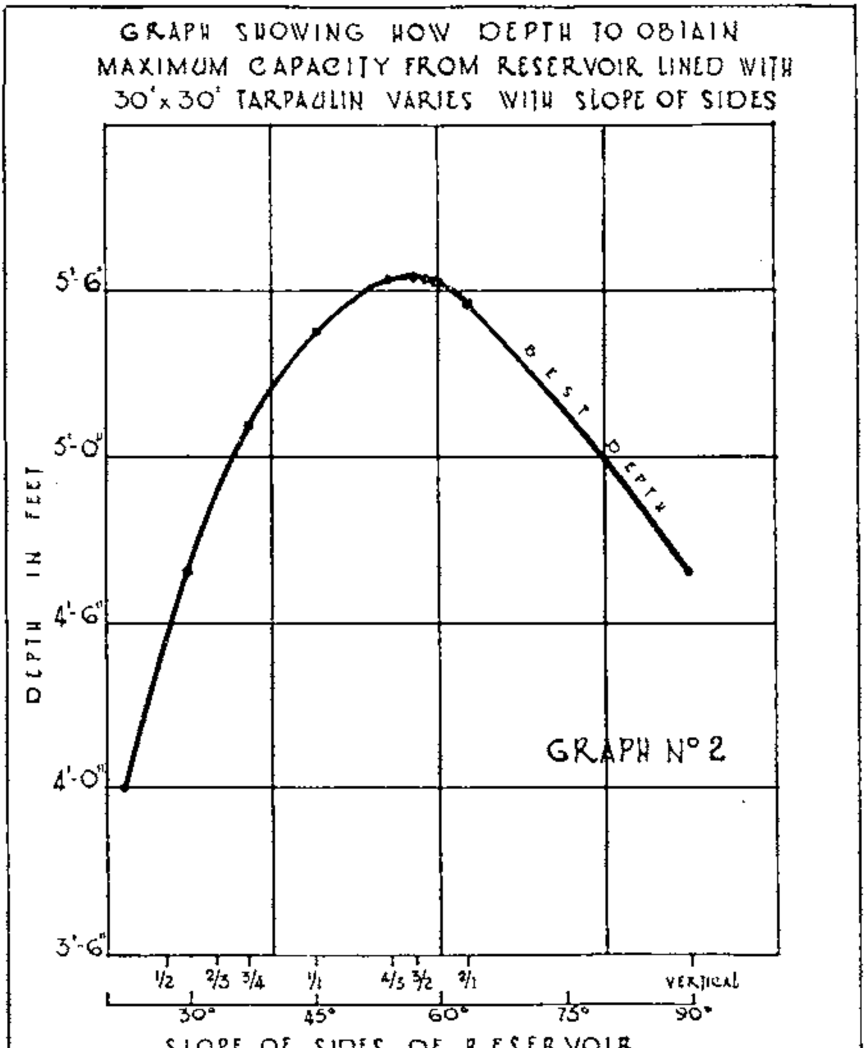

GRAPH SHOWING HOW DEPTH TO OBTAIN MAXIMUM CAPACITY FROM RESERVOIR LINED WITH 30'x30' TARPAULIN VARIES WITH SLOPE OF SIDES
5'-6"
5'-0"
4'-6"
4'-0"
3'-6"
DEPTH IN FEET
BEST DEPTH
GRAPH No 2
1/2
2/3
3/4
1/1
4/3
3/2
2/1
VERTICAL
30°
45°
60°
75°
90°
SLOPE OF SIDES OF RESERVOIR

TABLE 2

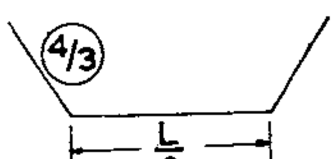
Dimensions for maximum capacity of a reservoir with sides sloping at 4/3 lined with a square paulin whose effective length of side is L.

Dimensions	Values in terms of L	
	As calculated	Practical approximations
z	L/4.065	L/4
x	L/5.081	L/5
b	L/1.969	L/2
a	L/1.245	4L/5
Capacity (when L is in feet)	$\frac{L^3}{1.867}$ gal.	$\frac{L^3}{2}$ gal.

Now there is no need for an officer to bother about even the simple formulae shown in the right hand column of Table 2. It is merely necessary to remember that the **length of the floor of the reservoir should be L/2, and sides of the excavation should slope at 4/3.** When the floor of the reservoir is L/2 the effective length of paulin up each side must obviously be L/4 and the other dimensions can be easily worked out by solving the 3, 4, 5, triangle.

It will be easy to remember also that the *capacity* of such a reservoir will be rather more than $\frac{L^3}{2}$ **gallons.**

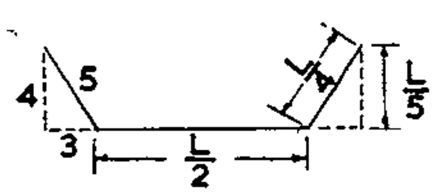
All that need be remembered :—



Capacity is $\frac{L^3}{2}$ gallons

Fig 2.

Working out dimensions.



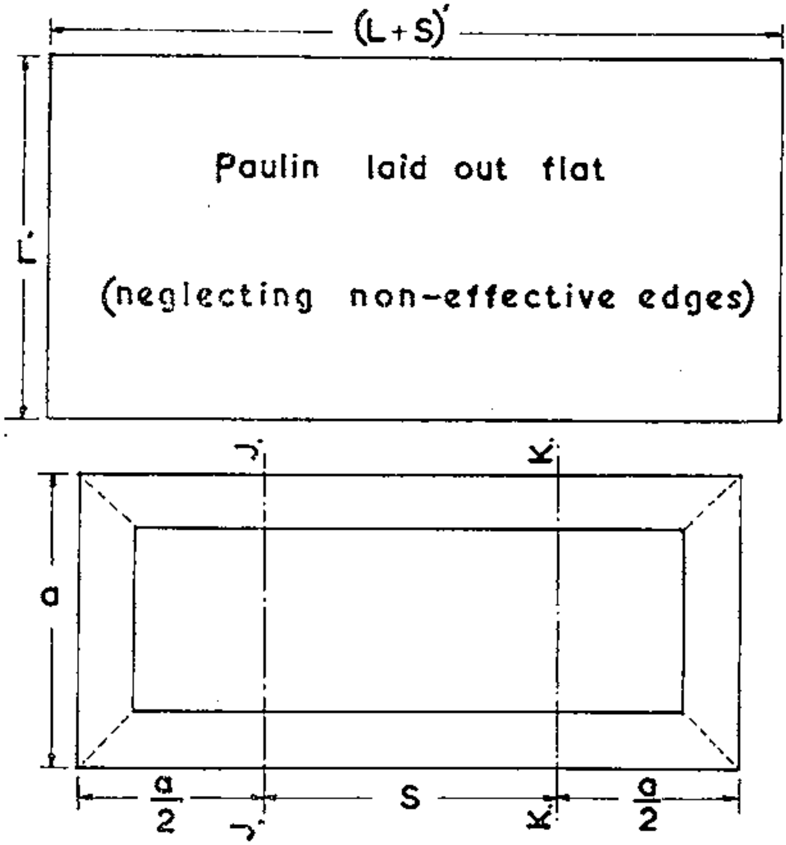
Sloping side forms hypotenuse of a 3, 4, 5 triangle. Effective length of paulin is L and length on floor of reservoir is L/2, hence length up each side equals L/4. Hence depth must be L/5.

Fig 3.

Rectangular Paulins

So far we have considered only the best use of a square paulin. Although large square black tarpaulins, or white specially prepared canvas sheets, may be obtained from Ordnance, sometimes tarpaulins or paulins obtained from other sources, or canvas canopies from vehicles may be used, and these may be rectangular. Also a rectangular paulin may be produced by joining together two or more square paulins.

RESERVOIR USING A RECTANGULAR PAULIN, LENGTHS OF SIDES L AND L + S FEET



Plan: Reservoir lined with Paulin.

Fig 4.

Fig. 4 shows a paulin-lined reservoir formed from a rectangular paulin. The vertical sections of this reservoir at J–J or K–K are assumed to be dimensioned in the same symbols as shown in Fig. 1.

To arrive at the capacity of such a reservoir, it is convenient to regard the ends, beyond the sections J–J and K–K, as together forming a frustum of a pyramid (as already calculated), and the centre portion as forming a frustum of a prism.

As regards the capacity of the two end portions—we have already seen that this is a maximum of $\frac{L^3}{2}$ gallons when the sides (and ends) slope at $\frac{4}{3}$.

As regards the intermediate portion, S ft. long, we can calculate that for maximum volume, $z = \frac{L}{2(2 - \cos\theta)}$, and the maximum volume will be $\frac{L^2 \sin\theta}{4(2 - \cos\theta)} \times S$. Hence it will be found that the maximum capacity of the intermediate portion will be when its sides are sloped slightly more steeply and its depth is slightly greater (and width on floor of the reservoir correspondingly less) than the end portions.

Practical considerations smooth away this difficulty. If the width of paulin overall is 30 ft. (28 ft. effective) then the best depth of a square reservoir, such as is formed by the two end portions is $L/5 = 5.6$ ft. Since this can in fact be regarded as about a practical maximum, it follows that it must apply to the intermediate portion as well as to the ends of rectangular reservoirs formed from large paulins. If the paulin is a small one, then the difference in volume which the correct depth would make is negligible.

The practical result therefore is that, with a rectangular paulin, L should be taken as the effective length in feet of the shorter side and the cross section designed as for a square paulin. If S feet is the difference between the effective lengths of the longer and shorter sides of a rectangular paulin then the capacity of a reservoir lined with it could exceed $\left(\frac{L^3}{2} + \frac{3L^2 S}{4}\right)$ gallons.

Revetted Banks

The paulin is usually supported partly by the sides of the excavation and partly by the surrounding banks formed from the excavated earth. Although the sides of the excavation will stand at 4/3 in most cases, the natural angle of repose of the excavated soil will be less. Hence in order to obtain the maximum capacity the excavated soil must be revetted.

If the walls of such a reservoir above ground are formed of sand bags as shown in Fig. 5, on page 216, or otherwise suitably revetted, excavation of half the total depth will produce enough earth to provide the surrounding walls with requisite height above ground level.

RESERVOIR WITH REVETTED BANKS

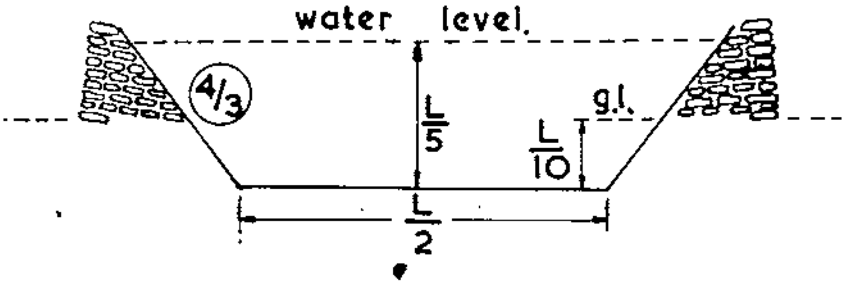


Fig 5.

RESERVOIR WITH UN-REVETTED BANKS

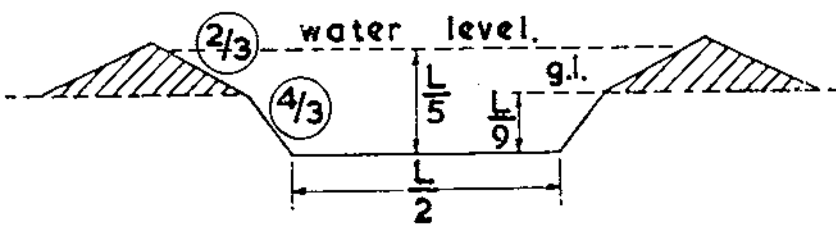


Fig 6.

UN-REVETTED BANKS

If the sides of the reservoir are not revetted, they will slope at their natural angle of repose. Unless this is as steep as 1 in 1, the capacity of a square reservoir will be less than $\frac{L^3}{2}$ gallons. Moreover, excavation of only half the total depth will not produce enough soil to build the surrounding banks to the required height.

If, for example, the natural angle of repose of the soil is 2/3, then, in order that the excavation may produce enough earth for the banks, its depth should be slightly greater than half the total, as shown in Fig. 6 above.

(The calculations for this are laborious, no simple general formulae can be arrived at, and cases of each different angle of repose have to be worked out separately.)

It will be seen in Fig. 6 that the excavation is dug to L/9. When L is in feet, the capacity of such a reservoir will be $\frac{9L^3}{20}$ gallons.

Those who like to be mathematically meticulous will realize that though L/2 is the correct width of floor of a reservoir which has the sides sloping throughout at 4/3, when the angle of the slope of the upper part of sides is different, the best value for width of floor will also differ. The difference is very slight, and besides being an easy figure to remember and work to, L/2 width allows for the banks being subsequently revetted to obtain the maximum capacity.

Excavating

A reservoir formed from a single 30 × 30 ft. paulin, being only 14 ft. square on the floor, 5 ft. 6 in. deep, and having all four sides sloping steeply, cannot suitably be excavated by any mechanical plant commonly available in field units. Such a reservoir designed for maximum capacity must be excavated manually.

If a number of paulins are joined together to form a rectangular paulin, then most of the excavation might be done by a dozer, but its entry and exit at the ends will not be steep enough. Hence either some capacity must be sacrificed, or manual labour must be used to steepen up the ends. In any case labour will be needed for filling and laying sandbags, if full capacity is developed.

Conclusion

The foregoing research originated from an officer not being content merely to do what he had been told, but desiring to ascertain the right answer to what he might have been told.

It is fortunate that the answer can be expressed as simply as in Fig. 2, and so 11,000 gallons may be contained in what might otherwise be a 5,000-gallon dish.

GENERAL SIR GEORGE M. KIRKPATRICK, K.C.B., K.C.S.I.

GEORGE MACAULAY KIRKPATRICK was born in Canada on 23rd August, 1866, and was the son of Sir George Kirkpatrick, K.C.M.G., Lieutenant-Governor of Ontario.

He was educated at Trinity College School, Port Hope, Canada, Wilkinson's Preparatory School at Clifton, and Haileybury College, and passed into the Royal Military College of Canada at Kingston in 1882.

From 1881 one commission in the Corps had been given annually to a cadet from the R.M.C. Kingston, but a war scare in 1885 found the Royal Engineers short of officers, and so five extra commissions were offered that year to Kingston. Kirkpatrick, then in the 2nd class, was selected for one of these, and was gazetted to the Corps on 30th June, 1885, being the junior of a batch, of which Stairs (who was also a Canadian, and who died in Africa on exploration) was the senior.

"J.E.E." writes: "Tall, good looking, with a charming manner and an attractive burr in his voice, and a fine horseman, he immediately became popular, and as 'Kirk,' well beloved by those who served with him. The number of important posts which he, a stranger with no political or social influence, held, is sufficient testimony to his outstanding abilities and judgment."

After two years at the S.M.E., he did some special service at Colchester, and was then posted to the 23rd Field Company at Aldershot. His brother Subalterns were H. B. Williams (later Major-General Sir Hugh B. Bruce-Williams) and H. A. Livingstone (later Major-General Sir Hubert Livingstone).

After a three years' tour with the 23rd Company, he was posted to the 15th Company at Gibraltar in 1890. While there he was sent on a special mission to Fez in 1892, with H.B.M's. Minister in Morocco, and on return he was appointed A.D.C. to the G.O.C. Thames District.

In 1894 he passed into the Staff College and was in the same batch as H. A. Lawrence (later General Sir Herbert Lawrence and C.G.S. in France during the 1914–18 war) and F. S. Maude (later General Sir Stanley Maude of Mesopotamia). He was Secretary of the Staff College Drag and in 1895 he won the R.E. Heavyweight Point-to-Point race—the Lindsell Cup.

On the conclusion of the Staff College Course in 1896 he married Mary Lydia, the daughter of J. F. Dennistoun of Peterborough, Canada. She died in 1945.

General Sir George M. Kirkpatrick, KCB KCSI

In 1897 he was posted to Malta, to command the 42nd Company R.E., and to be the Staff Officer R.E. The Cs.R.E. were first, Colonel E. Wood (later Major-General Sir Elliott Wood) and second, Colonel H. Settle (later Major-General Sir Henry Settle).

In 1899, Kirkpatrick took his company from Malta to South Africa, where it was employed on railways. He himself was posted to the Staff as a D.A.A.G. (Intelligence). In this capacity he served throughout the war, being successively Intelligence Officer to the Mounted Infantry under Sir Ian Hamilton and Sir Archibald Hunter and Chief Intelligence Officer in the Orange River Colony, in which capacity he took the Free State delegates to the conference at Vereeniging.

In 1902 he was appointed D.A.Q.M.G. on the Staff at Halifax, Novia Scotia. The Imperial troops were still there. By this time the Boer War had brought Kirkpatrick promotion, and he was a Captain R.E. and Brevet Lieut.-Colonel.

In 1904 he was transferred to the General Staff at the War Office in the Intelligence Division, under Colonel Charles Callwell and Major-General Sir James Grierson. During this appointment he visited the Antipodes on duty.

He left the War Office in 1906 when Lord Kitchener offered him the appointment of A.Q.M.G. at his Headquarters in India. He joined at Simla in October, 1906, to take charge of the newly formed strategical branch at A.H.Q., and also to be Secretary of the Indian Defence Committee. He was promoted Brevet Colonel.

In 1909, Lord Kitchener took him as his Staff Officer to Australia, whose Government had invited him to advise them upon their military organization and how best to introduce the universal military training which was the policy of the Government.

The visit covered New Zealand, whose Government had also invited Lord Kitchener, and lasted from November, 1909, until February, 1910. At the end, both Governments decided to adopt Lord Kitchener's recommendations as set forth in a memorandum. The Government of Australia asked for Kirkpatrick to be their Inspector General, to advise them as to the introduction of the recommendations.

Accordingly, in May, 1910, Kirkpatrick arrived in Melbourne and for the next four years was actively employed in assisting the Minister and the Australian Military Board to initiate universal and compulsory military training for cadets from the age of 14, and adults from the age of 18–24.

He was promoted substantive Colonel, and given the temporary rank of Major-General while holding this appointment. He received the C.B. in the Coronation Honours of King George V.

Towards the end of his four years in Australia he was offered, and accepted, the appointment of Director of Military Operations at Army Headquarters, India. Accordingly, after four months' leave in England, he joined at Simla in June, 1914.

He remained on the strength of Indian Army Headquarters throughout the 1914–18 war, although he was at different times in five theatres of operations. In 1916 he became Chief of the General Staff in India, with the temporary rank of Lieut.-General. He had been promoted substantive Major-General in the Birthday Honours of 1915.

In 1919 he came home on leave pending the expiration of his four years as C.G.S. in 1920, when he went on half pay and reverted to Major-General. He had received the K.C.S.I. in the New Year's Honours of 1917 and the K.C.B. in 1918.

In 1920 he was appointed G.O.C. in China, and arrived in Hong Kong at the end of that year. The year 1921 saw him touring China and attending the combined naval and military manœuvres in Japan. In September he was promoted Lieut.-General and accordingly vacated his command early in 1922.

After a period of half pay, he was appointed G.O.C.-in-C., Western Command in India, taking up his post at Quetta in June, 1923. Upon the termination of this appointment in 1927 he was promoted General and went on half pay.

In 1927, he was appointed Colonel Commandant Royal Engineers. In 1930, after three years' unemployment he was placed on retired pay; and in 1933 he reached the age limit for the Reserve of Officers.

In 1934 and 1935, he was Representative Colonel Commandant R.E., in which capacity he led the R.E. at King George V's Jubilee Review at Aldershot. Although Colonels Commandant were due to retire at 70, his tenure was extended until he was 73, and he was finally retired on 23rd August, 1939.

He died at Roehampton on 6th February, 1950.

(*Note.*—This memoir has been compiled almost entirely from details supplied by Sir George Kirkpatrick before his death.)

BRIGADIER E. BRADNEY, D.S.O., O.B.E.

EDWARD BRADNEY was born on 20th June, 1889, son of Sir Joseph Bradney of Tal-y-coed Court, Monmouth. Educated at Clifton and the Royal Military Academy, he was commissioned in the Corps on 20th September, 1909. After the normal Chatham Course he embarked for India in 1911, and served as Garrison Engineer at Ahmednagar and Belgaum till September, 1913, when he joined the Q.V.O. Madras Sappers and Miners and was posted to 13 Field Company at Bangalore. Thus began a connexion with that Corps which was to last, with only two breaks, till 1937, by which time he had served for twenty years with the Madras Sappers.

In April, 1914, 13 Company moved to Rawalpindi and it was not until November, 1915, that it was ordered to Mesopotamia under Bradney's command. Here the company took part in the initial stages of General Aylmer's operations to relieve Kut. Bradney was mentioned in despatches and received the brevet of Major.

Invalided in 1916 he returned to Bangalore and became Adjutant of the Corps, an appointment which he held till September, 1918.

After a period of home leave he was posted to the command of 9 Field Company in Mesopotamia (April, 1920). During the Arab Rebellion, Bradney was awarded the D.S.O. for an exploit at Tuwairij, when he and his sappers were largely responsible for the capture of the boat bridge which the rebels had set on fire.

In April, 1921, Bradney returned to Bangalore with 9 Field Company, but he was soon on the move again. In October he took 13 Field Company to Waziristan, where he spent the next two years, and was twice mentioned in despatches.

In December, 1923, he was appointed Military Adviser to the Indian State Forces, and in this capacity dealt with many small Sapper Units in Indian States from his Headquarters at Roorkee. He was largely concerned with efforts to improve the general administrative efficiency of these units and the conditions of service of the men.

In February, 1927, he returned again to the Madras Sappers at Bangalore as Superintendent of Instruction, which appointment he held until he reverted to the home establishment in March, 1931. At home he served as D.C.R.E. at Sheerness and Hounslow until he returned to India again in December, 1932, to command the Madras Sappers and Miners.

Bradney commanded the Madras Sappers for nearly five years, in which time he was able further to develop in that Corps his ideals of orderly administration and training. He had married in 1932 and Mrs. Bradney's interest in family welfare led to great advances in the care of the Indian families.

He was promoted Colonel from 1st October, 1937, and after a short period on half-pay became Officer i/c R.E. Records, from 1938–41. This period saw the vast war expansion and the move of the Records from Chatham to Brighton.

His next appointment was on the staff of the E.-in-C. in India, at New Delhi, as Director of Personnel with the rank of Brigadier. By his previous experience and temperament he was singularly fitted to cope with the complex problems of those times and his work throughout that period was truly invaluable.

Mrs. Bradney who joined him at Delhi in 1941 gave much of her time and care to the Burma refugees in 1942. She had had much illness and to the great grief of her husband and many friends died suddenly that winter.

Bradney continued his work in Delhi until he retired in April, 1947, having been awarded the O.B.E. in 1946.

In retirement he remarried, but was not long to enjoy his home in the Round House, Withdean, with the barge *Sidwell* as mobile quarters. He died on board the *Sidwell* on 29th October, 1948.

To his many friends remains the memory of a man of honesty and tenacity of purpose and most entertaining cynical humour. Their sincere sympathies are with his widow who gave him such devoted attention in his last illness.

J.F.D.S.

BOOK REVIEWS

THE BATTLE OF AMIENS 1918

By LIEUT.-COLONEL A. KEARSEY, D.S.O., O.B.E., *p.s.c.*

(Published by Gale & Polden Ltd. Price 7s. 6d.)

The title of this book is extremely misleading because out of seventy-three pages only thirty-one have much bearing on this very interesting battle. Lieut.-Colonel Kearsey starts with a description of the German offensive of the spring and summer, 1918, showing how Ludendorff whittled away his valuable reserves by attacks launched at far separated points ; attacks which in each case surprised the Allies and the Germans themselves, throwing the latter off their balance and allowing the defences to close. When the turn of the Allies came, Foch learning from the mistakes of Ludendorff, used the method of limited and convergent offensives which exploited only success.

What the author fails to emphasize sufficiently is the effect of the ever-increasing flow of American divisions to the Allied front. The British offensive by Rawlinson's Fourth Army is well, but rather briefly, described and it is a pity that the maps at the end of the book are not easier to follow. Having brought the reader to the end of the British offensive before Amiens, however, the author appears to have improvised in order to complete the book, because, out of the blue, one is faced with a list of questions, most of which are in no way related to the subject matter. There then follow some general notes for the solution of these questions and the answers themselves.

Indeed, it is an extraordinary technique for writing military history, especially when the reader has to wade through a mass of place-names without the aid, in most instances, of any maps. The last of these questions invites the reader to illustrate the principles of war ; surely the military historian, as well as the commander in the field, should maintain his object.

It is difficult to recommend *The Battle of Amiens 1918* to a student of military history.

S.E.M.G.

SECRET FORCES

By F. O. MIKSCHE

(Published by Faber & Faber. Price 15s.)

The author of this book held office in de Gaulle's Secret Service and its contents justify the publisher's claim that he is an expert in the field of underground warfare.

In the Introduction he himself gives a good summary of the book's four chapters. In essence, this reads " The first gives a historical outline of the subject with emphasis on the importance which Marxists attach to People's Wars. The second deals with strategic elements of the People's War, its dependence on the operations of the Regular Armies, and various factors such as terrain, political situations, traditions and characters of the people involved. The third chapter deals with the tactics of underground warfare, such as intelligence, propaganda, sabotage and open fighting. The last chapter contains an analysis of defence against underground activities."

In the Introduction he also says, " Some of the statements and ideas in this book may appear to be truisms." They do so appear, but only in the same way as F.S.R.II was crowded with truisms. He justifies himself with the words, " In order to explore the unknown, one has to lean on the known and established facts " ; he might equally have justified himself by saying that he had made his book particularly suitable for study by young officers. It is, for instance, a truism that " underground warfare has become as much a part of modern warfare as armoured divisions," but, like many apparently platitudinous sentences in F.S.R.II, it is worth writing down, so that it may be not only read but pondered. This is not to suggest that the book reads like a manual, but merely to emphasize that it deals with its subject from basic principles.

To illustrate that the book is worth study by regular officers, this extract may be quoted :—

> " When General Bugeaud took command of the French troops fighting the guerillas of Abd-el-Kadr, he made a speech to his Officers beginning ' You will have to forget a great deal.' "

Those trained in regular warfare might easily be well " off-net " against irregulars, or in co-operating with them.

The chapter on defence against underground activities is a very short one ; its length should not be taken as a measure of its merits. As it so rightly says, " action against them should be taken principally in the political field," but there is much in it for soldiers. For example, there is quoted an order by a German Chief of Counter-Guerilla which is well worth study for the principles behind it.

There is no specific mention of a method of defence well known on the Indian frontier. Where it is too costly in men to defend a route so that no raider can reach it, it may be possible with many fewer defenders to intercept them returning to their fastnesses, and so achieve the ultimate object by making the chances of " get-away " too risky. This form of defence might be useful against guerilla bands elsewhere, but its omission from the chapter is not a serious matter. There is ample stress on active defence, rather than merely to waiting to parry the blows.

The author writes, " this work offers nothing of a refreshing nature ; it is not written for that purpose," and he dedicates it " to those whose task is the freeing of Europe from the horrors of Communism, in the hope that those who are responsible for policies and armies will draw the necessary conclusions." Alas, soldiers may find themselves in circumstances where that hope has not been adequately realized. They are likely to be better soldiers for having studied this book.

R.E.B.

ILL MET BY MOONLIGHT

By W. Stanley Moss

(Published by George Harrup & Co. Ltd. Price 10s. 6d.)

When you are driven frantic by filling up forms, or by being passed through the usual channels, or by being dealt with at the correct level, then let me advise you to turn for refreshment to *Ill Met by Moonlight*. For it is a story of real adventure, and of real adventurers breathing the spirit of Elizabethan England. It is as thrilling as any tale of fiction and it is all true.

It is the tale, told in the first person, of the kidnapping from German occupied Crete in 1944 of the German General Kreipe. The expedition was led by Major Paddy Leigh-Fermor, assisted by Captain Moss of the Coldstream Guards, the latter keeping a diary which is here published as a book.

It tells of the landing on the island from a motor launch, of the growing excitement before the kidnapping; of the deed itself; of the reaction after it; of the long and trying journey across the island—one can almost feel the cold, the wet, the aching limbs and the flea bites—and of the return to Cairo, and the flesh pots. It is full of photographs taken during the expedition and it is illustrated by two maps.

One gets a vivid picture of the country and of the characters, both British and Cretan; and in a strange way one comes to pity and to dislike the German General, not without sympathy for him in his adversity. One meets some curious people in this underground warfare: Sandy Rendel —the polished and educated *Times* Correspondent—"in patched and ragged clothes . . . a bottle to his lips and liquor trickling down his chin . . . continuously scratching himself from top to toe." Then there are all kinds of picturesque Cretans—George, "Wallace Beery," Manoli, Zahari and others—two cheerful escaped Russian prisoners and one extremely unpleasant one.

Here one sees the genius of John Bull, unfettered by red tape and lavish with golden sovereigns. If you have any taste for adventure stories you cannot do better than read this one.

M.C.A.H.

THE GUADALCANAL CAMPAIGN

By MAJOR JOHN L. ZIMMERMAN, U.S.M.C.R.

(Published by Historical Section U.S. Marine Corps.)

When the First Marine Division (Reinforced) landed on 7th August, 1942, in the Solomon Islands they were making the first amphibious assault by United States forces in World War II. It was a heroic adventure and marked the turn of the tide in the Pacific War; for after that date, as the Deputy Chief of the Japanese Army Staff later admitted, the Japanese went permanently on to the defensive in the Pacific.

The purpose of the campaign was to prevent the Japanese from cutting the sea routes between America and Australia. The point of attack had to be chosen with a nice judgment. To attack too far north was to court defeat; to land too far south was mere passive defence awaiting Japanese attack. At Guadalcanal and Tulagi a correct balance was struck. The enemy was there, but not in such strength that he could not be mastered by the Americans.

None the less it was a hazardous operation. Both sides were supporting a dumbell at arm's length. Intelligence was scanty, maps were almost non-existent and charts were poor. There was considerable confusion in American planning which resulted in the troops having to "combat load" their ships in great haste and under adverse conditions in New Zealand. The troops went short of food on the approach voyage, two meals a day (and those so inadequate that some men lost over 20 lb. in weight) were all that could be managed. There was not complete agreement between the air forces and the Marines, nor was friction absent with the Navy. The rehearsal, ten days before the landing, was described by the Commander of the Marines as "a waste of time" and "a complete bust." Owing to misunderstanding with the Navy the transports were removed earlier after the landing than the General expected. Only one bulldozer was available for the airstrip. There were present in fact all the growing pains which we ourselves experienced at Dakar. But in spite of it all the Marines succeeded; and one realizes when one reads this official history what determination and ability were displayed by the junior officers and enlisted men.

The whole story of the campaign is told in the U.S. Marine Corps monograph *The Guadalcanal Campaign*. It is an easily read narrative considering the great detail in which every action is described. The photographs and maps give one a good idea of the nature of the fighting. It is a pity the book has only a paper back, for with its excellent print and numerous maps it must have been an expensive work to compile, and it is worthy of a better binding.

M.C.A.H.

IMPERIAL MILITARY GEOGRAPHY

By Brigadier D. H. Cole, C.B.E., Litt.D (Retd.)

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

Between the First and Second World Wars few officers studying for their Promotion Examinations neglected to buy a copy of Cole's *Imperial Military Geography*. Some of the more widely read, however, discovered that a succession of distinguished writers (including Mr. Winston Churchill) contributed every week to a Sunday paper a series of well-informed articles telling much the same story as Captain Cole but in a more diverting setting. The seekers after truth were thus divided into two schools: those who read Cole all night and those who read the Sunday papers only.

I must confess to having belonged to this second school; finding the reading of Cole tedious. His book was like the London Telephone Directory—accurate but heavy. It is, therefore, ironical that having surmounted all the promotion examinations without him I now must read Cole from cover to cover to review the 1950, or tenth, edition of his book.

Cole and his book have both grown up: the author is now a Brigadier (retired) and his book costs 24s. But *Imperial Military Geography* still has many of the qualities of its youth. It is still full of information; it still has excellent maps—the "Air Age Map" is particularly fascinating—and it is still up to date, having extracts of documents as late as August of last year.

In its present reincarnation I seem to find it much more readable—perhaps because I too have grown up—but it has developed a number of printing errors. A paragraph, for instance, on page 125 terminates in the middle of a word, the marginal note "Atomic Energy" on page 38 is opposite POPULATION and there are other misprints.

None the less, Cole still holds the field as the best book on his subject; and if officers are seriously in need of guidance and have access to the libraries they are more likely to find what they want in the present volume than anywhere else.

M.C.A.H.

BROKEN THREAD

By Major-General F. S. G. Piggott, C.B., D.S.O.

(Published by Gale & Polden Ltd. Price 21s.)

This book is the autobiography of a Royal Engineer officer distinguished in the field of Military Intelligence and relations with foreign countries, most notably with Japan. It is, however, a great deal more than an autobiography, and, to use the author's own words, "many of the events recorded are important milestones in Far Eastern history."

The "Thread" which, with "Interludes" spent chiefly in England on regimental and staff duties, runs through the author's military career in Japan, where he served successively as a language officer, on special duty studying the engineer arm of the Japanese Army, as a military attaché after the first World War, and again as military attaché for the four years preceding the outbreak of the second World War. During the "Interludes," the author's experiences and work were largely connected with the country he loved so well, and his participation in the Washington Conference of 1921 was largely due to his unrivalled knowledge of Japan and its military outlook. This period is dealt with in the chapter appropriately entitled "Knot Unravelled," which led directly to the termination of the Anglo-Japanese alliance.

The author's connexion with Japan started in 1887 when, at the age of four, he accompanied his parents to that country. He remained for four years in Japan and it was against this background that he, some thirteen years later, "picked up the Thread again" as a very young officer student of the Japanese language.

His arrival synchronized with the period of the Russo-Japanese War, from which the Japanese emerged, not only victorious, but as the premier power in the Far East. This dramatic rise in the world's estimation had justified, in Japanese eyes, the reliance which they had placed in the Anglo-Japanese alliance, which was first signed in 1902 and lasted with revisions and renewals until its termination in 1921. The alliance is almost the keynote of the book under review; its maintenance was one of the author's main objectives throughout the long years of his association with Japan, and its termination was one of the keenest disappointments of his life. He worked harder than ever during his two tours as military attaché in his attempts to induce leading personalities of both nations to renew this alliance, but in vain. With the end of the first World War the international situation had become so complicated, with the effects of the Russian Revolution on the one hand and the gradual turning away of the United States of America from its traditional policy of isolationism on the other, that it is problematical whether the alliance could have been renewed. Anyway, the rise of three dictatorships in Europe during the inter-war period, together with the ineptitude of the League of Nations, kept the eyes of our Foreign Office glued to Europe.

It is hardly surprising that interest in Japan declined in the minds of the British public who knew little of the conditions in, and the aspirations of, Japan. The author deals very fully with this aspect of our relations with that country, and it is clear that, whilst Japanese leaders of his own generation were sympathetic to, if not in full agreement with, his advocacy, the rank and file of the Army were growing more and more hostile towards the British, and the Army led the nation.

To those who are either interested in or ignorant of the real state of affairs in Japan during the past sixty or seventy years I can recommend this book for careful study. A great deal of it, as the author himself admits, deals with his personal experiences and his social activities, but these details dovetail into his story of Japan and help one to understand the human side of the problems with which he deals. His loyalty to his Japanese friends was unswerving and extended even to an attempt to help his friend of many years standing, General Homma, who in 1946 stood his trial for War Crimes, of which the United States Military Commission found him guilty. His affidavit which was placed before the Court is given in Appendix "A"; but to the author's great grief, failed to achieve Homma's acquittal.

The book is liberally illustrated and the writer's style makes for easy and pleasant reading.

J.R.E.C.

ALEXANDER GIBB, THE STORY OF AN ENGINEER

By Godfrey Harrison

(Published by Geoffrey Bles. Price 15s.)

The eminent consulting civil engineer, Sir Alexander Gibb, the hero of this book—for he is dealt with in a somewhat heroic vein—has had an unusually long engineering experience covering a golden jubilee of active work.

He received a commission in the Royal Engineers during the 1914–18 war, rising to the rank of Colonel. He was engaged mainly with docks and harbours on the grand scale, for which he was eminently suited, having recently completed, as contractor, Rosyth Dockyard just in time to ram home the fruits of victory after the battle of Jutland.

He has long been an honorary member of the Institution of R.E. and during the inter-war years did more than any other civilian engineer to obtain greater co-operation between civilian and military engineers, as he realized the prime necessity for this if another war were to eventualize. To this end he was very active and successful in breaking down the barrier which hitherto had prevented properly trained military engineers from being admitted as corporate members of the Institution of Civil Engineers, and thereby being able to come into close contact with their opposite numbers. This feature of Sir Alexander's co-operative work is not mentioned in the book as it would be of little interest to the general reader for whom the book caters, being written in a modern journalistic style, a feature being made of the character study rather than of the engineering details involved.

Nevertheless the reader is taken briefly through a long series of civil engineering works of very varied descriptions, carried out in many parts of the world, some quickly ended, others like Barking Power Station with its several extensions, covering over a silver jubilee of years. A little world map would be handy here, as there is considerable strain on one's geographical memory, despite the filips of a world war, and the cross-word puzzle. Sir Alexander led the fashion of world travel to see his engineering clients face to face, and although he flew but little he covered a lot of ground.

Gibb was a man of very wide experience. He had looked on life's problems from many aspects. Pupil to the leading consulting engineer of the day; resident engineer on heavy works; contractor for schemes culminating in the £2 million construction of Rosyth Dock—a terrific battle against time; a commission in the Royal Engineers; Government service under Sir Eric Geddes as Director General of Civil Engineering in the Ministry of Transport; Director of companies with world-wide interests; and, since 1922, consulting engineer with probably the biggest staff and practice in London.

Most men have, quite rightly, at least one hobby. The activities undertaken by Gibb outside his own very busy professional life would be sufficient to knock out an ordinary man, if indeed anyone would dare to undertake them. The Presidency of several Engineering Societies, including the senior one, the Institution of Civil Engineers, dovetailed into his professional work. Other activities—too many to list—included such variations as Freemasonry, in which he rose to the highest position then open to a commoner, President of the London Chamber of Commerce, membership of the Fine Arts Council, rearing of pheasants (as he was a great shot and liked to organize entertaining shooting parties), a good, if slightly impatient, fisherman, President of the Burns Federation, for he was a sincere Scot and a lover of poetry from his boyhood, President of the London Fife Association, Chairman of Queen Helena's College. These are but samples of his versatility. He threw himself body and soul into these extra tasks, partly because he loved to meet his fellow men and hear what their views were. Cabinet ministers, lords, commoners, working men. All were of supreme interest to him. He was a delightful host and very generous, friendly and versatile. Courageous in his engineering. Brave to a degree when hard hit by personal misfortunes in his later years.

The blow that he probably felt most was that when war broke out in 1939 he was laid up and therefore not able to take up any high Government engineering appointment, which his unique experience would have warranted.

RADIATIONS

By T. Bedford Franklin, M.A., F.R.S.E.

(Published by The British Society of Dowsers. Price 8s. 6d.)

The author has had long experience of dowsing phenomena and has studied the effects and their causes for many years. He was joint author with Dr. Cecil Maby of *The Physics of the Divining Rod* which was, at the time of its publication, quite the most authoritative book on the subject.

This book, *Radiations*, contains a clear and concise description of the electromagnetic spectrum and is therefore of interest to others besides dowsers who may be interested in the relationship between, and use of the various electromagnetic wavelengths which are playing such an increasing part in our everyday life.

Although the author does not link any particular wavelength with dowsing, by implication he connects the dowsing effect with some part or parts of the electromagnetic spectrum, but the dowser who hopes to find a scientific explanation of the causes of the movements of his twig or pendulum will be disappointed. In fact most readers will be disappointed when they reach the final chapter which is headed "Conclusions" to find that the author's only conclusion is the same as that of Sir A. Eddington, when he was speaking of atoms, who said, "Something unknown is doing we don't know what."

K.W.M.

TECHNICAL NOTES

THE MILITARY ENGINEER

(Published by the Society of American Military Engineers, January–February, 1950)

1920–50.

The Society of American Military Engineers celebrates the thirtieth anniversary of its formation and publishes a number of personal messages from Past Presidents of the Society and former editors of the *Military Engineer.* In thirty years the Society has expanded to include a total of 18,000 members and subscribers. The primary purpose of the Society is to maintain in time of peace the interest of the engineering profession as a whole in the rôle which it will be called upon to play in time of war. It is realized that in total warfare of today, all engineers—civilian and military—and all engineering are involved. Professional military engineers can form no more than a nucleus of the engineering strength required, and great dependence is placed on civilian engineers and every effort made in peace to encourage, foster and develop relations of helpful interest between the engineering profession in civil life and that in the military service. This close co-operation in peace facilitates the rapid expansion and integration so essential in war. Admiral John J. Manning, the President of the Society, considers that the thirty years of service which the Society has offered in providing a forum for the interchange of ideas on engineering development cannot easily be measured. The analyses of problems, the stimulation to thinking, and the practical advice gained have been invaluable to service personnel in their profession as engineers and as officers of the armed forces.

Put Forts where They are Needed. COLONEL C. L. HALL.

In the past our permanent fortifications have been on the sea front. Their object was to make seaports proof against bombardment or capture. There is no point in spending money to keep warships beyond range of our cities because cities can now be destroyed from the air. Coast defence engineers have become victims of unemployment. But there is still a fortification job to be done. Our modern equivalent of a sea coast is our arctic frontier. The places corresponding to our old vital seaports are the airports of that area. We must compel hostile airborne troops to land on adjacent inhospitable ground before they can seize an airport. How can we build at reasonable cost adjacent to every northern airport a fort capable of all-round defence, and of sheltering all purpose artillery, which can be held by a small garrison for two days against any parachute force which can land and operate in the vicinity? Against what size of aerial bombs would it be economical to protect it? Shall we destroy all larger airports for which we do not provide forts? In an interesting article the author suggests a new future for fortifications of vital airports, not on the basis of "Maginot Line" philosophy, but on the basis of command of the air and early relief by air power within a reasonable time. Mahon proved that a nation which loses control of the sea always loses its fortified islands, but he also showed that a good island base properly protected could be held for a while against a hostile fleet and would be of great aid to a friendly fleet arriving in reasonable time.

Speedy Bricklaying. Paul Severance.

The author describes, in a well-illustrated article, a new bricklaying device which speeds up bricklaying to a rate of 2,000–3,000 bricks per working day. This machine was produced by two Army engineers, Colonel John Hodgson and Major Paul Sommers, and presented to the public at a recent demonstration at which Major-General Lewis A. Pick, Chief of Engineers, was the principal speaker. The device is simple, costs less than $50 and weighs less than 20 lb. It does not lay bricks, it speeds up bricklaying. Built-in spirit levels, sides and ends, constantly check plumb. This is reputed to do away with the need for plumb-lines, for string wall guides and the repeated delaying use of the level. The rigid sides ensure true walls and adjustable guides keep a constant measure of the thickness of the mortar so that the courses run true level. Speed is aided further by a master scoop that beds eight bricks with a single scoopful. The bricks are then placed by hand as fast as a man can pick them up and lay them down. Guides on the side walls of the device direct the quick, accurate placing of each brick. A second scoopful tops the course and a swift back-and-forward movement with an auxiliary screed smooths the mortar and grouts it deep into the joints. It is claimed that this builds a better wall that is more moisture-resisting than by normal methods. Walls of all types, solid or cavity can be built with equal ease. For circular walls, manholes, etc., the inventors have another model that is even faster than straight wall construction. Test walls are reported to have been built with it at the rate of 6,000 bricks in a working day. The device is basically a tool, almost foolproof, and enables unskilled labour with a little practice to produce excellent results. It is estimated to effect a 60–80 per cent saving in labour costs. This new tool apparently has a ready market and is fast getting into production. If the author's favourable impression of it is justified, our own housing problems would appear to be partly solved.

COLD WEATHER CONCRETING

(*Civil Engineer and Public Works Review*, dated March, 1950)

Every winter a decision has to be made as to whether to continue or to suspend concreting during cold weather. It is a question that should be considered in good time, so that the possible loss incurred by suspending work can be balanced against the additional cost of the special precautions necessary in cold-weather concreting.

Many specifications require that concreting be discontinued when the temperature falls below 35–40° F. and it is usually found more economical to do this. If, however, work is of such urgency or importance that it must be continued, it can be carried out with complete success provided certain precautions are taken

In all concreting work undertaken during the winter, one basic law must be observed :—Fresh concrete must not be allowed to freeze before it has fully hardened.

The rate of hardening of all Portland cements varies with the temperature. It becomes slower in cold weather and almost stops at a point slightly above the freezing point of water. It will recommence at the normal rate as soon as the temperature rises again, provided the concrete has not become frozen.

If the concrete should be frozen, the water will separate from the cement, turn to ice and expand about 9 per cent in volume, breaking up the structure of the concrete so that normal strengths can never be reached. Even partially hardened concrete may disintegrate in this way when exposed to frost if it has not yet reached a strength sufficient to resist the bursting forces set up by the expansion of the freezing water. Poor quality concrete will be damaged even if fully hardened.

It is convenient to divide cold weather into three degrees of severity :—

(1) When the temperature is low but does not fall below freezing point ;
(2) When frosts occur only at night and are not very severe ;
(3) When night frosts are very severe and it freezes all day or nearly all day.

The following table summarizes them briefly :—

TABLE I

Always take these precautions at low temperatures.	Add these when there is frost at night	Add these also if there is severe frost day and night
Extend the period of curing or	Ensure that the aggregate is not frozen	Heat the water and aggregate
Insulate the concrete after placing to prevent loss of heat or	Ensure that the ground or moulds are not frozen	Keep the concrete heated and protected after placing
Accelerate hardening by (*i*) Using an extra rapid-hardening cement, or an accelerator or (*ii*) The application of heat and provision of insulation	Heat the water	

The time taken by concrete to reach a given strength will vary with a number of factors, including :—

(1) The temperature of the concrete at placing.
(2) The average air temperature during curing.
(3) The type of cement used.
(4) The size and shape of the concrete member.

It is impossible to give a precise duration for the curing period in cold weather but an estimate may be made by adding to the normal curing time the number of days on which the air temperature does not rise above 45° F.

The striking of formwork and removal of props must also be delayed until the concrete has reached a sufficiently high strength. Again it is difficult to give exact times, but the Building Research Station has suggested periods on which the figures given in Table 2 are based.

TABLE 2
(Minimum times for stripping formwork)

	Ordinary Portland cement		Rapid-hardening cement	
	Normal weather (about 60° F.)	Cold weather (about 35° F.)	Normal weather (about 60° F.)	Cold weather (about 35° F.)
	Days	Days	Days	Days
Beam sides, walls, columns	1	6	1	5
Slabs (props left under)	3	10	2	7
Beam soffits (props left under)	7	12	4	10
Removal of props to slabs	7	14	4	14
Removal of props to beams	16	28	8	21

If the concrete is heated and insulated, the above curing periods can be reduced.

Use of rapid- or extra rapid-hardening cement: The use of rapid-hardening cement is an advantage in cold weather, as it compensates to some extent for the slower rate of hardening at low temperatures. Special extra rapid-hardening cements, in which an accelerator is incorporated during manufacture, can also be obtained for cold weather work.

In certain types of structure care may be required in choosing the place at which changes are made from one cement to another, as different cements may have slightly different rates of shrinkage on drying.

MARINE BORERS

(*The Work Boat*, U.S.A., dated January, 1950)

The United States Navy Bureau of Yards and Docks is making a determined effort to investigate, from all aspects the age-old problem of marine borers and the destruction caused by them to wooden ships, piling, piers, bridges and other wooden structures exposed to sea or brackish water. Such damage cost $100 million in the United States alone in one year.

A floating laboratory equipped with all necessary scientific equipment has been set up in conjunction with the University of Miami, under the control of the Director of Marine Laboratories of that University.

Most previous studies have been devoted to adult organisms after they have obtained a foothold in the wood. Present researches are with the object of preventing the larvae from entering the wood. Larvae of a number of specimens are being grown in the laboratory and studied stage by stage in conjunction with the effects of temperature, salinity and the motion of tides upon their development. It is too early to report results in detail but all findings will be made available to the public.

So far it has been found that rapid growth of ship worms is associated with sewage, which indicates that the presence or otherwise of quantities of plankton may be an important factor. It has also been found that, whilst ships may be safe from barnacle fouling whilst in motion or anchored in water currents, they may well be open to attack by ship worms.

The article refers to various types of marine borers, other than the 15 in. ship worm (Toredo), such as Lomnoria, which is related to the wood louse and found in every climate. One major problem is the Teredinidae, which enters by a minute hole but enlarges rapidly once it is in the wood and may destroy the interior completely without its presence being noticed from the outside. Another borer, the Chelura, follows up attacks by the Lomnoria and enlarges the burrows of the latter. It is pointed out that the Sphaeroma, which attacks the caulking from the seams of boats, thrives in fresh as well as salt water.

The action of preservatives, such as creosote, is being closely studied to determine whether they act in the nature of a toxic by dissolving slowly in sea water or function as an non-soluble poison, only effective after the borer has consumed some of the treated wood.

The investigations and findings will be awaited and studied with close interest by all engaged in shipping, port construction, fishing and allied industries, also by railways whose lines cross swamps and estuaries on pilings, etc.

MONORAILS

Overhead " Monorails " or " Telphers " are valuable mechanical aids for transporting stores and materials without encroaching on floor space, where predetermined handling operations allow the installation to handle materials on fixed lines of travel. They are especially suitable inside buildings, where overhead support can easily be provided by the building structure.

This device, in use for many years, has recently found a new application in transporting and placing panels of shuttering for the pouring of large concrete walls in the erection of a steel-framed warehouse. The installation of the monorail in this instance was facilitated by the use of overhead travelling crane rails which were to be a permanent part of the finished structure.

The overhead monorail comprises a single steel rail, generally supported from side stanchions or slung from the roof structure, and cars or carriers which can incorporate hoisting gear and a means of power travelling, suspended from the rail.

Automatic discharge gear can be used in the installation and speeds of from 150–800 ft. per min. can be achieved with the carriers.

For large works construction projects, " Monorail " transporters using a single rail laid on the ground have been found of value where limited traffic of a light nature is to be conveyed over long distances, and where flexibility of layout is required. The track can be roughly laid, can incorporate sharp bends and can compete with uneven ground or ground of poor bearing capacity.

On original types, buckets or trucks were manually operated and were balanced straddling the single rail on two single wheels in line. The latest patterns now incorporate driverless wagons fitted with petrol-driven power units and can be supplied with or without trailer capacity. Spring-loaded " Steady " wheels are fitted to the wagons to retain them upright on the single rail. Trains can negotiate curves of about 12 ft. radius and slight gradients of the order of 1 in 20. The track is light and sections can be handled and laid by two men. Automatic discharge points can be incorporated, the buckets being emptied by side tipping.

USE OF BITUMEN IN HYDRAULIC WORKS

(*Journal of the Institution of Civil Engineers*, dated February, 1950)

Bitumen, widely used on roads, has in the last twenty years found fresh applications to hydraulic works in the construction of breakwaters, lining of reservoirs and dams, and in the protection of coasts, estuaries and rivers.

The paper gives the definitions and properties of the various types of bituminous compounds and tests for checking the composition, and describes various works in which the elastic and plastic properties of the material, plus its imperviousness to moisture and resistance to impact, abrasion and chemical attack, have made its use particularly suitable.

Groynes and breakwaters have been constructed using bituminized sand laid over sand as an alternative to the normal boulder clay, and the straw and willow and stone protection given it.

Sea walls of stone or concrete poured with bitumen grout, which penetrates deeply around the boulders to provide a structure of great strength and durability, have been constructed and have been shown to require very much less maintenance than similar walls set in cement, specially where settlement is possible. This reduced maintenance is considered to amply justify the higher first cost of bitumen as compared with cement :—(e.g., 3 : 1).

Flexible apron revetments consisting of precast concrete or stone pitching laid over clay and jointed with a bitumen-sand-asbestos mix have proved successful.

For coast protection and linings for canals and reservoirs asphalt carpets have proved very effective, provided that percolation from the rear is not such as to cause failure through surface lubrication between the carpet and soil on sloping banks. Clays overlaid with asphalt must be treated with weed killer to ensure that vegetation does not break through to destroy the waterproof seal.

Asphalt grout can be successfully poured through several feet of water to repair underwater works.

OXYGEN CUTTING STAINLESS STEEL AND NON-FERROUS MATERIALS

(*The Mechanical World*, dated 23rd December, 1949)

One of the main requirements of the oxygen cutting process is that the melting point of the oxide should be lower than that of the material being cut, and in the case of steel this requirement is fulfilled. With stainless steel and non-ferrous metals, however, the oxide produced has a higher melting point than the parent metal, and while any of these metals can be severed by melting along the line of cut, the severed edge is in no way comparable with that obtained by flame-cutting steel.

Recent development work has provided a means of eliminating these oxides, thus allowing the oxygen stream to react with the metal. This work can be undertaken by the use of one of two processes :—

(*a*) Powder cutting process.
(*b*) Flux injection process.

The powder cutting process is one in which finely divided iron powder is carried by means of compressed air through the preheat flame into the cutting oxygen stream. The extreme heat of the reaction, which occurs on the surface of stainless steel enables the refractory oxides of chromium to be removed by a combined melting and fluxing action. This process has been applied to cutting stainless steel from $\frac{5}{16}$ in. to 14 in. thick, as well as nickel and nickel base alloys, brass, bronze and copper.

Comparative cutting speeds of $\frac{1}{2}$ in. thick materials are as follows :—

Stainless Steel	15 in. per minute
Brass	8 in. per minute
Copper	5 in. per minute

The normal speed for oxygen cutting of mild steel is 13–18 in. per minute.

The flux injection process involves the use of a chemical flux powder which is carried directly into the cutting oxygen stream and due to a combined thermal and chemical action removes or prevents formation of the oxides of chromium.

Satisfactory results have been obtained for straight line, bevel and profile cuts on stainless steel up to 1 in. thick and further experiments are proceeding on even thicker material. The speed of cutting by the flux injection method on $\frac{1}{2}$ in. stainless steel is approximately 8 in. per minute.

SOIL CEMENT STABILIZATION

(*Roads and Road Construction*, dated March, 1950)

This article outlines in general terms the construction of roads using cement stabilization.

Stabilization of soil by cement has as its object to increase the bearing capacity of soil and to produce a material the properties of which will not be appreciably affected by water. These results have in some cases been produced by grading and compaction of the soil without the aid of any admixture (this latter method was adopted on some war-time airfields and roads, the compacted soil at optimum water content being protected against further ingress of water by a waterproof covering—P.B.S. laid over).

Stabilized soil has a strength of about 10 per cent the crushing strength of concrete and in civil practice is used to provide a firm subgrade on which the road structure can be built. It can be used however, with a surface dressing, for roads carrying very light traffic. (Dirt roads of this type are used to a greater extent in the U.S.A.)

Three methods of stabilization with cement are used—travelling plant method, mix-in-place method and pre-mix method. For each method a necessary preliminary is the removal of the top spit of soil and vegetation. The travelling plant, usually a single pass stabilizer, breaks up the soil, mixes it with cement, adds the water and spreads the mixed material ready for compaction. 30,000 sq. yds. per day is easily achieved with such plant, but its employment is uneconomical for areas under 100,000 sq. yds.

In England the mix-in-place method is stated to be that most normally used. The soil is first broken up or pulverized to a depth of about 6 in., usually by a rotary mixer. The cement is next spread over uniformly and then thoroughly mixed with the soil. Water is sprinkled over to the required moisture content and, after thoroughly mixing, the material is graded and compacted by pneumatic tyred roller. From 3,000 to 5,000 sq. yds. can be done in a day using this method.

The Pre-mix method follows the lines of conventional concrete road construction, except that soil is used as the aggregate. This method gives a better measure of control but is slow by comparison with the other methods giving an output of around 2,000 sq. yds. per day.

CORRESPONDENCE

The Secretary,
Institution of Royal Engineers,
Chatham. Kent.

20–22 Abchurch Lane,
London, E.C.4.
13th March, 1950

DEAR SIR,

Having been intimately concerned with two important aspects of his work, I should like to add my tribute to the appreciation of the late Colonel A. M. Henniker, which appeared in the March number of the *Journal.*

The secret arrangements for the embarkation of the expeditionary force at Southampton in 1914 involved the solution of highly complicated problems of the allocation of troops from trains arriving every twelve minutes, for three different destinations, to vessels which had to accommodate complete units when the size and number of vessels for each day's work could not be known until late the evening before. Henniker solved the problem and arranged for the results to be recorded on a special board on which subsequent changes could be made visually. This arrangement was the keystone of the plan of embarkation.

At the Paris Peace Conference, Henniker's qualities of "method, industry, and accuracy" were displayed to a remarkable degree by his complete grip on the innumerable transport problems dealt with at the Conference. He never missed a point. He was never at a loss for information and his penetrating analyses prevented many a half-boiled proposal from being adopted. In all this he seemed to prefer to work in the background and never sought credit for himself.

Yours truly,
H. O. MANCE,
Brig.-General.

NAIROBI'S FIRST EUROPEAN

The following extract from the *East African Standard* dated 14th March, 1950, has been sent us by a correspondent

A correspondent asked in our columns yesterday whether it would not be a "nice gesture" to name a street in Nairobi after Sergeant George Ellis who, by common agreement, appears to have been the first European resident of the town. There seems to be good reason why the name of the Sergeant should thus be perpetuated. Others with much less claim to the distinction have been similarly honoured by the Nairobi Municipal Authority in the past, and no doubt will be so again in the City of the future.

Not much is known of Ellis and it is only by one of the accidents of history, and somebody's proper regard for the keeping of a file or a roster, that his name has survived. After all, he could not know that he was engaged in the making of Imperial history, that he was a pioneer of pioneers, a blazer of trails.

As, indeed, he was. In 1894 Her Britannic Majesty's Government had declared a Protectorate over remote Uganda. Most of that part of what we now know as the Highlands of Kenya was, in fact, part of the Eastern Province of Uganda and between these uplands and the Coast lay a great area of sun-scorched, semi-arid, sparsely populated Africa across which wound the track which led to Uganda. Slave-raiders, slaves, European explorers, traders, missionaries, men and women, had used it for half a century, trekking wearily and in frequent danger from man and beast, from thirst and hunger, on the long journey from the Indian Ocean to the Great Lake.

The year after Uganda had been brought officially into the British Empire the Foreign Office decided to build an East African highway. The road from the coast stopped at Kibwezi. The need for reliable communications with Uganda (the idea of a railway was only then germinating) required something better than the various tracks made by the feet of thousands of African slaves. It was a job for the Royal Engineers. Captain B. L. Sclater, R.E., was given the task of extending the road from Kibwezi to Kedong, 130 miles. Sclater knew about Africa. He had made bush roads in Nyasaland. So he brought with him men who knew what it entailed—a second-in-command, Lieut. G. E. Smith, and five N.C.Os. of the Royal Engineers—Ellis, Clarke, Smith, Simmonds, Brodie. All good British names.

They did the job. Sclater's Road was finished in a year and a half and it is with us yet. Even the feet of the slaves did not help much because, scared of the wild Masai and the no less savage Kikuyu, slave traders took their victims by circuituous routes. So Sclater and his team had to blaze their own trail, basing their choice of route on the requirements of the engineer. These requirements, and water, always the final dictator of human enterprise in Africa, led them to what is now Nairobi.

Ellis was then a corporal. But after all, the rank of corporal is that critical stage in a military career at which men have made history—though not always with results as happy and as successful as time has shown the achievements of Ellis to be. The conclusion of his task in 1896 gained for him another stripe and Ellis passed into the category of the men who have always been the backbone of the British Army. He carried out with credit to himself and to the distinguished Corps to which he belonged, the job of establishing at what is now Nairobi a transport depot for the maintenance of the road he had helped to build.

It is on the record (and properly included in the history of Nairobi to be published tomorrow) that Sergeant Ellis built "an excellent group of substantial bandas for accommodating stores, posho, etc" and a "large and strong boma" for his cattle and mules. In those days the forbears of the lions which now earn dollars for Britain by posing for their photographs in Nairobi's National Park had a taste for cattle and mules which could only be restrained by a boma which was large and strong.

So it seems to us a nice tribute from the people of Nairobi to honour the name of Sergeant George Ellis, a Surrey man, born in Newington Butts in 1862, who before he was thirty was bringing his engineering skill and enthusiasm to bear on the tasks of road-making in Britain's young African Empire. And, perhaps, it might also be both a wise and a kindly thought to record something of his claim to fame on an enduring plate which would in due season be affixed to Ellis Street so that all who walk might read. For the public memory is short, so short that those in Authority would be hard put to it today to inscribe even on a small plate an adequate explanation of how some of our street-names came to be selected.