The Royal Engineers Journal

VOL. LXI MARCH, 1947

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Published Quarterly by

THE INSTITUTION OF ROYAL ENGINEERS

CHATHAM, KENT

Telephone: Chatham 2669

AGENTS and PRINTERS: W. & J. MACKAY & CO., LTD., CHATHAM.

THE ROYAL ENGINEERS JOURNAL—MARCH, 1947. VOL. LXI. Pages

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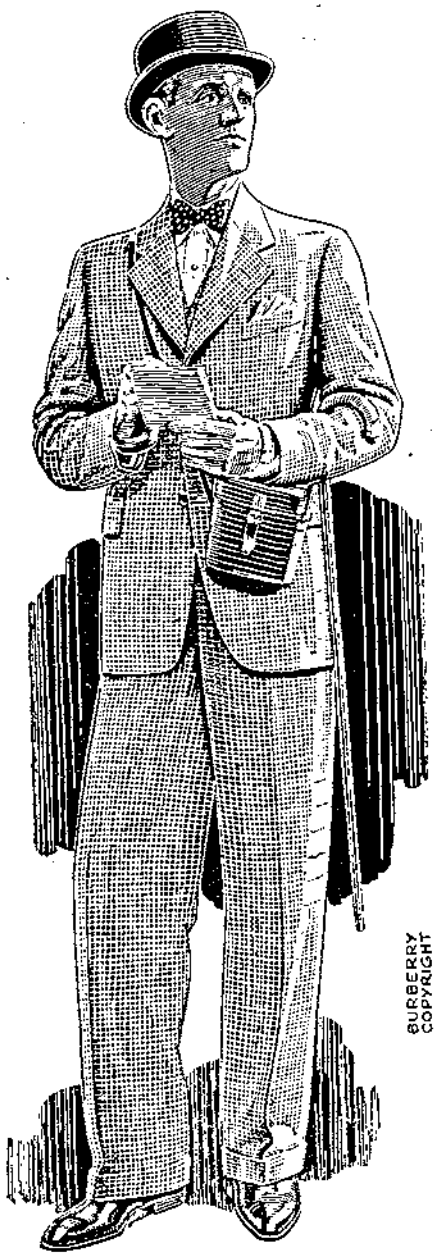

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Cup presented by the R.E. Yacht Club to the Royal Ocean Racing Club.

Presentation of cups 1

Silver Bowl presented by the Corps of Royal Engineers to the Engineer Officers of the Greek Army

Presentation of cups

EDITORIAL NOTES

Presentation of Cups

We reproduce photographs of two pieces of plate which have recently been presented by the Corps of Royal Engineers.

(a) Silver Bowl presented to the Engineer Officers of the Greek Army

The bowl is 10 in. in diameter, stands on a plinth, and bears the following inscription :—

> " Presented to the Engineer Officers of the Greek Army by the Officers of the Royal Engineers, British Army, as a token of sincere respect, and in commemoration of a long standing friendship."

It was purchased by the R.E. Corps Committee out of the General Purposes Fund.

(b) The " Ilex " Cup presented to the Royal Ocean Racing Club

The Santander Cup was given by the citizens of Santander to commemorate the first Plymouth–Santander Ocean Race in 1929, and was presented to *Ilex* as Second Prize by His Majesty the King of Spain. The second, and only other, Santander Race was held in the following year, and was won by *Ilex*.

In 1946, to mark the centenary year of the Royal Engineer Yacht Club, the Santander Cup, which was the most striking of all the prizes won by *Ilex*, was presented by the R.E.Y.C., with the approval of the Corps Committee, to the Royal Ocean Racing Club, to be competed for annually in ocean racing.

The presentation coincided with the introduction of a third class for ocean racing yachts ; and the Committee of the R.O.R.C. have accepted the R.E.Y.C. suggestion that the cup should be awarded to the best yacht of the season in the new (Medium) class.

The cup stands nearly 2 ft. high and is gilt. In addition to the original inscription, the plinth has been engraved :—

" Royal Engineer's Challenge Trophy
Presented by
The R.E. Yacht Club, to mark its centenary year, 1946."

It will be generally known as the *Ilex* Cup, and as such it is well fitted to take its place between the *Trenchemer* and *Ortac* Cups, now given for the Large and Small Class respectively.

The following letter has been received from the R.O.R.C. :—

The Royal Ocean Racing Club,
20, St. James's Place,
London, S.W.1.
10th January, 1947.

The Hon. Secretary,
R.E.Y.C.

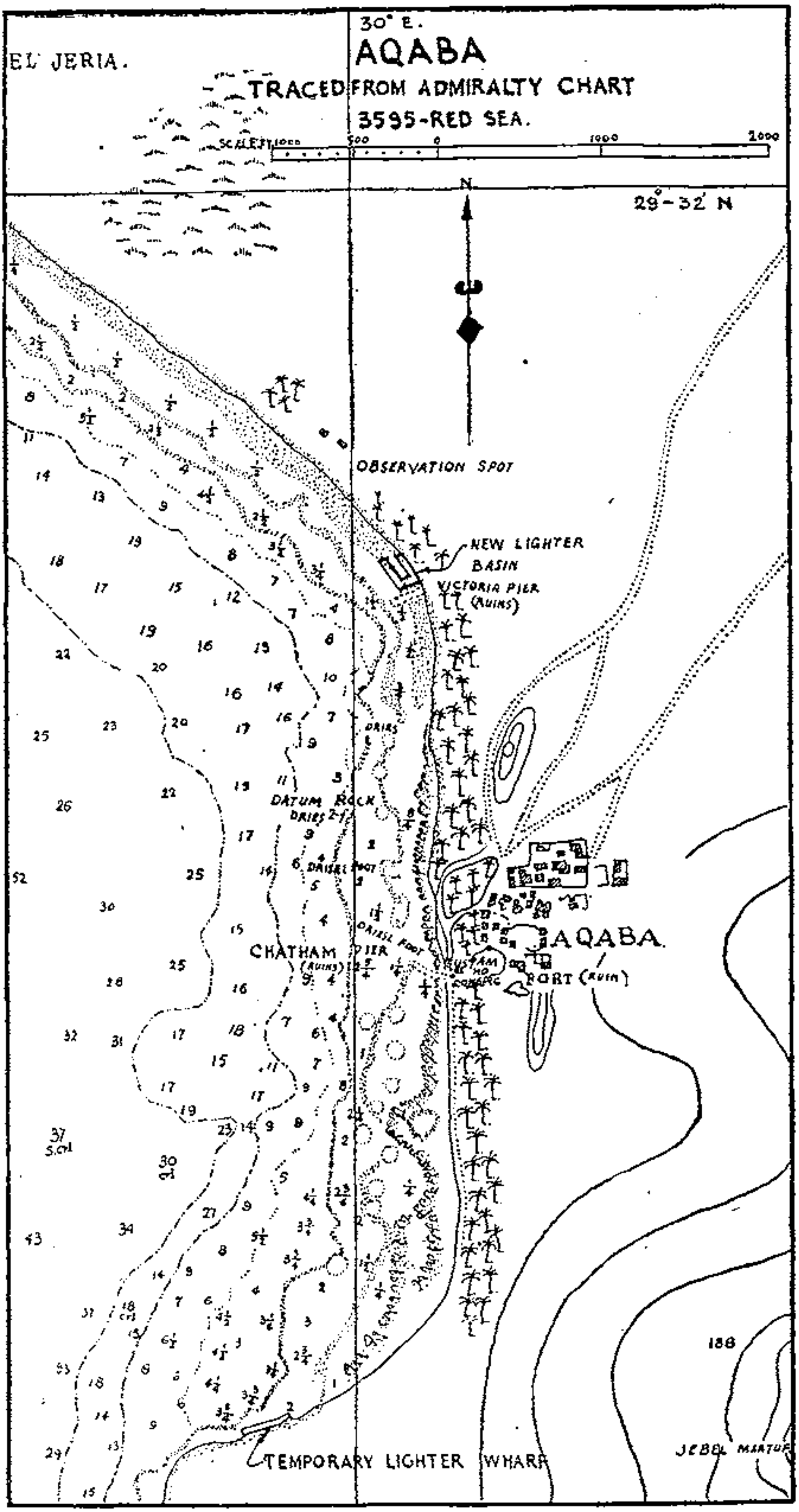
Dear Sir,

I am directed by my Committee to thank the Committee and Members of the R.E.Y.C. for the magnificent gift of the Royal Engineers Challenge Trophy.

My Committee very much appreciate the spirit of this gift and have decided to award it as the Points Cup for Class 2.

In conclusion may I express our very warm feelings towards the R.E.Y.C. and extend our best wishes for the future.

Yours faithfully,
(sgd.) F. R. H. Swann,
Secretary.



30° E.
AQABA
TRACED FROM ADMIRALTY CHART
3595-RED SEA.
EL JERIA.
29°-32' N
N.
OBSERVATION SPOT
NEW LIGHTER BASIN
VICTORIA PIER (RUINS)
DATUM ROCK
CHATHAM PIER (RUINS)
AQABA.
FORT (RUIN)
TEMPORARY LIGHTER WHARF
JEBEL MARTUF

Map 1.

AKABA 1941-42

By Lieut.-Col. E. L. Botting, R.E.

AKABA, from a casual glance at the map, suggests itself as an excellent backdoor into Transjordan, Palestine and Syria, and in June, 1941, when things were looking black, I found myself a member of a reconnaissance party sent there to report on the practicability of building a lighter wharf to handle 600 tons a day and the necessary road work to connect the port to the Hejaz Railway at Ma'an, 70 miles away, or to the nearest point to which the railway could be brought. Afterwards I spent ten months there as C.R.E. Works and O.C. Troops.

Prior to going there the place was little more than a name to me. I remembered one stray fact which came in useful, and that was that Lawrence, when he captured it in July, 1917, captured a German well-borer at work. As a port it has never been popular with seafarers owing to the southerly gales which spring up without warning in the winter season. There is a record in the Bible of the fleet of Jehoshaphat, King of Israel, being destroyed by the Lord there ; doubtless by one of these gales and probably the earliest record of them. Although Hiram built ships here for Solomon to fetch gold from Ophir, generally, throughout history, sufficient commercial reasons have seldom been found for any extensive use or development of it as a port.

In the course of construction we turned up a good many remains of pillars and corbels, and remains of buildings more ambitious in character, with the exception of the castle, than anything in Akaba at the present time. But a " Carry-all " scraper is not the best tool for undertaking a scientific archæological investigation. However, I did recover and bring back with me, an incised lid of a pot made of steatite, which the British Museum stated was not later than 850 B.C.

The village is in the north-east corner of the Gulf, facing west (see Photo 1). The Admiralty Chart shows two piers : Chatham Pier opposite the Police post and the centre of the village, and Victoria Pier, north of the village, and almost exactly in the north-east corner of the Gulf (see Map 1). The former is of no practical value except for very small boats, and its approaches are rendered difficult by submerged rocks. The latter, which I presume to be the one built for Lawrence in 1917-18, was in 1941 a heap of rubble with nothing standing above low water mark. The southerly gales of twenty winters had battered it to pieces. A shoulder south of the village provides a certain amount of shelter. Opposite the village itself the Gulf is shallow and rocky. At the northern end of the Gulf is a sandy beach, about four miles long, which is exposed to the full force of the gales. The mean rise and fall of the tide is 2 ft. 6 in. The gulf is very deep, and there is practically no anchorage with sufficient sea room in an emergency.

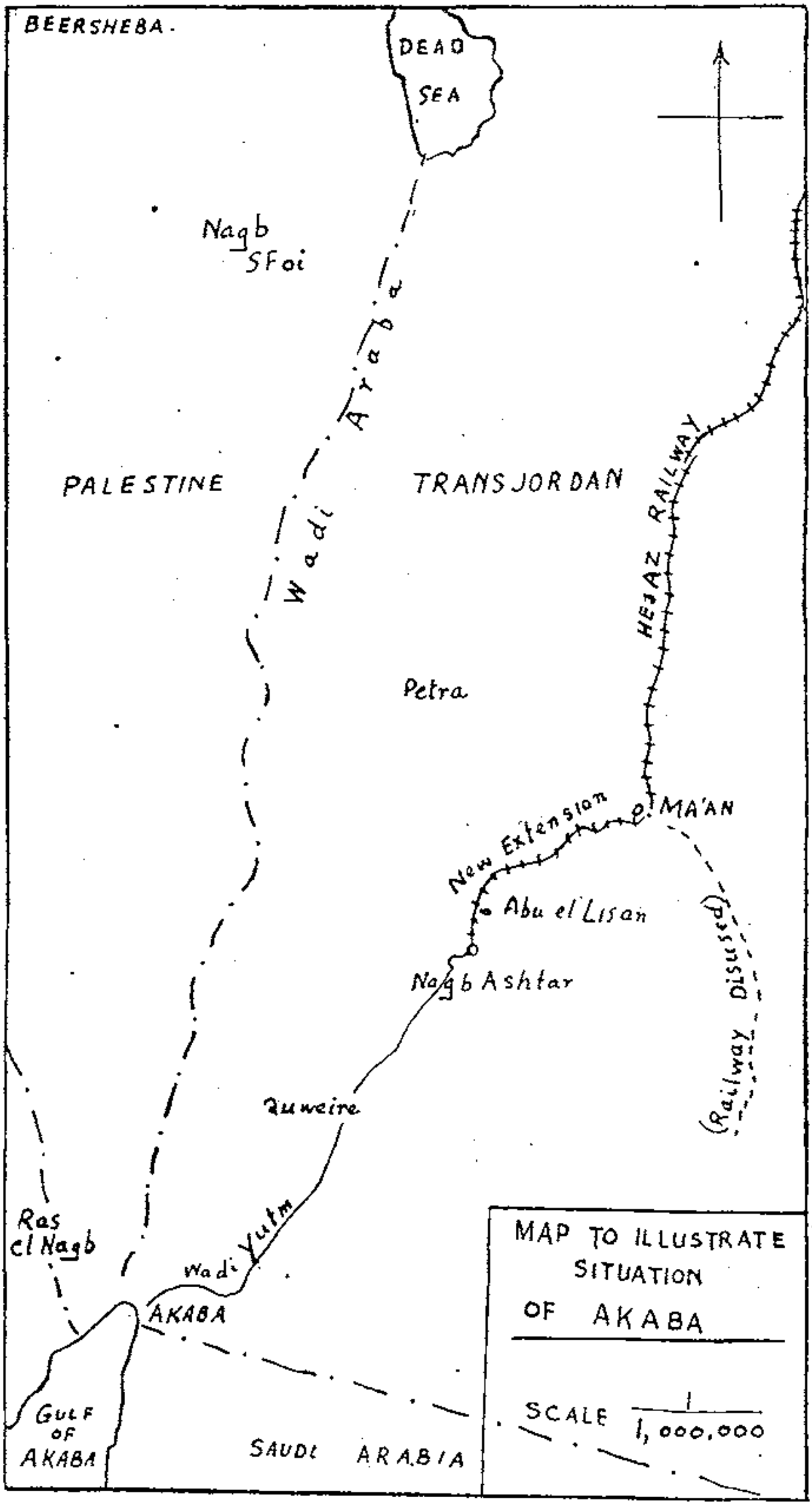
For the site of the lighter wharf there were two alternatives : either the shoulder south of the village, or anywhere along the northern shore of the gulf. For protection from southerly gales the former would have been preferable, although the area behind it was a little restricted. But on the given figure, two tons per yard of wharf frontage per day, there was not enough room here. Furthermore the S.T.O. was concerned that the prevailing northerly winds, with which we were blessed most of the year, would interfere with lighterage. Both these arguments I now believe to be unsound. Subsequent experience of discharging lighters at a temporary lighter wharf at that point seemed to show that the figure of two tons per yard per day is a pessimistic figure, and the northerly winds never interfered with the work. However, at the time, those two arguments between them ruled out the site, and a site along the northern shore, alongside the old Victoria Pier, was selected. Before deciding on the type of construction—steel sheet piling—a further reconnaissance party, which included a small detachment of a well-boring section, equipped with a gyn and a pumping set, jetted down a 2 in. pipe at several points along the proposed line of piling, to check that rock was not likely to be encountered. To support the "rig" a raft was made up of two of the small village fishing boats (see Photo 2).

The acceptance of this site, however, entailed the provision of shelter for lighters against southerly gales and, therefore, the lighter wharf was planned in the form of a basin entered from the west. This meant more piling, more filling, and from Movement's point of view two thirds of the frontage was against a pier, necessarily of limited width, and, therefore, liable to give rise to congestion with continuous traffic. It also meant that during the construction periods, if extended into the winter, any pile driving equipment (especially if floating), lighters or tugs would be in danger.

As regards other aspects of the project: a railway reconnaissance showed that the Hejaz Railway could be extended to within 19 miles of Akaba by a devious route, but further than that the gradient was uneconomical. The eventual decision was to extend it twenty miles only from Ma'an to the top of the Nagb Ashtar (see Map 2). The limited quantities of rolling stock of the required gauge, 105 cm., which could be obtained, was a factor which had to be taken into account in deciding how far the railway could be usefully extended.

The extension of the railway to the Nagb Ashtar left about 50 miles of road. Of this, nearly 20 miles was up the bed of the Wadi Yutm, which was known to experience violent floods, two or three feet deep, for a few hours during some winter seasons. The next 25 miles was across a plain, rather sandy in places. The last 5 miles was a climb up the escarpment of the Nagb Ashtar with several hair-pin bends. The chief problems associated with the road were the specification of the road in the Wadi Yutm, if that were in fact the only route, and the possibility of a diversion to ease the gradient and avoid the hair-pin bends of the Nagb Ashtar (see Photo 3). The former was probably insoluble in wartime without bringing to bear more resources than could have been spared, and while I was there floods washed away most of the roadwork in progress in the Wadi on one occasion, and I have been told has done so since. The bed of the Wadi is composed of the detritus of the granite mountains through which it passes and remained in very fair condition under a lot of traffic during the ten months that I was there, and looking back it seems possible that with maintenance gangs, especially if augmented by a grader, it could have been kept open indefinitely without any surfacing. The way the unmetalled Wadi bed stood up to traffic with very little attention was a revelation.

Several interesting but fruitless explorations were made, to see if any alternative to the Wadi Yutm existed; but none was found, and it is pretty certain that none exists that is not subject to the same disadvantage of being in a Wadi bed liable to floods. As regards the Nagb Ashtar, on an


BEERSHEBA
DEAD SEA
Nagb SFoi
Wadi Araba
PALESTINE
TRANSJORDAN
HEJAZ RAILWAY
Petra
MA'AN
New Extension
Abu el Lisan
Nagb Ashtar
(Railway Disused)
Quweira
Ras el Nagb
Wadi Yutm
AKABA
GULF OF AKABA
SAUDI ARABIA
MAP TO ILLUSTRATE SITUATION OF AKABA
SCALE 1/1,000,000

Map 2.

early reconnaissance, the escarpment further west, where the track of the Roman Road going south from Petra can still be traced, was explored. But the Roman ruling gradient was too steep and eventually a satisfactory alignment was found by climbing round a spur to the west of the existing road.

In addition to the port, road and railway works, the project involved accommodation for G.T. Companies, Dock Operating personnel, etc., at the port, and for G.T. Companies at railhead, also transit sheds at both places with the necessary water supply services.

Undertaking a job of work at Akaba was nearly as bad as working on a desert island. There was at least 100 miles of desert in every direction and the only natural resources were stone for aggregate, sand and a suitable brick-earth for making sun dried bricks. Most of the stores, therefore, had to be brought in. We were about 70 miles from railhead at Ma'an, with the Nagb Ashtar to negotiate on the way. We were about 150 miles from Suez with the very steep climb up to the Ras el Nagb in Sinai. This climb, of which the general gradient was one in seven, included one short stretch of one in three-and-a-half with a sharp turn at the top of it. The Australians on railway construction succeeded in bringing ten-ton lorries down it without mishap. We tipped two lorries over the edge, but on each occasion the driver succeeded in jumping clear, and, other than damage to the driver's cab, the lorries suffered very little. We were 200 miles from Jerusalem via the Ras el Nagb and Sinai. There was an alternative route by going north about 100 miles up the Wadi Araba and then climbing out of the Wadi by the Nagb Sfoi, which had about twenty hair-pin bends. This latter route was sometimes quite convenient when the Sinai roads were closed by rains.

However, from the job point of view, although we could get stores delivered to a limited extent by road, the bulk and weight of much of the stores, and the total quantity involved (some 10,000 tons before I left), meant that most of the stores had to be delivered by ship, and the first job on arrival was to arrange for the facilities to discharge any vessel that should arrive. For this purpose Victoria Pier was rebuilt. In shallow water, and above water level, concrete was laid in sandbags, and in deep water laid by tremie.

The first vessel scheduled to arrive was known as a Turkish Ferry (see Photo 4), a boat whose bows could be lowered to enable wheeled and tracked cargo, carried on deck, to get on and off. Shortly before it was due to arrive a longitudinal section of the ship was received and when compared with a section of the sea bottom in continuation of the line of the pier, it showed that the ship would not be able to approach sufficiently near. A timber trestle pier had to be hastily designed ; the necessary timbers were cut to length in depots in Egypt and sent us by lorry ; and the trestles were made, launched and decked in time to enable the Turkish Ferry to deliver its first cargo without any hold up. As I remember, the first cargo consisted chiefly of road rollers, compressors and stone crushers. If we could have relied on the first ship being this particular vessel, the profile of the sea bottom at right angles to the shoulder south of the village was such that the Turkish Ferry could have been brought in and its nose could have been dropped straight on shore. However, Victoria Pier was necessarily and usefully used for discharging by lighter the succeeding stores ships until a temporary lighter wharf was constructed.

As work proceeded it became evident that congestion around the pier, while work was in progress on the adjacent permanent lighter basin, was such a hindrance that it was decided to build a temporary lighter wharf on the shoulder south of the village. At first, 50 yards. was built up on piers of bridging cubes, bridged by 12 in. by 5 in. R.S.J's (see Photo 5) and


Photo 1.—AKABA.


Photo 2.—AKABA. Boring rig on boats.


Photo 3.—NAGB SHIAR. Hairpin bends on road.

Akaba

Photo 4.—" Turkish Ferry " at Victoria Pier, Akaba.

Photo 5.—Temporary lighter wharf.

Photo 6.—Akaba water supply.

Akaba 1

with timber decking, designed to carry a 19 R.B. The piers were built up on their mudsills, attached and jetted down to a level bed on the rather steeply shelving sea bottom. Later, a further 50 yards of wharf of steel sheet piling was added.

On the permanent lighter basin I am not sufficient of an expert to comment. It was designed down to the last nut and bolt before we set out to do the job, and there was only one modification of any consequence afterwards. It consisted of steel sheet piling stiffened by a reinforced concrete capping, and walling of steel sheet piling, with steel tie-rods going back to a reinforced concrete anchor wall.

The storms of which we were warned gave us one nasty sample. Arrangements were made that when meteorological conditions were such as to make a gale probable we were warned by signal so that we could take such precautions as were possible to safeguard lighters and other floating equipment. However, the gale that came just before dusk on the 1st January, 1942, came without any warning and blew lighters, tug and everything floating on to the beach. The tug was undamaged, but most of the lighters were, and we were unable to accept any stores by sea for a month. From actual experience of a gale it was thought prudent to make certain modifications to the design of the basin: first the entrance to the basin was made narrower, and secondly a stout wall was provided down the centre of the pier to prevent, in some measure, heavy seas breaking right over the pier in a southerly gale and damaging craft lying in the basin.

If the lighter basin was designed early, a problem on which Engineers and Transportation only needed to agree, the same could not be said of the extent and layout of the associated accommodation. Doubtless it had to take its turn in a large number of G.H.Q. projects, and today I should try to regard it more philosophically. We arrived at Akaba on the 12th August; a G.H.Q. planning party arrived on the 20th October; and the Key Plan arrived on the 20th November.

The plan, to our surprise, specified fully hutted accommodation for about twice the numbers we had been mentally catering for. We also had never imagined the luxury of fully hutted accommodation, so that we had about four times as much work as we had expected, all required by late January or early February, just when our brief winter season would interfere with the manufacture of mud bricks. However, the gale effectually destroyed any small chance we might have had of achieving the target date.

Of the general construction there was nothing of special interest to note. The buildings were of 13½ in. mud-brick walls with curved corrugated iron roofs without trusses. Foundations, door and window jambs were of sand and cement bricks, made on the shore where a suitable grading of sand and plenty of water for curing was available. The provision of special ventilation over the site of the kitchen range in one of the mess kitchens demonstrated, quite accidentally, the advantage in a hot climate of free ventilation to reduce the temperature inside a building with a thin corrugated iron roof. That feature was afterwards standardized.

An item of interest was the water supply. There was plenty of fresh water about, but nowhere in large quantities. Along the shore opposite the village it was possible to scrape up the sand a yard from the sea and get fresh water. Of the large number of wells, few gave more than 100 gals. an hour and most gave much less. The main village well, by Chatham Pier, gave 350 gals. per hour, and for most of the time that I was there most of the water for our requirements was carted round by lorry from this well. The permanent water supply for the project was based in the first instance on three new wells, sited in a line parallel to and about 150 yards from the shore and 50 yards apart. The water was only a few feet below the surface and the wells were connected by an "adit" which consisted of a circular reinforced concrete slotted pipe made in short lengths and laid with ends butting, loose stones being pitched around the junctions. To lay the "adit" the complete depth was excavated (see Photo 6), a pneumatic sump pump being found very effective to keep the water down to the lowest possible level while the work was in progress. This system, which I understand was afterwards extended, gave 1,500 gals. per hour on test, and will help to put the water supply of the village on a sound footing if the local people trouble to keep it up.

We had one flood while I was there. On the 5th March there had been heavy rain in the afternoon. It was quite usual for Akaba itself to get no rainfall at all during the year, but on this occasion about a couple of inches fell in the village itself. We were sitting having tea in the dusk when we became aware of a slight continuous roar. Going out, we found this was the noise of the water coming down the Wadi Shellal just behind the village. The water poured down the Wadi and right over the stores dump for the port works, ruining cement and washing the most unexpected things out to sea. (One defect in the siting of the new basin was perhaps that it was right across one of the principal natural channels for storm water to the sea.) In a short while water seemed to be flowing down the full width of the Wadi Araba to the depth of 6 in. To the alarm of the doctor, all the dirt and excreta of all the fauna, human and wild, seemed to be washed by a special providence into our new water works, which were half completed. However, we pumped and ladled out all the muck. Our "adit" was big enough to crawl through, and there was no permanent damage or defilement. That evening everyone was a bit depressed, but the next day the sun shone again as usual and we realized that no permanent damage was done. We had already constructed one bund to protect a camp on a slope. The absence of stores for a month had given us the necessary spare labour to undertake the task. This bund had on the whole done its job, and a further bund was designed to deflect the waters of the Wadi Shellal.

Water services were required at other places: at the railhead, and also, if possible, on the road to shorten the lift of water to labour employed on road construction. For the former, a well was sunk about 100 yards from the well at Abu el Lisan, the site of one of Lawrence's battles, and a pump installed. For the road, boreholes were put down at Quweira, 30 miles from Akaba (500 ft.) and another at a site in the Wadi Yutm, about 20 miles from Akaba, but they met with no success while I was there. There were, however, in the Wadi Yutm, six ancient cisterns, sited in pairs, designed to catch storm water. These were completely full of silt and it was thought worth while to clean them out. Enquiries were made as regards the activities of Lawrence's German well-borer and we were referred to the approximate site near the mouth of the Wadi Yutm, and discovered the borehole with the pump still in position, all completely covered in silt. The unserviceable pump was removed. There was very little depth of water, so the lining was extracted, and the bore deepened and relined, and a new pump was installed on a stout masonry platform above flood level.

There were practically no contractors in Transjordan, and efficient Jewish contractors from Palestine were not permitted to undertake contracts there. All the work, therefore, had to be undertaken by direct labour—the military units we had, augmented by the local Arab. Unfortunately, there were three biggish jobs going on at the same time: the extension of the railway by an

Australian Railway Construction Company ; the road work by the C.R.E. Haifa-Baghdad Road ; and the port and ancillary works by the C.R.E. Akaba. There was, therefore, some competition for labour. The Assistant British Resident, Transjordan, acted as labour recruiter for all the military works going on in South Transjordan and the district was roughly zoned for the supply of labour to the three jobs. The influx of labour was far in excess of the normal population of the locality and had to be fed and " housed." For the former, rations were provided under a contract arranged by the C.R.E. Haifa-Baghdad Road. For the latter, labour camps were set up using the black tents of the bedouin, which we hired at rates agreed and arranged with individual owners by the Assistant British Resident. The paying, rationing and accommodation of the civilian labour, threw a lot of extra work on the C.R.E's Staff.

As usual, transport was at a premium and was a bit of a problem. All P.O.L. and all food, except fresh meat, had to be brought from Ma'an, 70 bumpy miles away. As the days shortened we found it desirable to make this journey a two day turn round, otherwise tomatoes and eggs were reduced to pulp and the proportion of leakers in the petrol containers increased as the result of the extra hurried journey back. The percentage of vehicles off the road, including those off for their one day in the week maintenance, gradually rose to 40 per cent, and arrangements were then made to hold a larger stock of spares, including major items such as engines, back axles and steering assemblies complete. This improved the state of affairs a lot. Our mud-bricks had to be carried two or three miles from the brickfield to the various sites of the work. Eventually this was done by decauville, whose completion was delayed by the aggravating non-arrival of nuts and bolts, lost in transit, a deficiency which took upwards of two months to get made up. In the meantime we experimented with a camel contract ; a hundred magnificent but expensive camels brought down from Syria at 15/- a day each, eked out by the diminutive local donkey, which at 3/- a day, was infinitely better value.

Food was another problem. Fresh meat, sheep and goat, were obtained from a local contractor. Bread and fresh vegetables came from Ma'an, the latter not too appetizing after the bumpy and dusty journey down. Our New Zealanders, fond of their " tucker," found it hard, especially when in the severe weather in January, 1942, some of the contractors supplies of sheep were lost in the snows in the hills farther north. As soon as we had a ten-ton cold store installed we had frozen meat sent down from Haifa. A visit to Jerusalem, and the sight of the fruit and vegetables piled high on the stalls at the Jaffa Gate, made us realize why the Israelite spies reported Palestine as a land flowing with milk and honey.

One great advantage of Akaba was that until a week before I left there was no telephone communication with the outside world. All urgent messages came in wireless in high grade cipher. For the first few months there was only one mail a week, brought on the weekly train to Ma'an ; later there were two. We got used to getting irate signals asking for replies to letters which we had not yet received. One nuisance was that to the casual ear and eye, Akaba was easy to confuse with Ataka, near Suez, and on some occasion we received Ataka's signals and they got a lot of our accommodation stores which took about four months to catch us up. Confusion was avoided to some extent by the publication of an M.E.F. Order directing that Akaba should be known as Akaba T.J.

We were a mixed crowd. Apart from the C.R.E. Works, there was only one complete unit, the 7 Art. Wks. Coy., I.E. and only a few other U.K.

personnel in signals and ciphers. There was a section each of the 19 Army Tps. Coy. and the 21 Mech. Equip. Coy., N.Z.E.; a detachment of a Mauritian Dock Operating Unit, R.E., and for a short while a Mauritian A.M.P.C. Coy. The R.A.S.C. were at first a platoon of an M.T. (Works Services) Coy. of Palestinian Jews, who were afterwards relieved by Cypriots. For a short time we rejoiced in a N.O. i/c and an S.T.O., and we had two padres, R.C. and C. of E., whose parishes were the whole of Transjordan. The local garrison of the Arab Legion Police was augmented and their officer lived in our mess. We were a little nervous of the Arab reaction to our Palestinian R.A.S.C. Jews, but although they were involved in a couple of accidents, in which several Arabs were killed and injured, there never appeared to be any illwill towards them after the first few days. All these stray detachments threw a lot of extra work on the C.R.E's staff, until eventually a Town Major was appointed.

Of local amenities there were few. Although Akaba figures on practically every map which includes the locality, however small the scale, it is only a very small village. Most fortunately for us there was an ice plant, operating in normal times to preserve fish which was taken to Palestine. The only other Europeans, for whose presence and hospitality we were extremely grateful, were the crew of the M.V. *Imperia*, a B.O.A.C. rescue and search vessel which happened to be stationed there. Of other amenities the scenery, of its kind, was magnificent, and there was quite good fishing, but for nine months of the year it was much too hot for enjoyment.

During one of my first visits to Jerusalem I picked up a Guide Book, " Guide du Nil au Jourdain par Sinai et Petra " sur les traces d'Jarael par le P. Barnabe Meisterman, and it was amusing to read therein :—

" A la suite des evenements de 1905 et 1906, le gouvernment turc avait songé à rattacher Aqabah au chemin de fer de Damas à Medine et y créer un port militaire. Mais d'un côté les anglais ont fait opposition à la création de ce port ; et d'un autre côté, en temps de guerre, un port militaire au fond d'un golfe étroit n'est aucune utilité, on reconce donç à la création du port et du tronçon de la ligne de chemin de fer."

And so the English, who had used their influence to prevent the Turks developing the port after 1906 had to turn to and do the job themselves in 1941–42.

PRE-STRESSED CONCRETE

GENERAL DESCRIPTION AND A FEW EXAMPLES OF RECENT APPLICATION

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1. Definition

PRE-STRESSING, as the name implies is a method whereby specific stresses are induced at an early stage in order to counteract, i.e., reduce or eliminate stresses due to loads and other causes to be imposed on the material or structure.

The principle of pre-stressing has already been applied to the design of thick cylinders, viz., gun barrels, by either shrinking tubes on to the barrel and thus inducing an initial pre-compression in the material of the barrel in order to reduce the tensile stress produced by the high internal pressures ; or by winding thick layers of flat steel strip at an appropriate tension in order to produce the same effect.

Pre-stressing as applied to reinforced-concrete work is a comparatively recent development and dates from the beginning of this century though investigation commenced towards the end of the last century.

Normal reinforced concrete as is well known, is a composite material consisting of concrete, which can be made strong enough to resist comparatively high compressive stresses, but is weak in tension, and steel reinforcement in the form of round, square, twisted rods, etc., which is designed to take the tensile stresses as well as the shear stress.

Modern improvements in the manufacture of concrete have shown that with proper selection and proportioning of the cement, with careful grading of the aggregate and with a well controlled low water/cement ration, coupled with adequate vibration and curing, the compressive strength of concrete could be greatly improved. Unfortunately the increase in its tensile resistance is not of the same order and no matter how well made the concrete is, its low tensile strength precludes any economy in steel by the use of high tension reinforcement because of the danger of fissuration and increased cracking in the tensile regions of the concrete.

Shrinkage, the effects of which can be considerable and rather difficult to predict, is another factor producing tension and cracking in normal concrete work.

To counteract these factors, to obtain full benefit from the improved compressive resistance of concrete and at the same time economise in the use of steel by employing hard cold drawn wires (or other high tensile steels) capable of withstanding far higher stress than normal mild steel, pre-stressing is employed.

Pre-stressing induces compressive stress in regions where tension would develop normally under load. This pre-compression can be adjusted to totally eliminate all tensile stresses in the concrete or to reduce the resultant tensile stresses to values below the tensile resistance of concrete.

The result is that pre-stressed reinforced concrete can be regarded as a homogeneous material and advantage can be taken of the full section in resisting bending and shear.

Furthermore, pre-compression reduces the resultant principal shear tension stresses and effects, therefore, economy in the use of shear reinforcement (viz., links).

2. Methods of Pre-Stressing Reinforced Concrete

Pre-stressing can be carried out in a number of ways. Some methods employ bonded reinforcement, other methods rely on non-bonded reinforcement.

In some methods the steel is contained within the concrete, in others it is hooped or wound around the surface and cement gunned later. Another ingenious method utilizing the action of the concrete to effect its own pre-stressing as developed by M. Freyssinet will be described later. The underlying principle is, however, the same, i.e., the imposition of certain initial stresses to counteract the action of loads, etc.

(*A*) *Pre-stressing with bonded reinforcement.*

(*a*) General Principles.

The hard steel wires (viz., special improved patent steel 90 to 100 tons per sq. in. ultimate tensile stress) are placed in continuous moulds or troughs and subjected to a definite extension. This predetermined extension can be effected by fixing the wires to a prepared abutment at one end and to hydraulic jacks or other stretching devices at the other end.

Concrete is then placed in the moulds and around the wires. When the concrete has hardened sufficiently and acquired the requisite strength, the tension imposed on the wires is released. The wires tend to shorten and being restrained by the concrete, induce a compression in the concrete.

The nature of this pre-stressing could be regulated to produce either a uniformly distributed pre-compression by placing the wires in the centre of gravity of the section (for ties or pure tension members) or a reverse bending moment (to the bending moment induced by loads) by placing the wires below or above the centre of gravity of the section (viz., for slabs and beams).

This principle has been applied to the manufacture of pre-cast pre-stressed bridge girders. The girders were cast end to end with short spaces between the end moulds, in continuous rows, each continuous row of moulds consisting of about twenty-five girders or more. One stretching operation thus serves twenty-five girders. On the hardening of the concrete and on its acquisition of the necessary strength, the tension at the ends was released and the force was transmitted in the form of pre-compression to the concrete.

The wires between the ends of adjoining girders were subsequently cut and the girders were then ready for transport to the various sites.

The Schafer method of producing pre-cast pre-stressed elements as used in Germany, during the war, is based on the same principle.

An interesting feature of this method is the mobile concrete mixing, placing, tamping and cutting machine which feeds the continuous moulds in which the wires are embedded and subsequently cuts the concrete to the requisite lengths.

Pre-stressed concrete railway sleepers are being produced by a modified method utilizing the same principle of pre-stressing in Messrs. Dow-Mac's factory in Tallington, Lincs., according to the design of the Pre-stressed Concrete Company. The main features are careful control of ingredients and mixing, and high mechanization of the plant to minimize manual labour. These sleepers have now been installed in the main railway lines and have proved most satisfactory.

This form of pre-stressing is suitable for the manufacture of large numbers of pre-cast elements that can be cast in continuous moulds, troughs, etc., but unless it is coupled with artificial curing to speed the hardening of the concrete it imposes a limitation by immobilizing the moulds during the hardening of the concrete. The effect of this is to limit the productive capacity of the plant or conversely to tend to increase the factory space and plant required for a certain production figure. To overcome this it is necessary to introduce a form of steam curing or heat treatment, or to adapt Freyssinet's principles of quasi-instantaneous hardening to the production of pre-cast girders, sleepers, etc.

The whole question resolves itself, therefore, to a comparison between the advantages of a far higher output coupled with a saving of factory space and the necessity to employ more costly moulds and artificial curing devices.

(*b*) H. Schorer's method as developed in the United States employs self-contained pre-stressed reinforcing units which consist of two groups of wires wound or braided over a centre member in a clockwise and counter-clockwise direction respectively. The centre member consists of a cold-drawn and heat-treated steel rod which serves as a temporary compression member. This central member, which is braced against buckling, is enclosed in a paper or sheet metal tube to prevent it from bonding with the concrete and thus allow its removal.

The pre-stress force is applied by hydraulic jacks and end attachments which simultaneously stretch the wires and compress the central balancing rod. This self-balanced pre-stressed unit (load capacities ranging from 2 to 20 tons per unit) is placed in the concrete in the same manner as normal reinforcing rods. The pre-stressing forces are ultimately transferred to the concrete by means of jacks which are attached to the protruding ends of the self-balanced reinforcing units and withdraw the central balancing rods. The holes left by the central rods are subsequently grouted in.

(*c*) M. Freyssinet's ingenious method of pre-stressing as applied to high pressure concrete pipes is based on the following two principles :—

(*i*) Concrete subjected to vibration followed by compression and heating, hardens and acquires strength at a far greater rate than normally treated concrete.

Thus, with the proper choice of pressure and temperature, it is possible to develop a 28-days' strength in a matter of 2 hrs. or less.

The compression treatment imposed on the wet concrete may range from 15 to 500 lb. per sq. in. depending upon the type of product required. This compression enables the use of higher curing temperatures to speed the hardening.

High pressure pipes produced by the Freyssinet method were thus subjected to vibration followed by a compression of 500 lb. per sq. in. and heated up to 212°F. The compressive strength of the concrete was more than 5,000 lb. per sq. in. after 1½ hrs. only.

(*ii*) The second principle discovered and employed by Freyssinet was that a " non-coherent mass composed of small particles such as fresh concrete is endowed with mechanical properties similar to those of a solid body, when submitted to pressure from all directions."

" If in such a mass elastic reinforcements are placed and the mass is subjected to a deformation whilst the pressure is being maintained, the reinforcement is induced to follow the deformation of the mass and is strained as long as the reactions between the stretched reinforcement and the mass are not higher than a limit depending on the actual pressure existing in the mass."*

The application of this principle to the manufacture of high-pressure concrete pipes was effected by introducing a pressure in the inside annular mould of a higher order than the one on the outside mould, and allowing the outside annular mould to extend whilst maintaining its pressure on the

* Dr. K. W. Mautner, *The Structural Engineer*, March, 1945.

concrete. This extension of the compressed concrete induced the contained circular reinforcement to extend likewise and to develop a pre-tension which could be transferred in the form of a pre-compression to the concrete after 1½ hrs.

This process as well as a good number of others is described in detail in Dr. Mautner's paper on "Pre-Stressed Concrete in Annular Cross Sections." (*The Structural Engineer*, March, 1945.)

These two principles, i.e., the quasi-instantaneous hardening of concrete due to vibration followed by compression and heating, and the mechanical properties of fully compressed and contained concrete, had also been applied to the manufacture of straight members, viz., girders, with the resultant speed up in output.

(*B*) *Pre-Stressing with Non-Bonded Reinforcement.*

This method overcomes the main disadvantages of the first method (i.e., pre-stressing with bonded reinforcement), i.e., immobilization of moulds during the hardening of the concrete and the requirement of special anchoring abutments.

In this system, the high-tension wires (1/5 in. diameter say) are made up into cables each consisting of 8, 10, 12, 19 or 32 wires, placed around a mild steel spring spacer and enclosed in thin gauge steel sheaths, paper sheaths or bituminous fibre sheaths.

These cables are placed inside the moulds in straight lengths or curved, in accordance with specified requirements (similar to bent rods in normal R.C. work, or curved to accommodate specific shapes).

Pre-cast concrete female cones (see Fig. 2) are fixed in the moulds at specific points and the above cables are threaded through these cones and the wires made to fan out and project at least 18 in. beyond the outside flat surfaces of the female cones.

Thus each sheathed non-bonded cable is bonded by two female cones one at each end. By virtue of the fact that the cables are sheathed, the high tension steel wires forming these cables are not bonded to the concrete and the wire-stretching operation can be carried out as and when desired.

Beam and column elements as well as short lengths of long-span girders can thus be pre-cast under the very best conditions in an enclosed factory or a pre-casting yard. After vibration, the moulds containing the concrete are placed in steam curing kilns and after a period of curing the concrete elements are withdrawn and stacked ready for pre-stressing.

The pre-stressing operation is carried out by means of special hydraulic double-acting jacks, designed by E. Freyssinet, which are placed at each end of the cable.

These double-acting jacks are made in two compartments each fed by a pipe containing a fluid (water or oil) at a pressure of up to 5,600 lb. per sq. in. The extension compartment is the farthest from the cable end and consists of an outside sleeve-like hollow cylinder which slides outwards under the action of hydraulic pressure. The compression or plugging compartment has an internal piston or ram, which moves towards the concrete under the action of hydraulic pressure.

The pre-stressing operation is carried out as follows :—

Pre-cast concrete male plugs are placed inside the annular space formed by the wires in the cavities of the female cones. The double-acting jacks are then placed against the outside flat faces of the female cones. The projecting wires are wedged on to the outside mobile sleeves of the extension compartments, fluid pressure is then admitted into the extension compartments of the double-acting jacks (one at each end). The extension of the wires is thus effected by the movement of the outside sleeve-like cylinder of the extension compartment to which the wires are fixed. When the requisite extension has been reached, pressure is admitted into the compression compartments of the double-acting jacks which force the male plugs into the annular spaces formed by the wires.

The resultant side pressure between the surfaces of the male and female cones creates a considerable wedging action which enables the hard steel coils which are exposed in the surfaces of the male and female cones to grip the cable wires and thus effect a permanent bond.

The pressures in the extension and wedging compartments are then released and the jacks detached and grout is injected through the annular holes in the male plugs to effect a bond between the cable and the concrete.

The whole pre-stress operation need not last longer than ten minutes per cable and could be reduced.

A few examples of the application of this system will be quoted later. It will be seen that it has been successfully applied to long span bridge construction and to the construction of long span aircraft hangers. Note should also be taken of the work of the Royal Canadian Engineers who erected two bridges of a similar type over a part of the Ghent to Terneuzen canal. Each bridge had two main girders which consisted of hollow pre-cast blocks assembled into complete units by pre-stressing non-bonded cables and erected by a floating crane.

Developments are now taking place in this country to adapt this system to the construction of multi-storey buildings, the framework of which will consist of pre-cast beam and column elements assembled into complete frame units by pre-stressing. The object is to produce a completely prefabricated multi-storey building with the resultant saving in timber, steel and erection time.

A similar principle is also being applied to the treatment of load bearing and stiffening frames in assembly halls, canteens, stores, shops, and other similar single storey buildings of comparatively long spans and heights of 12 ft. and over.

Interesting developments are taking place at present in France where it is proposed to apply a similar system to the construction of aircraft landing grounds with the resultant saving in concrete and elimination of cracking.

Design Problems

In the design of pre-stressed beams the Engineer is presented with the choice of sections not hitherto contemplated in normal reinforced-concrete design.

Owing to the fact that Pre-stressed Concrete can be considered as a virtually homogeneous material it is possible to design effectively I-shaped sections, square or oblong hollow sections with very thin ribs and in other shapes normally available to the structural steel designer. The effect of this is greatly to reduce the weights of the members employed and thus effect economies in transport and erection charges.

A useful guide to the efficiency of the section is the following ratio :—

$$K = \frac{h^2}{4 r^2}$$

where h = total depth of the section.
r = radius of gyration of the section.
r^2 = Moment of Inertia of the section referred to a horizontal axis through its centre of gravity/Area of the section.

Low values of K (between 1·8 to 2·2) will indicate efficient sections such as I girders and thin hollow tubes. The higher figures will apply to solid sections normally used in R.C. design.

When estimating the initial pre-stressing force required allowance must be made for the losses due to the following actions.

(*a*) Shrinkage. (*b*) Elastic deformation of the concrete. (*c*) Creep. (*d*) Slip. (*e*) Friction losses due to the curvature of bent or curved cables.

(*a*) Assuming a shrinkage of 300×10^{-6} per unit length (as specified for P.R.C. railway sleepers, nominal mix 1 : $1\frac{1}{2}$: 3, cube strength at 28 days, 6,000 lb. per sq. in. See B.S. 986 : 1945) and a Modulus of Elasticity for the high tension steel equal to 28×10^6 the reduction in the intensity of pre-stressing due to shrinkage of concrete is equal to $28 \times 10^6 \times 300 \times 10^{-6} = 8{,}400$ lb. per sq. in.

(*b*) Elastic deformation of the concrete. Taking the elastic strain in the concrete at $0{\cdot}25 \times 10^{-6}$ per lb. per sq. in. (i.e., $Ec = 4 \times 10^6$) and assuming that the pre-compression is say 1,000 lb. per sq. in., the pre-stress loss due to this cause will be say $= 1{,}000 \times 0{\cdot}25 \times 10^{-6} \times 28 \times 10^6 = 7{,}000$ lb. per sq. in.

(*c*) Creep. The action of creep which is described as " the progressive movement which takes place in the concrete as a direct result of the load imposed upon it " has been thoroughly investigated in this country (Dr. O. Faber ; Drs. W. H. Glanville and F. G. Thomas of the Building Research Station) and abroad, and information is now available showing the development of this action over a period of up to $7\frac{1}{2}$ years. (See Building Research technical papers 12 and 21). It is thus possible to allow for this action which is comparatively " rapid " during the first few months and very slow after twelve months, tending to a limiting figure which can be assessed.

For carefully graded and a low water/cement ratio type of concrete, this figure could be taken at $0{\cdot}3 \times 10^{-6}$ per unit length per lb. per sq. in. (see spec. for railway sleepers). Assuming that the resultant pre-compression on the concrete is say 500 lb. per sq. in. (after deducting the tension on the lower fibres of the beam due to dead load bending-moment) the pre-stress loss due to this cause will be of the order of $500 \times 28 \times 10^6 \times 0{\cdot}3 \times 10^{-6} = 4{,}200$ lb. per sq. in. (or 8,400 lb. per sq. in. if the resultant pre-compression is 1,000 lb. per sq. in.).

(*d*) Slip. As the name implies is the tendency of the wires to slip through the concrete in the case of bonded reinforcement.

This is overcome by employing large numbers of small diameter wires (1/5 in. or less) and can be totally eliminated by the application of Freyssinet's quasi-instantaneous hardening methods, which produce a very dense concrete. The bond between a pre-stressed wire and the surrounding concrete is better than in the case of normal R.C. work owing to the swelling at the ends and consequent wedging action of the wires on release from the stretching apparatus.

Where slip has to be considered, allowance is made in the form of a percentage reduction.

(*e*) Friction losses due to the curvature of the embedded cables are allowed for by the formula :—

$$\frac{T_1}{T_2} = e^{m\phi}$$

where T_1 = Active pull at one end.
T_2 = Effective tension at the other end of the bend.
e = 2·718.
ϕ = angle subtended at the centre of curvature.
m = Coefficient of friction.

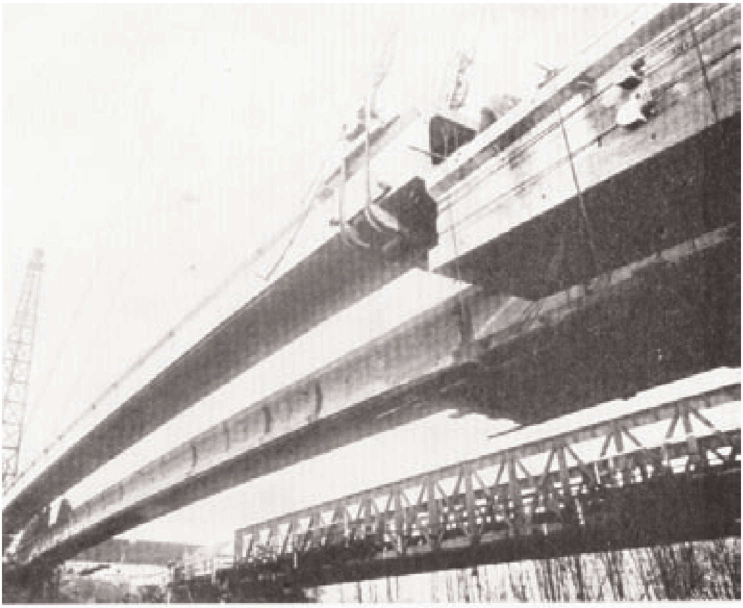


Fig. 1.—Luzancy Bridge.

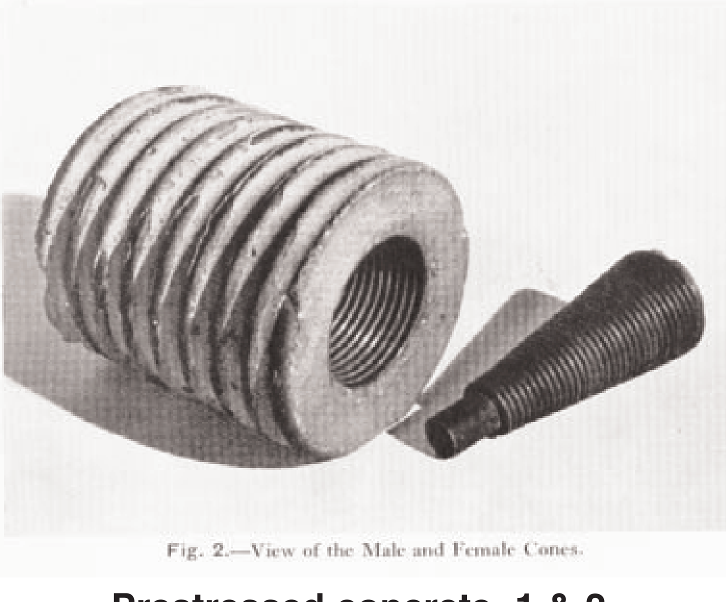


Fig. 2.—View of the Male and Female Cones.

Prestressed concrete 1 & 2

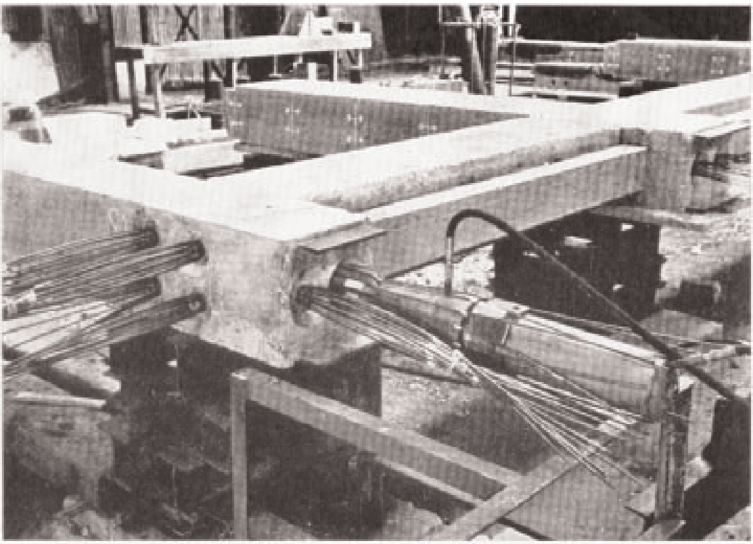


Fig. 3.—Close-up view of a double-acting jack.
The pipe on the extreme right feeds the extension chamber. The pipe nearest to the frame feeds the ram that pushes the male cone into position.

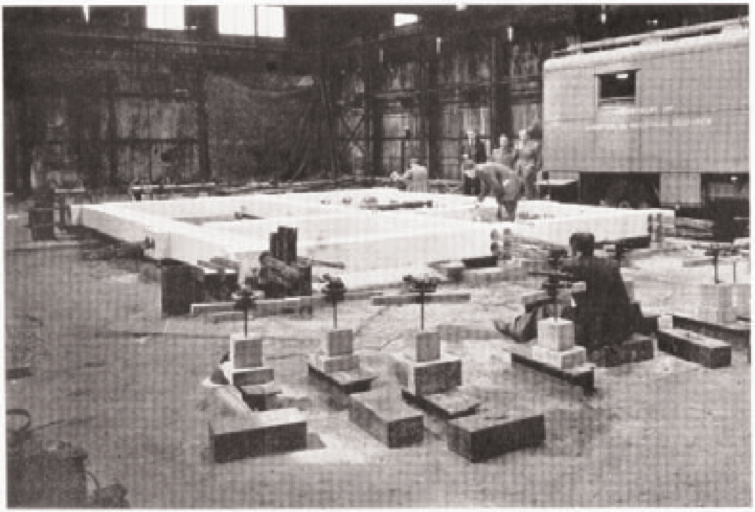


Fig. 4.—The frame shown resting on rollers and undergoing a load test.
Note the anchoring and the fixing of the frame to the R.S.J's. The steel prop used for imposing the load is shown in the background.

Prestressed concrete 3 & 4

The foregoing should serve to demonstrate the necessity of employing high initial tensile stresses on the pre-stress wires (150,000 lb. per sq. in.) and will also explain why early attempts at pre-stressing with lower initial tension (32,000 lb. per sq. in.) did not prove as successful. Furthermore modern improvements in cements, methods of mixing and curing as well as methods of pre-stressing have tended to minimize the combined effects of these losses and to render the utilization of this new form of construction economical and practical.

A Few Examples of Recent Applications

Aircraft Hangers were built recently by Messrs. Gammon in India to the design of Dr. K. W. Mautner, Chief Engineer of the Pre-Stressed Concrete Company, London.

Two such hangers were built in Meerut and one in Karachi.

The main features of the design were the $2\frac{1}{2}$-in. thick concrete shell vaulted roof, the 6-ft. high tie beams, 120 ft. to 130 ft. span with ribs of a 9-in. thickness only. These tie beams were reinforced with five non-bonded pre-stress cables each consisting of 32 in. × 1/5 in. diameter wires (i.e., 1 sq. in. of steel per cable).

In the Karachi hanger the door beam had a span of 194 ft. and supported five concentrated reactions from the tie beams of 93 tons each. The resultant maximum bending-moment was 23,200 tons ft. and the shear force amounted to 435 tons.

The depth of the door beam was 22 ft. at midspan and the width of the flanges was 4 ft. 6 in. The thickness of the web at midspan was 9 in. only. This beam was reinforced with 28 pre-stress cables (each 32 wires 1/5 in. diameter, i.e., a total of 28 sq. in.). These cables were bent up in catenary shape curves and were anchored at the ends by male and female cones.

The weight of steel used amounted to about 8 tons per door beam as compared with 100 tons of steel that would have been required for a steel beam of the same depth.

Fig. 1 shows the Luzancy Bridge constructed recently in France.

The bridge was designed by M. E. Freyssinet, the pioneer of pre-stressing and erected by Messrs. Campenon-Bernard, the French Contractors.

The bridge is 180-ft. span and was built on existing abutments. Of interest are the main girders which were pre-cast in short lengths and in hollow sections. The short lengths were formed into complete units equal to a part of the full length of the span by pre-stressing with non-bonded cables. The parts of each girder were then lifted into position by specially designed derricks and finally formed into full lengths by a second pre-stressing operation applied to the complete unit. A layer of stiff mortar coating was applied to contact surfaces prior to pre-stressing in order to ensure even butting. A complete description is in the course of preparation.

Fig. 2 shows the pre-cast concrete male and female cones used when pre-stressing with non-bonded cable reinforcement. The female cone is a $3\frac{1}{2}$-in. diameter and 4-in. high hollow cylinder with an inside cavity tapering from 2 in. at one end to 1·1 in. at the other. It is reinforced with a close coil of 1/10 in. diameter hard steel wire which is exposed on its inside tapered face and with an "open" coil of 1/5 in. diameter steel wire around its outside cylindrical surface. As explained, this female "cone" is embedded in the concrete with its top flat surface (nearest to the camera) exposed flush with the top of the concrete or exposed a few inches below. The cable wires pass through the inside conical cavity and fan out to leave an annular space for the male cone.

The double-acting jack will be subsequently made to rest on the top flat surface of the female cone. The male cone or plug consists of concrete encased in a closely wound hard steel wire coil (1/10 in. diameter) it tapers from $1\frac{1}{2}$-in. down to $\frac{3}{4}$-in. diameter and has a $\frac{1}{2}$-in. diameter annular hole for the injection of grout.

The cones illustrated are suitable for 8–10 or 12 wire cables (1/5 in. diameter wires), i.e., initial pre-stressing forces of 16·7 tons, 20·8 tons and 25 tons and final pre-stressing forces (i.e., after deducting elastic deformation, creep, etc.) of about 13·5 tons, 16·5 tons and 20 tons respectively.

The Slough Test Frame

Figs. 3 and 4, illustrate details of a test carried out recently in the Slough factory of Messrs. Structural and Mechanical Development Engineers (of the Almin group) to the design of Dr. K. W. Mautner of the Pre-Stressed Concrete Company, London.

The object of the test was to demonstrate that separately pre-cast beam and column elements could be effectively assembled into complete frame units by pre-stressing with non-bonded cables.

Three beams and six columns were pre-cast and assembled by pre-stressing into two separate frames which were subsequently formed into a complete double-storey frame by welding steel plates which projected at the bases of the upper columns to corresponding steel plates at the tops of the lower columns.

The complete frame was lowered on to prepared abutments and was fixed to the ground at its base.

Hydraulic jacks were used to impose test loads on the frame. One series of test loads represented the action of wind pressure by imposing a load on the top right-hand joint (see Fig. 4) and another series of test loads represented the action of the superimposed loads (Note the steel prop and the hydraulic jack in the top right hand corner of Fig. 4). The test was carried out by the Building Research Station under the supervision of Dr. F. G. Thomas.

Acoustic strain gauges, mirrors and deflection dial gauges were used to record strains, angles of flexure and deflexions.

The test has proved successful and developments are now taking place (by the Structural and Mechanical Development Engineers of Slough, Bucks) to adapt this form of prefabrication and assembly to multi-storey structures as well as to other buildings where the elimination of timber shuttering coupled with the great economy in steel and erection time will be of great advantage.

Editor's Note—The following authors have published papers on the subject and further details of such papers can be obtained on application to the Secretary, Institution of Royal Engineers, Chatham.

E. Freyssinet, K. W. Mautner, T. J. Gueritte, H. Schorer, R. S. V. Barber, D. R. Lester, Prof. R. H. Evans, Prof. Ross, and the Building Research Institute.

THE CROSSING OF THE IRRAWADDY BY 4 CORPS FEBRUARY, 1945

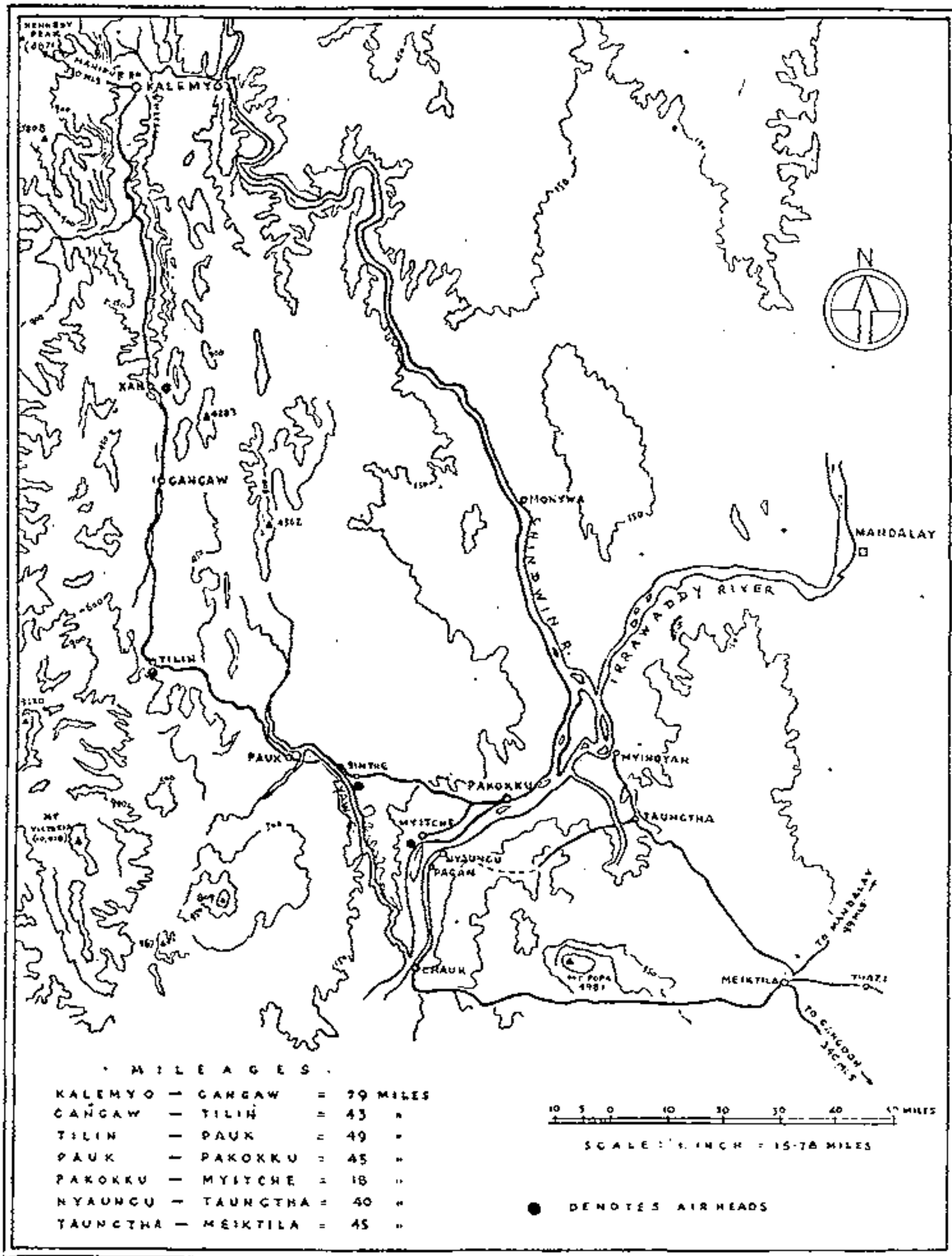
By Colonel A. Murray

THE early days of 1945 saw stirring events in Europe which overshadowed the campaign in Burma. A security black out and the fact that S.E.A.C. was a long way from home resulted in scant attention being paid by Press and Radio to the operations of 14th Army. This was especially the case where 4 Corps was concerned as it was supposed to be moving in an attenuated form across Northern Burma whereas in fact the Black Elephant was charging through the jungle with its tusks pointing south. One result of all this was that no details of its doings became known until long after they had happened. When the Japanese in Burma had been beaten and there was no further need for secrecy, our armies in the west were moving into Germany and V-day was in the offing. It was, therefore, hardly to be expected that the Irrawaddy could compete with the Rhine, except in the thoughts of those who had actually crossed it. All the same the crossing was a notable operation, especially from the point of view of the sapper, and deserves some limelight, albeit somewhat belated.

At the end of January, 14th Army was well on its way towards the reconquest of Burma, although the Japs probably didn't realize it. 15 Corps working independently, was pushing along the Arakan Coast and had taken Akyab, while 33 Corps had crossed the Chindwin and was deploying southwards towards Mandalay. 4 Corps was moving down the Gangaw Valley with 255 Tank Bde. and 7 and 17 Div. under command, and was to put itself astride the Jap L. of C. at Meiktila. It was maintained entirely by air. This was an ambitious plan which gave the sappers many headaches of a type unknown in the West. The first problem was to get the Corps along the cart track down the Gangaw and then over a narrow hill road into the Irrawaddy Valley. The second was to cross the River itself, in few places less than a mile wide between firm banks. Although we are primarily concerned with the River, the two problems were complementary and the approach march cannot be dismissed lightly.

From Kalemyo to Pakkoku near which the crossing was to take place, is 230 miles (see Map 1)—a pleasant day's run in the family car at home. Unfortunately, few people had cars in that part of the world before the war, and bullock carts and elephants were *de rigueur*. The road was scarcely suitable for Sherman Tanks and Diamond T Transporters, let alone 6,000 vehicles, ordinary and extraordinary. Nor did it favour the lorries of the Bridging Company with their attendant train of 5 tonners borrowed from the L. of C. These vehicles had seen better days and protested at the exertions they were called upon to make in their old age. It was only the promise of an honourable grave in the Irrawaddy that forced them forward to their journey's end.

The road for the first 140 miles as far as Tilin, was never less than 12 in. deep in dust—dust which varied in colour from Elizabeth Arden's face powder to terra cotta. In spite of the frenzied efforts of the sappers and their motor graders and dozers, this stretch claimed many victims and the convoy



· 4 CORPS ADVANCE THROUGH BURMA ·
· FROM KALEMYO TO MEIKTILA ·

Map 1.

commander felt satisfied if he could make 50 miles by nightfall with the head of his column, and spend the next day bringing in most of his lame ducks. From Tilin to Pauk came the hill section. The surface here was better till the tanks got at it but the gradients were severe and the corners designed for Jeeps. Moreover it was so narrow that it was quite impossible to move against the traffic. Sappers working on the road had their rations dropped by parachute as they could get neither forward nor backward to fetch them for themselves. Bridging lorries which could not make the grade were either pushed over the hillside or pulled to one of the few passing places, there to languish for several days till the overworked recovery vehicles could deal with them. One pontoon vehicle gave up the ghost astride a hairpin bend. It could not be unloaded as there was a chasm just behind it, nor could it be pushed over the side as there were two senior R.E. Officers present. The only solution was to attach 100 men to its anchor cables and haul it by brute force out of the way.

The difficulties of the approach march have been dealt with at some length. How easy it was in a TEWT to bring the Bridging Equipment to an Assembly Area, loaded to taste, and in good order and military discipline. How different was it in practice! The Base was at Manipur Road, 370 miles from the start of the route just described, and it was hardly to be expected that all the equipment would be serviceable, even if its vehicles survived the journey, especially as few pontoon and F.B.E. lorries were available. Many bits and pieces fell off, some had been badly packed and were damaged, some never arrived at all and others struggled in so late that the operation was nearly over before their loads could be put into the water. We had done our best to sort it all out in the Gangaw Valley, but there was no time to do it properly. We had, however made good use of the delays on the approach march—tactical and topographical. Engineer Units which were to take part in the crossing had been given some polishing up training with outboard motors and a composite platoon of the best drivers had been organized. A R.E.M.E. detachment had set up a hospital and convalescent depot for these temperamental machines. These preparations took place about 140 miles from the River and at this point we felt we had the mechanical side of the business taped. How much happier we would have been had this overhaul been possible at the end of the journey! Luckily for us, when we reached the river, a reserve of equipment could be flown in to an airhead* we had established 35 miles from its banks, and we faced the crossing with a reasonable array of pontoons, motor boats, outboard motors, folding boats, assault boats and dukws.

The Irrawaddy near Pagan, where it had been decided to cross has no "treacherous current" beloved of the journalists, and is a very ordinary stretch of water. The wet gap was 1,200 to 1,500 yds. and the beaches were so situated that loaded rafts had to cross slightly upstream and generally upwind. Nowhere did the current exceed 1½ knots although it had been reported by reconnaissance and by locals as anything between 3 and 5 knots. On the west bank, the approach was over 600 yds. of very soft sand ending at the water's edge in a bank about 4 ft. high at a slope of 1/1 with at least 2 ft. depth of water, 10 ft. from the shore. On the east bank there was a slope of baked clay ending in a vertical bank varying in height from 2 ft. to 12 ft., with deep water close in shore.

These conditions stretched along the banks for 500 yds. only, with muddy flats and shallow water both upstream and downstream. Landing stages and equipment were, therefore, congested and were a perfect target for air attack.

* The construction of this airhead was an outstanding piece of work by 457 Forward Airfield Engineers, R. Bombay S. & M. (Lieut.-Col. B. Utting).

The crossing was to be made in the following stages, the whole operation rejoicing in the name of "Multivite."

Vitamin "A"	Capture of Pakkoku and concentration of 4 Corps in the crossing area.
Vitamin "B"	Establishment of a Bridgehead over the River Irrawaddy.
Vitamin "C"	Concentration of the Corps on the left (further) bank of the Irrawaddy.
Vitamin "D"	A lightning overland thrust assisted by an airborne build up, to seize the Meiktila-Thazi area, followed by the liquidation of the Japanese forces between 4 and 33 Corps.

Vitamin "A" has already been described and Vitamin "D" does not concern us. Vitamin "B" was the task of 7 Div. with the Engineer responsibility vested in the C.R.E., while Vitamin "C" was to be undertaken by C.A.G.R.E.

VITAMIN "B"

C.R.E. 7 Div. had under his command his own Fd. Coys. plus 36 Ind. Fd. Sqn. and two Fd. Coys. of 17 Div. The necessity for speed and secrecy made his job very difficult and he could not pause to sort everything out as thoroughly as he would have liked, but by the evening of D minus 1, he had succeeded in concentrating his men and equipment as close to the beaches as he was allowed to go. The last stage of the journey was no picnic, and the ancient bridging lorries only reached the bank 1½ miles away, after 5 hours of toil and sweat. At one moment the C.R.E. almost despaired of getting them there before daybreak and felt like asking for a 24 hours postponement of the assault. However, he courageously refrained from doing so and by 01.00 hrs. on D-day the off loading points had been reached. But this was not the end of the story. The water was still 500 yds. away across the softest sand in Asia, and the assault craft had to be man-handled to the launching points at "C" beach. The plan was roughly as follows (see Map 2):—

One company of infantry was to make a silent assault from "C" beach before dawn and establish itself on high ground above the selected landing beaches. This was to be followed just before light by the rest of the Battalion in assault craft manned by the composite Outboard Motor Unit. The route from "C" beach to the landing points on the far side was about 4,300 yds. long and ran between two difficult shallow sand banks. The assault boats, on disembarking the infantry, were to return to "B" beach which was in a direct line with the opposite beaches and only about 1,800 yds. away.

The first silent assault party embarked very quietly and disappeared into the night, whilst the main sapper party stood by. No sound was heard and it was cheering to think that the infantry had established themselves without interference. They had, in fact, achieved complete tactical surprise. All would have been well had the remainder of the Battalion been able to get across before daylight but this was not the case. Outboard motors refused to start and the infantry did not embark as quickly as had been expected. There had been no opportunity for a rehearsal and the two parties had not trained together. When daylight broke, boats were strung out across the river and as they approached the far bank, small arms fire was opened on them from the cliffs and beaches. Some boats put back to their own bank and others were sunk, with the result that the assault was only partly successful and the infantry and sappers both sustained heavy casualties. All this time the enemy positions were being heavily straffed by close support aircraft and by the gunners, and it was not long before the remnants of the first wave and fresh waves of infantry overcame the opposition and formed a secure bridgehead. By nightfall, three Battalions with essential vehicles and some Shermans were across the river. They had travelled on Class 40 Bailey rafts from " C " beach and by F.B.E. rafts from " B " beach. The building of the Baileys was a remarkable achievement by 36 Fd. Sqn. as every single bridging lorry had to be hauled across 500 yds. of the softest sand in Asia by Dozers. Nevertheless, they soon had three 70 ft. rafts disgorging tanks and other vehicles on the other side. It may be argued that bad planning and execution allowed the initial setbacks to occur, but it had been decided to get across at the earliest possible moment and to rush the operation through before the Japs had an inkling of our intentions. A day's delay would have meant a much tidier operation but might have caused heavier casualties in the long run. The enemy was strung out over many miles of river and was weak everywhere. Given time, he might have succeeded in concentrating a force at the crossing point. The casualties suffered were most unfortunate but were not a high price for the results achieved.

D+1 was spent in ferrying the balance of the leading Bde. and its attached tps. from " B " and " C " beaches, while the infantry and tanks ferreted the enemy out of the catacombs and fox holes which still lay between them and Nyangu where the main crossing was to take place.

Vitamin " B " had been a success after a shaky start.

Vitamin " C "

A reconnaissance of the river banks on D+1 confirmed the plan to plump for " A " beach and it was decided to waste out the resources at " B " and " C " beaches as soon as possible. C.A.G.R.E. took over at 06.00 hrs. on D+2 with the following sappers under his command,

7 Div. Engrs.	C.R.E. 7 Div. Engrs.	(Lieut.-Col. T. Wright, R.E.)
	62 Fd. Coy.	Q.V.O. Madras S. & M.
	77 Fd. Coy.	K.G.V.O. Bengal S. & M.
	421 Fd. Coy.	Q.V.O. Madras S. & M.
	331 Fd. Pk. Coy.	Q.V.O. Madras S. & M.
17 Div. Engrs.	60 Fd. Coy.	Q.V.O. Madras S. & M.
	70 Fd. Coy.	K.G.V.O. Bengal S. & M.

(Note.—The remainder of 17 Div. Engrs. were otherwise engaged—one Coy. preparing for an airborne operation—and the C.R.E. (Lieut.-Col. Ffoulkes) could not be spared from Div. H.Q.)

4 Corps Tps. Engrs.

C.R.E. 4 Corps Tps. (Lieut.-Col. H. A. MacDonald, R.E.)

	2 Faridkot Fd. Coy.	Indian State Forces
	75 Fd. Coy.	K.G.V.O. Bengal S. & M.
	424 Fd. Coy.	Q.V.O. Madras S. & M.
	305 Fd. Pk. Coy.	R. Bombay S. & M.
255 Tank Bde.	36 Fd. Sqn.	Q.V.O. Madras S. & M.
Army Tps.	854 Ind. Bridge Coy., I.E.	

In addition, 12 (Madras) Ind. Eng. Bn. (Lieut.-Col. Rossell), and one Mech. Eqpt. Pl. I.E. who were working on the road, came into the crossing area a few days later.

All the Corps Tps. Fd. Coys. did not arrive for the first stages of the ferrying operation, as they could not be released from their road making duties, but nearly the whole sapper Army was concentrated by D+4.

D+2 and D+3 were disappointing days on "A" beach. The indispensable track manufactured by "Mr. Sommerfeld" should have reached us on D-day. At the forward airhead, Dakotas and Commandos landed in a continuous stream but disgorged everything but Sommerfeld from their bellies. Eventually the welcome rolls appeared—alas, with few pickets, no selvidge bars, and no backing material. Infantry working parties tore asunder the nearby villages to make a substitute track, while dozers and teams of soldiery hauled the bridging vehicles across the sand to the water's edge. At nightfall on D+3 these strenuous efforts had resulted in the construction of sufficient landing stages and rafts for a reasonable programme of sorties to be planned for D+4. Moreover the "B" and "C" beach flotilla floated down to join us in the evening having done yeoman service until we were ready for them. Sommerfeld had at last arrived complete with his accessories and a main road and branch tracks to each landing stage were ready to take the traffic. Impatient Brigadiers, and even heavier guns, were by now asking us when we were really going to get started, as our not so grand total of sorties for the first two days had only been 188. Drawing a bow at a venture, we told them to send us 500 vehicles the next day, and not to be surprised if a few were left to spend the next night on the beach. Our fears were unnecessary. The maddening delays and difficulties were over and the crossing started to go with a swing. 307 sorties were completed and the 500 vehicles all spent the next night on the far bank. The decision had been made to work a 12-hour day making full use of the hours of the daylight. A certain amount of pressure had been brought to bear to make us work at night but we held out against it. We had no relief crews and accidents would have been inevitable in such a congested site especially as there was no moon. This would have cut down our output for the rest of the operation by reducing the amount of equipment available. As it was, not a single accident occurred while we were on the river and during that time upwards of 20,000 vehicles of all types were ferried across. Although night work was off, there was no nonsense about the 12-hour day. If the first flight of rafts from every landing stage had not started on its journey by 06.15 hrs., no quarter was asked or given. The C.C.R.A. was in charge of Traffic Regulating H.Q. and saw to it that the Police and the Gunner Officers who were feeding the traffic forward were in position punctually. A stream of vehicles had to be ready at each landing stage, and the rafts were manned and their various engines ticking over. The Fd. Coys. became so keen that half the rafts invariably beat the starter's gun. At 18.15 hrs. the same punctuality was observed and any late comers however important they thought they were, had to doss down on the sand.

On D+5 we topped the 400 sortie mark and matters were progressing so favourably that the few rafts left on "B" beach were told to move to "A" the next day. A private navy of local sampans was left upstream to look after the Brigade which had carried out the original assault. The Commodore, a figure well known to "Ilex" in better days, flew his broad pennant in the most impressive vessel of the fleet and made subtle attempts to steal our motor boats and outboard motors, but without avail.

The next day we further increased our sorties and determined on D+7 to beat all records. By now the whole Sapper Army was in position, except for those who had already left us to join their formations for Vitamin "D."

We had at our disposal 8 landing stages on each bank—4 for F.B.E., 2 for Cl. 18 Mk. V. Pontoon rafts and 2 for Cl. 40/70 Bailey rafts. The number of rafts and units to man them varied day by day and hour by hour. Companies left for the Meiktila dash and handed over their duties to new arrivals from "B" beach while the availability of DUKWS and motors never remained constant. The average number of rafts at the peak period must have been

Class 9 F.B.E.	16
Class 18 Mk. V. Pontoon..	7
Class 40/70 Bailey..	6

We had been asked to make a special effort on D+7 to ferry 1,000 vehicles across the river in the 12 hrs. A thousand Jeeps would be child's play, or even a thousand three tonners, but we had to compete with the inevitable gunner with about half a dozen limbers hanging on to the back of his tractor. This was counted as one vehicle. So were the suspended tows and the two 7·2 in. hows., known as Gert and Daisy, who more than once on the L. of C. had given us a packet of trouble. Their favourite food was ribands which they crushed with their enormous jaws, while their only saving grace was that a couple of Jeeps could nestle beneath their barrels on a raft. No one who did not see 14th Army on the move can have any conception of what its transport looked like. Its vehicles were aged and as they broke down they were converted into home-made trailers and towed behind their stauncher brethren. There were hundreds of these trailers in addition to the official ones and they all took up deck space and didn't count as two vehicles. However, by now our Gunner friends were adepts at packing the three types of raft and could get eight Jeeps and a Sherman Tank on to a Bailey and an impossible amount of miscellaneous transport on to the others. The result of all this was that by 15.15 hrs. the thousand vehicles were finished with, traffic dried up and the Sappers had a half holiday. They had become good watermen and were thoroughly conversant with the idiosyncracies of their motors. There was no delay in casting off or coming alongside and the whole show went with a swing. All three Corps of Sappers and Miners were represented and competition was terrific. Great efforts, too, had been made to create the right atmosphere. Each raft flew its Company " House " Flag and had established its shipping office complete with advertisements, on the beach. These varied from the slogan variety " Don't waste time, Travel by Red Line," " Quickest and safest by Blue Line "—to an enormous archway extolling the virtues of the " Irrawaddy Steamship and Transport Coy." The control tower housed the " Clerk of the Course " of the " Irrawaddy Regatta " which became the popular name for the whole operation, while a large board labelled " Form at a Glance " showed the progress of sorties day by day. The scene resembled Margate on a Bank Holiday, with the female element represented by the W.A.S. (B) Canteen which did a daily trip. Picnic and bathing parties were much in evidence and tea was being brewed everywhere. Although there were no side-shows the B.O.R. did his best to liven up proceedings. Every vehicle in 4 Corps had at least one hen or duck sitting in it, and great excitement was caused when three ducks were produced out of a three tonner and given a swim behind their raft on the end of a piece of string. Unfortunately they could not last the pace and had to be removed from their natural element after a few delighted quacks.

This hardly sounds like war and we were lucky that it worked out like this. The speed of the advance and the secrecy maintained had completely foxed the Jap, who thought that a small force of ours might try to cross at Chauk many miles downstream. The result was that he had no artillery to oppose us. His air effort was confined to one straffing attack by eight " Oscars " whose only bag was a motor boat sunk, a damaged raft and 4 casualties to the Sappers.

From D+8 onwards the ferry became a humdrum affair, still with a large output, but traffic never reached dimensions which taxed its capacity. Anything up to 400 sorties a day were completed, but this was mere child's play and unit commanders took the opportunity to train their clerks, storemen, and batmen in the arts of watermanship. Our Engineer battalion also took over a number of rafts and were soon as expert as the Field Units.

We had all thought that rafting was a slow business. Events proved otherwise. In the peak period, lorries could not move down the approach road fast enough to feed the rafts. The capacity worked out at about 120 vehicles per hr. in one direction, while it was possible to pass vehicles in the opposite direction at the same time. Rafting may even have been quicker than passing traffic both ways across a hypothetical single way bridge 1,500 yds. long.

The whole operation may perhaps seem rather light-hearted by European standards but it was one of the most important factors in the defeat of the Japanese in Burma. It enabled 17 Div. and 255 Tank Bde. to appear at Meiktila before the Japs could make any changes in their dispositions, and it was in the Meiktila area that the Jap forces in Burma were destroyed by 4 and 33 Corps. The part which the Sappers of 4 Corps played was recognized by the Corps Comd. in the following signal sent to the C.E. (Brigadier W. W. Boggs, C.B.E.) :—

> " I wish to congratulate all engineers of the Corps on the splendid success of their work during the operations to date. It is by their skill and energy amounting often to continued exertions both by day and night that the Corps with all its heavy equipment has first been passed over an extremely difficult jungle country and mountain track, and secondly put across a vast river in ten days. Speed has been the essence of our success. Speed has been achieved by the supreme effort of our engineers in spite of jungle, mountains and rivers and often with faulty equipment. I wish all ranks to realize the great part they have played in our success to date and I would be grateful if you would pass on to them my thanks for their magnificent work."

Appendix " A "

Lessons Learnt

1. Methods of Propulsion

Class 9 *Rafts.*—The ideal is to have one motor on each of the four folding boats. They should be fixed to brackets if available, but the boat will stand up to motors without brackets for at least three weeks constant use. In a weak current the 9.8 h.p. motor is adequate, but directly the wind begins to blow, or in a current exceeding three knots, two 22 h.p. motors must be used. Some rafts were propelled by two motors on the outside boats with a Mk. III assault boat propelled by an outboard motor attached to the centre and pushing. This is a great aid to steering. The time of turn round under these conditions was reduced to about 30 minutes. The DUKW can be used for pushing these rafts but in this case the landing stages were too close together to give it room to manœuvre.

Mk. V. Pontoon Rafts.—Two types were used (*a*) the Batwing, working to improvised landing stages and (*b*) the Class 18, four-pier raft, working to a pontoon half floating bay, with raft connectors. The batwing is economical in equipment but uneconomical as a load carrier as it is designed to carry one heavy vehicle and is most unsafe with two three tonners on it. There is also no saving in the time of turn round. It was soon given up and all Class 18 rafts were of the four pier type. These rafts were ideal for heavy guns or for two heavy lorries, and for the assorted uneconomical loads which appeared from time to time at the ferry point. Whenever anything out of the ordinary arrived, it was immediately sent to their landing stages. Propulsion was either by Motor Boat pushing or by two propulsion units pulling in the bows of the inside pontoons. The motor boat (the type issued with the American Pontoon Equipment in this case) was quicker but not quite so manœuvreable. The Petter engine (if reasonably new) gives very little trouble and is much more reliable than the outboard motor. The usual trouble with the bevel drive of the propulsion unit itself was experienced.

Class 40 *Rafts*.—Both Class 40/60 and 40/70 were used. It was found that fewer rafts of 40/70 were preferable to more rafts of 40/60. The longer one with five piers not only gives larger deck space but is much easier to trim, thereby facilitating coming alongside and casting off. The 70 ft. raft with four piers is not considered satisfactory as the outside pontoon is liable to go under water if the heavy load is not accurately placed. These rafts (40/70) will take one tank and two 15 cwt. trucks or other light vehicles. They will also carry assorted loads, such as a matador towing a 5·5 in. gun, a three tonner and a Jeep. The only practical method of propulsion is the motor boat or the DUKW pushing, with steering reins to the outside pontoons. Propulsion units are only useful as stand-bys.

Great care must be exercised in loading the vehicles in the right order, so that they are symmetrically placed. Good traffic control is vital.

The Outboard Motor.—This is a temperamental piece of machinery and many hard words were said about it and Mr. Johnson, its maker, in the early stages. They frequently refused to start in the morning, mainly due to lack of proper covering overnight and to faulty carburettor adjustment. The oil also separated out from the petrol and gummed up the plugs, unless it was stirred before starting work. Once the raft crews had got used to them, however, there was no further trouble. It is considered essential to have a special detachment on the site to recondition the motors as they become unserviceable. We were lucky enough to have at our disposal the services of a R.E.M.E. Major, who was an outboard motor racing enthusiast in peacetime, and without him and his detachment it would have been difficult to keep all rafts supplied with strong "runners."

DUKWS and Motor Boats.—There is little of interest to say about these machines. They are undoubtedly the answer for heavy rafts and must be used as pushers. The DUKW bow is quite strong enough, although the drivers were anxious to use them as tugs to start with. If you have ten DUKWS, you can only rely on having about six in the water at any one time, as they require a lot of maintenance. They must be given a well made "slide" into the water as they dislike mud intensely, and although good swimmers, are indifferent divers.

2. Stores and Equipment

In a combined operation, stores and equipment can be loaded under careful supervision, complete and in the right order. In a river crossing such as this, at the end of 250 miles of an L. of C. consisting of mountain track and unmetalled road, it is a different proposition. Many vehicles broke down and their contents arrived at the site as much as ten days late in some cases. There was no time to assemble the equipment near the river and sort it out. Moreover, the loading had taken place at several different places and in many different types of vehicle. Time is bound to be spent in putting things right, and if time is not given at the assembly point, at least one day is likely to be lost in reorganization.

Apart from the stores carried by road, a large tonnage was flown in. However accurate the lists given to Rear Air Maintenance Organization, and however efficient that organization may be, the stores will not arrive in the right order and complete, unless a representative of the user is sent to assist him. This lesson was not learnt soon enough as the fly-in organization was new. It is suggested that in any future operation of this sort, which depends so much on the timely arrival of certain stores, there should be a staff officer sent to R.A.M.O. who is completely in the picture. An Officer was eventually sent and effected an immediate improvement.

3. Landing Stages

There were 4 F.B.E., 2 Mk. V. Pontoon, and two Class 40 landing stages on each bank over a distance of 500 yds. This is too close and rafts interfered with one another. There were, however, no serious accidents at all and not a single vehicle was lost, nor were any rafts seriously damaged except by enemy action. The time of turn round was affected by extra care in manœuvring and by rafts having to wait offshore of their own landing stages while other rafts cleared adjacent stages. One landing stage is required for every four F.B.E. rafts and one for every three Mk. V. Pontoon and for every three Bailey rafts. The number of stages would, of course, have to be increased on a narrower river.

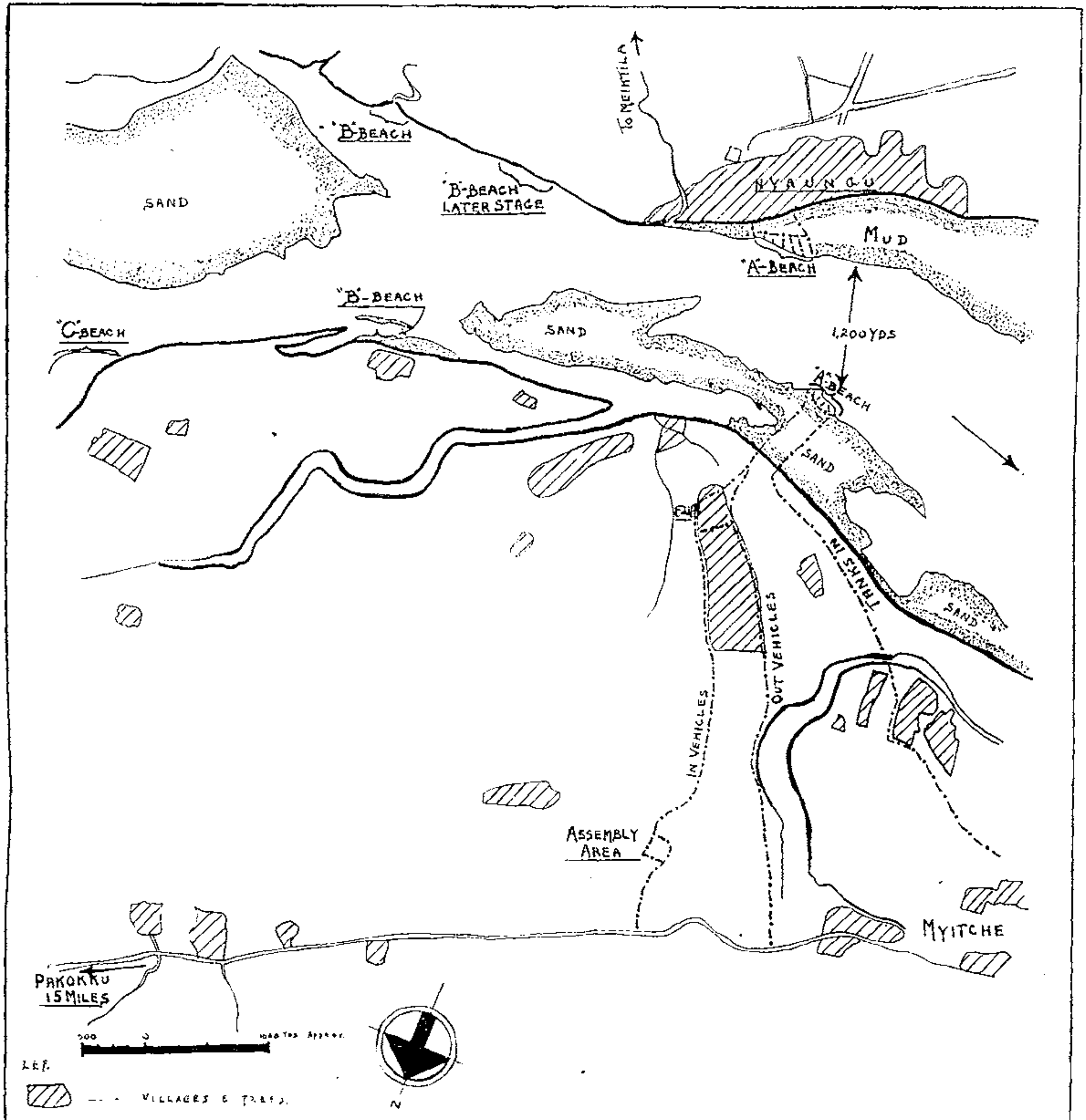
4. Miscellaneous

(*a*) A central mixing organization for outboard motor P.O.L. is desirable. All tanks should be topped up before knocking off work for the day. A central dump for motor boat, DUKW and Petter engine petrol should also be established.

(*b*) Class 40 landing stages need constant attention if the water level fluctuates daily, which the Irrawaddy does. If a spare stage is not available, a special party must be detailed out of normal rafting hours to adjust the level. Otherwise output will be seriously reduced.

(*c*) Telephone communication solely for Sapper use between control H.Q., far bank H.Q., and each group of ferry points must be established immediately. R/T is not good enough.

(*d*) A rescue boat must be constantly on duty downstream of the ferrying area to rescue rafts which have broken down.



SITE OF IRRAWADDY CROSSING.

COMMUNICATIONS WITHIN THE DIVISIONAL ENGINEERS

By Lieut.-Col. M. C. A. Henniker, D.S.O., O.B.E., M.C., R.E.

IN 1939, every fighting unit in the division except the Sappers had signal officers, signallers, cable detachment and wireless. It was not till 1942 that the Divisional Engineers received wireless sets and they still have no cable detachments. It is, therefore, not surprising that we are, as a Corps, not very "signals-minded." This has been a great handicap in battle to the Divisional Engineers themselves—particularly to the H.Q.R.E.—and to the Divisional Staff.

The C.R.E. himself usually knows what is going on from personal observation. H.Q.R.E., however, only knows what it is told through the signals network within the Divisional Engineers. There is no operation of war in which H.Q.R.E. can afford to be out of touch with the work of the sappers, as it is from H.Q.R.E. that the C.E's Staff and the Divisional Staff get their information.

Objects of this Paper

This paper is written with three objects :—

(*a*) To outline the requirements of a communication system in the Divisional Engineers.

(*b*) To indicate the short comings of the present system.

(*c*) To make some suggestions for improvement.

Requirements

Before entering into details of the requirements that must be fulfilled by the signals of the Divisional Engineers a word is necessary on organization. There is talk now-a-days of organizing the Divisional Engineers as a battalion. It seems that this is not likely to affect the signals problem. The sapper work to be done will still crop up in the same places—some far forward, some on the flanks and some in the rear. Wherever the battalion H.Q. is situated it will want to be in touch with all the work, and Divisional H.Q. is probably as central as any other place. It is, therefore, assumed that the H.Q. of the Divisional Engineers is near Divisional H.Q. To avoid dealing with the unknown, reference in this paper is always made to the present organization.

It is convenient to begin at the front. The sapper nearest the enemy is probably the Recce Officer. He must be in touch with the following :—

(*a*) The leading infantry, probably verbally.

(*b*) The leading field company, and the O.C's Rover.

(*c*) The leading Armoured R.E.

(*d*) H.Q.R.E. and the C.R.E's Rover.

(*e*) The other Recce Officer from his company (if out).

Lastly, if he has to dismount from his car and go on foot, which is often necessary, he must be in touch with his car. He, therefore, must have a man-pack set with a signaller and a relay set in his car. The set in his car must have a range that will reach H.Q.R.E. This last can be achieved with a less powerful set if there is a regimental net—of which more later. It is submitted that the Equipment Tables do not provide for this.

Next on the scene is probably either the Armoured R.E. or the leading field company in whole or in part. They, too, need similar communications. But in addition they may need communications to the bridge section of the field park company, and the field company commander himself must be in touch with H.Q. of the leading brigade. He cannot command his company and live at Brigade H.Q. There must be a wireless or cable link. Finally, the leading R.E. unit always has to have an administrative link with H.Q.R.E. Leave vacancies and E.N.S.A. concerts have a habit of turning up during an action and the overworked wireless net cannot be "cluttered up" with these things. There must be a cable communication too ; and the Equipment Tables do not provide for it.

Not far behind the leading field company there may be the bridging platoon of the field park company or a platoon of tippers or a pool of bulldozers. These require to be in touch with the leading field company, their own company and H.Q.R.E. The present organization does not provide for this.

H.Q.R.E. may be next on the line of march. They must have communication to :—

(*a*) Divisional H.Q. (verbally or by telephone).
(*b*) All field companies and the field park company.
(*c*) The Armoured R.E.
(*d*) All Recce Officers.
(*e*) All Brigade H.Q. (Divisional Command net or line).
(*f*) Flank divisions' H.Q.R.E. (on R.E. Rear Link).
(*g*) C.R.E's Rover.
(*h*) Tipper or bulldozer pool.
(*i*) Both F.E's.
(*j*) C.E. on the Rear Link.

The communication to field companies must be by line as well as by W/T. This can often be achieved through the divisional cable organization, but not always. A cable detachment seems essential. Its task may be to lay a cable from H.Q.R.E. to field companies, or branch cables to field companies from brigade, etc., exchanges. Most C's R. Signals agree that this cannot be guaranteed at present.

It is submitted that H.Q.R.E. on the present Equipment Scales cannot maintain touch with the Recce Officers (their sets have not the power) and that the line communications cannot be guaranteed.

The C.R.E's Rover needs special consideration. This needs W/T to all stations enumerated under H.Q.R.E. requirements. The C.R.E. must also be able to listen in on the divisional command net. On the present Equipment Scales he cannot do this. He should have his main set netted to his own command net with a flick to the divisional command net if called for. But he only knows when he is called for if he has a listening set on the command net. The present Equipment Scales do not provide for this. The same applies to the field company commander's rovers *vis-à-vis* brigades.

Last in the list comes the field park company. The field park company is liable to get very dispersed. H.Q. is in one place. The stores platoon and the workshops cannot function *and* move and may get separated from H.Q. The bridge platoon is frequently detached. All must be in W/T communication with company H.Q. It is submitted that the present Equipment Scales do not provide for this.

Appendix A (facing page 32) shows in diagrammatical form the communications required. The sets with the Armoured R.E. have been omitted from the diagram as their set-up is too elaborate to include in this paper.

A Regimental Net

Broadly speaking, there are two ways of organizing the signals of the Divisional Engineers.

(*a*) A command net and four company nets. This only demands a low standard of signalling but it necessitates many sets. There are many drawbacks. H.Q.R.E. is not in a position to speak direct to a platoon on the work, because they are on different frequencies. Recce Officers cannot speak to both the leading platoon and to H.Q.R.E. as they, too, are on different frequencies. This is the " mugs' way." It was almost universally adopted in N.W. Europe.*

(*b*) A regimental net. This presupposes everyone being on the same frequency—Recce Officers, field company H.Q., field company commanders' rovers, field company platoons, H.Q.R.E., C.R.E's rover, etc. In fact, everyone in the Divisional Engineers who has a set is on the regimental net. By this system it is almost impossible for anyone to get so far away that communication is lost altogether. It saves many sets. For example, at field company H.Q. on a regimental net one set can speak to H.Q.R.E. *and* to platoons, whereas on command and companynets two sets are needed as there are two frequencies. The drawbacks to the regimental net are two. First, a very high standard of wireless procedure is needed. There are 32 primary sets and 6 man-pack sets on the regimental frequency (c.f. armoured car regiment with 57). Secondly, administration must be handled by cable or other means. It is not possible to handle administration and operations on so large a net.

Reasons for Failure of Present System

It has been shown that a regimental net is the most economical in sets. From Appendix B it will be seen that the total number of sets required is 32 primary sets and 6 man-pack sets on a regimental net, one set on the rear link frequency and 4 receivers on other frequencies. The number of sets in the Equipment Tables is at present 25. This is the first short coming.

Next, it has been shown that on a regimental net there is no wireless time for administration. It is, therefore, necessary to have a cable detachment,† either to put companies on brigade, etc., switchboard, or to lay cable direct from H.Q.R.E. to companies. The alternative is to have a vastly increased number of sets on a command net and four company sets.

Thirdly, the standard of W/T training in the R.E. is seldom sufficient to work a regimental net. This is purely an attitude of mind and can easily be put right.

Lastly, the Recce Officers have no man-pack sets.

Some Suggestions

First, it is necessary to make R.E. officers more wireless minded. This must begin with the very young. Wireless is as much the stock in trade of the Sapper as mathematics ; but look at the discrepancy in the training in each.

Secondly, H.Q.R.E. must have a captain of the Royal Signals as O.C. of N. Section. The work is comparable with that of H.Q.R.A. and must have as good an officer.

* I, too, was a mug.—Author.

† Whether this should be composed of R. Signals personnel or regimental signallers is open to argument.

Thirdly, there must be a cable detachment with H.Q.R.E.

Fourthly, the power of the sets must be comparable with the job in hand. H.Q.R.A. demands communication with O.P's. Similarly (as noted above) H.Q.R.E. must have communication with Recce Officers. The type of set must have the range.

Lastly, the possibility of giving certain R.E. officers a receiving set as well as their primary set deserves consideration. The advantages of a receiver for the C.R.E's rover have been mentioned. The same applies to field company commanders. Study will reveal that other R.E. officers should have one too.

Conclusion

Whereas most of the requirements enumerated above can be met by improvisation or contacts on the "old-boy net" this is unsatisfactory. The organization and Equipment Tables must provide for all reasonable requirements. Anything obtained by improvisation must be a bonus and not an essential.

The standard of "signal-mindedness" in officers must be improved.

The standard we set in training and equipment in peace should be related to what we require and not to what is easily obtainable.

Appendix B

Summary of Sets Required for Regimental Net

Purpose	On Regt'l Net	On Rear Link Frequency	Man-Pack On Regt'l Frequency	Receivers Only on Separate Frequency
H.Q.R.E.				
Control	1	1	—	—
C.R.E's Rover	1	—	—	1
F.E's	2	—	—	—
"A" Field Company				
Coy. H.Q.	1	—	—	—
Tac H.Q.	1	—	—	—
O.C's Rover	1	—	—	1
Recce Officers	2	—	2	—
Platoons	3	—	—	—
"B" Field Company				
Same as "A" Field Company	8	—	2	1
"C" Field Company				
Same as "A" Field Company	8	—	2	1
Field Park Company				
Coy. H.Q.	1	—	—	—
Bridge Platoon	1	—	—	—
Field Stores Platoon ..	1	—	—	—
Workshops Platoon ..	1	—	—	—
Total..	32	1	6	4

DIVISIONAL R.E. W/T. LAYOUT.

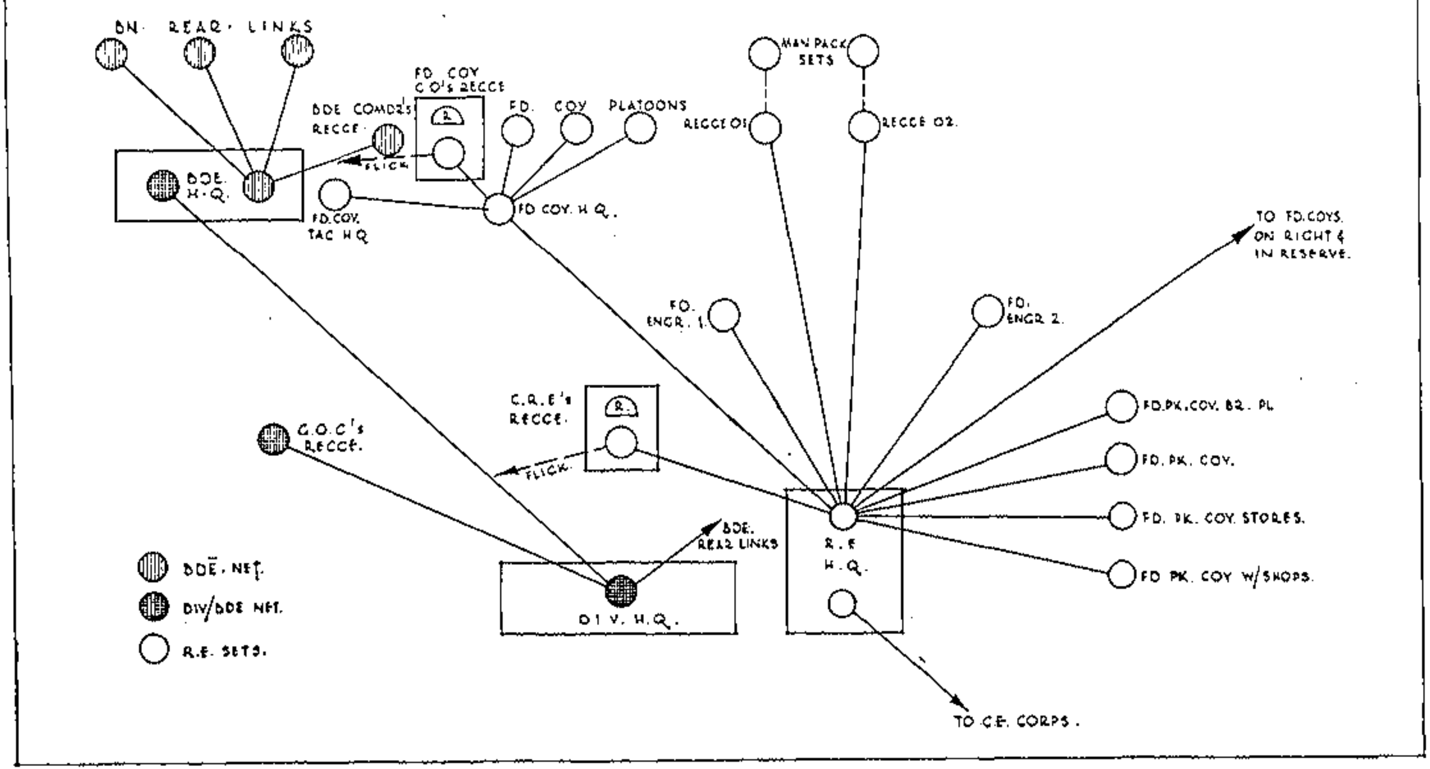


Fig. 1.—Demolition test on 1/10th-scale model of vault arch bridge.
(Note two halves of arch folded back.)

Fig. 2.—Demolition test on ¼-scale model of vault arch bridge.
(Note two halves of arch collapsed between abutments.)

The use of models in demolition experiments

THE USE OF MODELS IN DEMOLITION EXPERIMENTS*

By F. N. Sparkes, M.Sc., M.I.C.E., of the Road Research Laboratory, Department of Scientific and Industrial Research.

THE increasing size of structures used during the war for both defence and attack made it impracticable to carry out tests on new techniques in demolition on full-scale targets. It was, therefore, necessary to examine the possibility of using models for experimental purposes and a technique on these lines was developed by the staff at the Road Research Laboratory of the Department of Scientific and Industrial Research. Many different types of structure were modelled including reinforced concrete pill-boxes, bridges, bridge piers, anti-tank walls, etc., and earth and masonry structures such as canals and dams.

The requirements for model making are simple and involve only a scaling down of all linear dimensions to an appropriate figure. The scale required for the models was determined largely by the maximum quantity of explosive which could be used in a confined area. For reinforced concrete structures the procedure was as follows :—the approximate quantity of explosive required on the full-scale was estimated, and the maximum which could be used at the experimental site was divided into this figure. The cube root of the quotient then gave the approximate scale size which could be used for the models. For example, a structure which may require say 4,000 lb. of explosive would have to be made on such a scale that not more than ½ lb. was actually used in the model experiments. The scale would, therefore, be approximately the reciprocal of the cube root of 8,000, i.e., 1/20th. Assuming that the reinforcement in such a full-scale structure was 1 in. in diameter, the model would require reinforcement having a diameter of 0.05 in. The nearest commercial size of wire for this purpose is 18 gauge or 0·048 in. diameter ; the actual scale factor to be used would, therefore, be 1 divided by 0·048, giving a scale ratio of 1/20·8. The scale having been determined, models of the reinforced concrete structure would be prepared. It was, of course, impossible to scale down the concrete exactly and it was, therefore, common practice to scale down only the size of the maximum size of aggregate. For example, if the aggregate used in the full-scale structure was 1⅓ in. maximum size this would be reproduced in the 1/20·8 scale model as 1/16 in. down sand. In making the models the mortar representing the full-scale concrete was compacted by vibration.

The models were used to explore the effects of the variables associated with a particular problem. For example, the breaching of reinforced concrete anti-tank walls involved consideration of the design of the wall in relation to the type of explosive, the shape of the explosive in relation to the width of breach required, the effect of incomplete contact between explosive and target and so on. The examination of these effects was carried out using models of about one-tenth full size, and the main conclusions were checked on the full scale for which special walls had been built at Shoeburyness. In checking the full-scale results actual tanks were used to negotiate the breaches obtained and the final technique was then confirmed.

In translating the model-scale results into full-scale practice, the quantity of explosive required on the full-scale was obtained simply by multiplying the quantity of explosive used in the model by the cube of the scale factor. For example, if on a 1/10th scale model the tests had indicated that 8 oz. of explosive would produce the desired result the quantity used on the full-scale would be 8 oz. multiplied by 10^3, i.e., 500 lb. of explosive. It was also necessary to make allowance for the effects of gravitational forces which could not be scaled. A typical example of the effect of this is shown in Figs. 1 and 2. Fig. 1 shows the result of a demolition test using Hayrick charges on a model vault arch reinforced concrete bridge. The scale of the model was 1/10th and the model Hayrick charges had been so arranged as to cut a slot right through the crown and to sever the reinforcement at the springings on the underside only. The effect of the explosion was to cause the two halves of the arch to hinge upwards about their springing points and so to provide a positive obstruction in place of an actual demolition. It was important to know whether this same effect would apply on a full-scale bridge since the final vertical position of the two halves of the arch depended essentially upon gravitational effects. A larger bridge was, therefore, built to a scale of ¼ and the test repeated. In this case the two halves collapsed inwards and did not remain in a vertical position (Fig. 2). When gravitational effects were not present, however, the full-scale results invariably agreed closely with the model results.

This technique was used to develop large Beehive and Hayrick charges, to study the problems associated with the neutralization of live pill-boxes by hand-placed charges, the demolition of reinforced concrete bridges and bridge piers, the breaching of anti-tank walls, the breaching of canal banks by bombing, the breaching of masonry and concrete dams by aerial attack and many other problems. In addition, models and the model technique were employed in other sections of the Road Research Laboratory to develop formulæ giving the penetration of shot, shell and bombs into concrete, rock, earth, etc., to study craters produced by the detonation of bombs in earth, to determine the magnitude of blast waves in tunnels and trenches, to study the phenomena of underwater explosions and many other problems.

It is certain that without the employment of models and the model testing technique, many problems associated with assault and demolition would have remained unsolved during the war.

ACKNOWLEDGMENT

The work described in the note was carried out at the Road Research Laboratory of the Department of Scientific and Industrial Research on behalf of the Ministry of Supply, Department of Scientific Research, and is published by permission of the Director General of Scientific Research (D), Ministry of Supply, and the Director of the Road Research Laboratory.

LONGMOOR MILITARY RAILWAY

Reproduction of an article published in the *Railway Gazette* as a result of an address by Brigadier C. A. Langley, C.B.E., M.C. to members of the *Trade and Technical Press* on 30th April, 1946.

The Blocks of photographs and sketches have been kindly lent by the *Railway Gazette*

IT is a great pleasure to me to welcome you to Longmoor. I hope that we will be able to show you some items of interest and give you an idea of the scope of the training we carry out at this Centre, which is the home of the Transportation Branch of the Corps of Royal Engineers. I have not the time to tell you much about the achievements of this branch during the war, but I think it would be well to bear them in mind when considering the work of this Centre.

Transportation grew from a few Supplementary Reserve Companies into a force one-third the strength of the whole Corps of Royal Engineers. Transportation served the Army wherever they went, in Europe, Africa, Asia, from Norway to Nigeria, from Iceland to Malaya. In 1939, Transportation were the first troops to land in France, where they discharged all the stores and vehicles required for our force, built marshalling yards, and rail-served depots, and collected large stocks of railway material to succour our allies and develop our communications.

After the collapse of France, the Middle East became our main centre of activity. Here we built in one year the Palestine–Syria Railway—170 miles of very heavy construction, including one mile-long tunnel and many bridges. We extended the Western Desert Railway from Mersa Matruh to Tobruk, building at the rate of two miles a day. We developed the Ports of Egypt to serve the Middle East Base, and we supported the Eighth Army from El Alamein to Tunisia, opening and developing the ports of Tobruk, Benghazi, and Tripoli at high speed.

Special Railway Bridges

Again, in North Africa, Sicily, and Italy, a similar tale can be told. In Italy we were faced with many difficulties due to the heavy German demolitions, but these were surmounted, thanks largely to the use of the special railway bridges which had been designed early in the war to meet such a contingency. These bridges were so successful that they were adopted as standard by our American Allies.

When the time came to assault Hitler's West Wall, Transportation was again to the fore. The construction of "Mulberry" was largely the product of Transportation genius. Port repair and dock operation during the campaign was one of our major tasks. Railways also played a large part in this campaign, and presented a difficult problem due to the severe dislocation and damage caused by our bomber offensive. However, every obstacle was overcome and amongst our achievements were the bridging of the Seine, Maas, and Rhine.

In India and South East Asia, Transportation played an equally important role. It might interest you to know that half the total of the Transportation

Force were members of the Royal Indian Engineers. Not only was great assistance given to the Transportation undertakings of India, but the Burma Campaign was made possible by the large transportation effort combined with air supply. In the Arakan we supplied services of coastal vessels, creek steamers, and country craft of every type. In Burma we built an I.W.T. fleet on the Chindwin, carrying our craft in sections over the mountains. Similarly, for the railway we carried locomotives, some complete, some in sections, by air, road and river, to keep communications going in support of the 14th Army.

This brief survey gives you, I hope, the background of the Longmoor war effort, but before telling you something about our present activities, I think it would interest you to know something about the history of this Centre.

Early History of the Centre

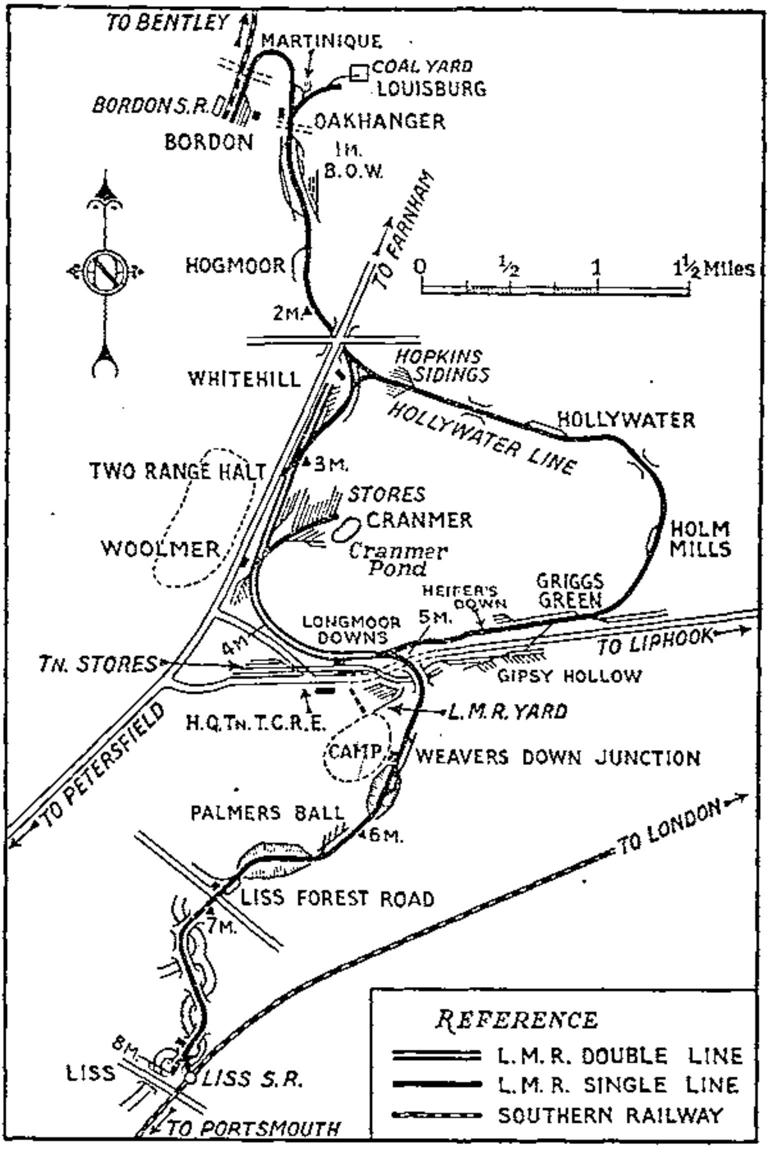
Longmoor Camp was built originally to provide accommodation for troops returning from the South African War. These camps were more or less completed by May, 1903, and were originally occupied by infantry regiments. The first railway troops, the old 53rd Rly. Coy., R.E., arrived here in May, 1903, not for the purpose of forming a training centre, but to undertake the movement of a number of huts from Longmoor to Bordon. These were hauled complete by rail, the work taking about 2 years to complete. This project was an ingenious railway enterprize, two 18-in. gauge tracks at 24 ft. centres being laid to carry the trolleys used for transporting the huts whilst a ship's donkey winch, driven by a steam boiler, provided the motive power, assisted by a couple of farm horses. The method of locomotion was to haul out a cable, fasten it to a tree, and then wind in on the winch, thus hauling the hut forward. The fastest time for the journey of 5 miles was one day.

Having started off in this rather unusual manner, Longmoor gradually began to develop as a permanent home for the railway troops—the 8th Rly. Coy., R.E., arrived in 1905, followed by the 10th Coy. shortly afterwards. The standard-gauge line from Bordon was started in 1906 and was completed, with a deviation and level crossing at Whitehill, as far as Longmoor in 1907. The present alignment with the under-bridge at Whitehill was completed in 1909. Some traffic, other than that for railway purposes, was accepted as early as December, 1907.

Up to 1914, annual training of the Royal Anglesey and Royal Monmouthshire militia, the forerunners of the Supplementary Reserve, was carried out on this military railway in co-operation with the regular railway units. On the outbreak of the first great war, Longmoor was taken over by the Railway Operating Department which formed a depot and training establishment for all railway troops, although the scope of the training was not nearly so comprehensive as that carried out here during the second great war.

Peacetime Work

By 1920, the war activities of Longmoor were over, and the task of building up a peacetime Transportation organization was commenced. It was clear that in any future war, much larger Transportation forces would be required than could be provided from the small nucleus of regular troops. Consequently, the Supplementary Reserve Scheme was authorized and the various British railway companies were asked to co-operate. Longmoor henceforth became not only the training centre for a small regular cadre, but also for the Supplementary Reserve units which formed the core of the huge Transportation organization which developed during the recent war. This training commenced in 1925 and continued annually until the outbreak of war.



Sketch map of the Longmoor Military Railway

Activity Between Wars

During the period between the wars, a number of improvements in the training facilities was undertaken. The line to Liss was completed in August, 1933, and the Hollywater line was started as a training ground for the Supplementary Reserve units. The workshops, running shed and yards were remodelled very much on the lines they are today. During the war, the Hollywater line was completed, and was opened to traffic in June, 1942.

So much for the development of Longmoor as a Training Centre, but further big developments have taken place to make Longmoor the largest Transportation stores depot in the country. When the war started we had only the store sheds in Longmoor yard, and were just developing the Applepie depot. Woolmer stores depot was built in 1941–42, and other depots followed; the last was completed in 1944.

So far, I have spoken about the early history of Longmoor and the development of the material resources of this Centre. I would now like to give you an idea of how the Transportation branch of the corps expanded during this war, and of the steps taken to meet the large training commitment which had to be undertaken.

In 1939 the only Transportation troops available for active service were :—

One Regular railway company—the 8th.

The following Supplementary Reserve Units :—

One group of railway construction companies.

One group of railway operating companies.

Two docks operating groups.

One transportation stores company.

A total strength of approximately 4,000 officers and men.

The peak figures reached by Transportation during the recent war were 4,330 officers, 148,000 O.R's, approximately 50 per cent of whom were Transportation units of the Royal Indian Engineers.

To cope with this growth, Longmoor, which has always been the main Centre, was expanded from a peacetime strength of approximately 500 all ranks, to a peak strength of 7,000 by September, 1942, when it consisted of a Headquarters and four Wings—Fieldworks Training, Technical Training, Collective Training, and Depot. A second Transportation training centre was opened at Derby in 1939 and operated in conjunction with the Melbourne Military Railway—a stretch of line leased from the L.M.S.R. In July, 1941, this Centre was closed down and converted into a Collective Training Wing under the control of the Commandant at Longmoor. This Wing trained Transportation units in heavy bridging and railway construction and continued to operate the Melbourne Military Railway as a training machine for complete railway operating units. This Wing was finally closed at the end of 1944.

The Port Operating Technical Training Wing was formed in 1943, originally located at Penarth, subsequently moving to Barrow, and finally Stranraer. Technical training was given in all port operating trades. This Wing has now been transferred to Marchwood, near Southampton.

In India, two Transportation Training Centres were opened in 1941—Railways at Jullundur, Port and I.W.T. at Deolali and Bombay.

During the war, the following numbers have passed through Longmoor :—

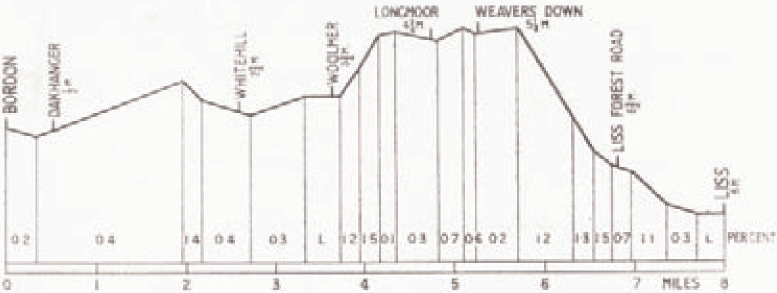
Officers	.. 6,960 including 1,000 for technical training.		
Other ranks	Trained in technical trades	..	27,350
,, ,,	,, ,, fieldworks	..	24,000

In addition, over 80,000 men have passed through the depot to form drafts for new units or reinforcements.

Running sheds, stores, and workshops, Longmoor Military Railway.

Longmoor Military Railway

L.M.R. passenger train hauled by 2-8-0 austerity locomotive " Major-General McMullen."



L.M.R. main line gradient profile.

The staff to run this machine has been drawn from every branch of civil transportation, and all credit is due to those officers and men who, throughout the years of the war, worked so successfully to produce the personnel to form units which played such a leading part in all theatres of operation.

As regards our present task, we are faced with the problem of releasing a vast majority of our experienced staff to civil life, and at the same time training up the new intake on the traditions of the old. The recruits coming forward today have not got the same experience as most of those who came to us during the war, and in consequence, we have to give them longer training. You will see during the course of your visit how we are undertaking this work.

I would now like to give you an idea of our present organization. This Centre consists of a Headquarters, divided into an administrative and technical side. The former is responsible for the smooth running of the machine, the latter for technical instruction and operation.

ORGANIZATION*

The technical side at Longmoor is supervised by the Chief Instructor and is divided into three main departments, each under a Senior Instructor :—

Railway construction (including survey and bridging).
Railway operating (traffic and locomotive).
Railway workshops.

The total technical staff is 619 (22 officers, 539 other ranks and 58 civilians), and the three departments have strengths of 172, 300, and 133 respectively. This staff is responsible for technical instruction of all officers, cadets, and other ranks, and also for maintaining the training machine itself, that is, the Longmoor Military Railway.

The training machine was capable of turning out 600 other rank initial trainees per month in corps trades peculiar to the Transportation branch. However, due to the reduction in our army and the release of personnel to civil life, numbers under training have dropped considerably, so that, at the present moment, we have only some 200 trainees under instruction.

Altogether we have given instruction in some 42 trades, including a number of trades common to the rest of the Corps.

The lengths of the courses vary according to the type of trade and its technical implications. For example, a checker can be turned out in 2 weeks, whereas draughtsmen require 12 weeks and machinists (metal) 16. It should be appreciated that personnel posted to the Transportation branch have been, for the most part, specially selected for their aptitude or previous experience, and the syllabuses were compiled to give intensive instruction in the military aspect of the relevant trade to be learnt.

ENCOURAGEMENT

When any trainee shows marked ability, his course is cut short and he is made available for taking his place in a unit without further training. Conversely, when a man is slow to assimilate instructions, but is considered a potential tradesman he is given extended training to make the grade. Very few men have ever turned out as failures after completing their courses at Longmoor. It is the proud boast of the Instructional Staff that the oft-repeated opinion of Unit Commanders in the field has been : "You can tell a Longmoor-trained sapper anywhere, but you can't tell him much."

* Since the date of the lecture (30th April, 1946) considerable reorganization has taken place at Longmoor. The Transportation Training Centre is now also responsible for training of R.E. (Movement Control) Officers and other ranks.

The figures in the second subparagraph on 1st January, 1947 were :—

Total technical staff (including Movement Control) is 340 (28 officers, 271 other ranks, 41 civilians).

It is the policy of the corps that every tradesman, be he clerk, railway engine driver, or storeman, should be trained basically as a sapper capable of turning his hand to any job of field engineering when on active service. Up to recently, practically all trainees went through a short fieldworks course at this Centre, to give them this general training. However, with the reduction in the size of the Corps, it has now become necessary to concentrate this training at R.E. training battalions.

The success of a training establishment relies very largely on the efficiency of its instructors. At this Centre, great care has always been taken in their selection, to obtain men with first class experience, either civil or military, but preferably both.

Although the normal tour of instructional duty was 12 months, it was necessary to retain many of the staff for much longer periods ; consequently many whose ambitions lay in a much more active field of operations were obliged to remain at this Centre, sacrificing chances of promotion overseas. Thus many instructors on leaving the Army have little tangible evidence of the yeoman service they rendered during the war, but they can rest assured that their work was fully appreciated.

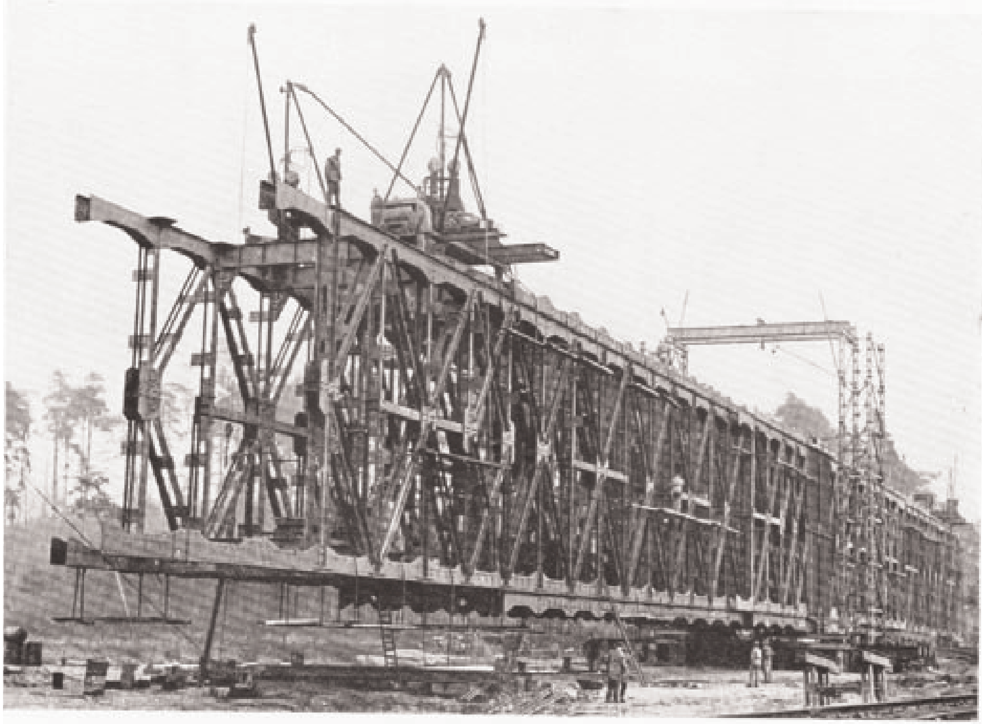
MINIMUM THEORY : MAXIMUM PRACTICE

To obtain speedy results, instruction in theory has been cut to a minimum and as much time as possible has been spent on the practical side of the work. The practice is, and has been, to make the trainee think for himself and not to attempt a " parrot fashion " type of tuition. Whenever possible, the class is encouraged to ask questions and to discuss the answers among themselves, steered in the correct channels by the Instructor. Wherever practicable, drawings, models, and component parts of equipment are displayed during the instructional periods, but demonstrations and handling of the full-size article is always covered at every available opportunity. Every trainee keeps a notebook which is periodically inspected by the Instructors. With few exceptions these books are of a high standard.

It may be opportune to mention some of the characteristics of the principal item of our facilities for training—the L.M.R. Inaugurated as a purely instructional railway with originally only a very small domestic commitment of freight traffic, it rapidly developed between 1942 and 1944, and functioned as a serving line for Tn. Stores Sub-Depots which had been sited on the many suitable areas adjacent to the line. Hence, railway operating, which, before 1942, had been a training expedient, became of vital importance in the reception and despatch of large quantities of strategic stores. And so, the trainee blockmen, brakemen, and shunters, yard masters, train crews, and traffic operators, found themselves producing something really tangible in the way of results. This is considered the best type of training, one to which the trainee most readily responds and which gives the Instructor more opportunities for assessing a potential tradesman's practical worth.

The increase of traffic on the system made greater demands on the maintenance of permanent way. Heavier locomotives were put into service ; the first type was L.M.S.R. Stanier 2-8-0s with 6-wheel tenders—the precursor of the Ministry of Supply austerity 2-8-0s and 2-10-0s, and American " Consols " which arrived later. Due to the rather " slack " road bed, increased attention had to be given to the formation and to ballasting, whilst severe curvature, coupled with light 75-lb. rail, kept platelayers busy.

Although the additional track laying in the new stores depots was undertaken by railway construction companies sent here specially for the work, the large earthworks required in levelling and draining the areas was under-



Everall sectional truss bridge: Construction of 320-ft. span by cantilever method.

Longmoor Military Railway 2

Officer cadets on platelaying instruction.

taken by the mechanical equipment section of this Centre, and proved the most profitable training medium for drivers T.P. The work was of the highest priority. Instructors and trainees tackled the job enthusiastically, putting in long hours, often under trying weather conditions, and completed the work to time.

In addition to the maintenance of increased route mileage, the Construction Department had to strengthen many of the bridges to carry the increased axle loadings. The longest bridge—98 ft. span over the east end of Longmoor Yard—was reconstructed, and most of the others were strengthened by introducing deeper joists and adjusting the abutments and piers to suit. A 300 ft. timber bridge on the main line was replaced by an embankment, the work being carried out by trainees without interruption to the Operating Department.

Naturally, the workshops were directly affected by the increase in traffic, and expanded their activities. Increased overhaul of locomotives and rolling stock became necessary. Additional commitments were experimental work in connexion with the planning of the ultimate attack on the French beaches, and much labour was expended in constructing various loading " mock-ups," slinging equipment, etc., etc.

Unfortunately, the workshops site at Longmoor is not so well laid out as might be desired, due in the main to its rather humble beginnings and the need for economy in peacetime. On the other hand, the plant and machinery is fairly comprehensive and steps have been taken to replace older types of machine with more up-to-date equipment. It is not possible to undertake all major repair work on locomotives, but we can cover most of the normal maintenance work resulting from heavy service on the L.M.R.

It is interesting to note that the proposal to use colour-light signals on military railways is to be implemented, and experimental work has been recently undertaken on the Longmoor Military Railway. In the near future, certain sections will be equipped with this type of signal.

The running sheds were not built to give covered servicing accommodation for the number of locomotives in steam during the peak periods of traffic during the war. Nevertheless, by improvisation of coaling facilities, etc., the locomotive staff met all the demands of the traffic department, and the men in training work under more or less active service conditions.

Unfortunately, the geographical limits of the Longmoor Military Railway prevent a reproduction of the long hauls associated with lines of communication, but by using the Hollywater Branch and a section of the main line as a circular track 6 miles in length, it is possible to give train crews some experience in handling freight trains of 1,000 tons.

In conclusion, I would remind you that we are but one branch of the Corps of the Royal Engineers, a Corps whose splendid traditions of service go back into the dim past of military history. At the present time we are saying farewell to many experienced officers and men who are returning to civil life, but we look forward to finding new recruits to take their place, and to carry on the traditions of the Corps which can best be summed up in our motto :—

Quo Fas et Gloria Ducunt

The following brief notes on the History and details of the Railway may be of interest.

Brief History of Longmoor Military Railway

1903.—First railway troops arrived at Longmoor.
1905.—Survey commenced on standard-gauge line from Longmoor to Bordon.
1909.—Line from Longmoor to Bordon completed. "One-engine-in-steam" working.
1914.—Longmoor taken over by Railway Operating Department for training purposes.
1925.—Supplementary Reserve Units began annual training.
1933.—Line from Longmoor to Liss completed.
1935.—Old name of Woolmer Instructional Military Railway changed to that of Longmoor Military Railway.
1939.—Total track mileage, 18.
1941.—Intensive training of railway tradesmen stepped up.
1942.—Transportation Stores expansion commenced. New connexion to Southern Railway at Liss completed.
1943.—Longmoor became H.Q. of Transportation Training Centre, R.E.
1944.—L.M.R. serving large stores area. Total mileage now 70; 27 engines in steam at peak periods. Maximum freight handled was 850 loaded wagons despatched in one day.
1946.—Track mileage reduced to 64. Colour-light signalling experiments carried out.

Railway Construction, 1939–1946

Main-line track is laid with 75 and 90 lb. per yard F.B. rail on timber or concrete sleepers with stone ballast.

Branch-line track is laid with 75 lb. per yard F.B. rail, with ash ballast.

All turnouts are standard 1 in 8 and 1 in 12 military pattern.

Maximum curvature is 15° (Bordon Station) equivalent to 6 chains radius.

Maximum gradient is 1·5 per cent equivalent to 1 in 67 uncompensated.

The Hollywater branch has been lifted and relaid many times as an end-on platelaying exercise for Railway Construction Companies engaged on collective training at Longmoor.

Number of other-rank tradesmen trained in railway construction trades, 7,320.

Railway Operating, 1939–1946

Maximum track mileage operated	70
Maximum number of engines in steam in one day..	27
Total engine miles run	1,750,000
Total number of passenger trains run	91,000
Total number of passengers carried	6,630,000
Total number of wagons exchanged with Southern Railway	311,000
Number of other-rank tradesmen trained in railway operating trades..	12,250
Peak traffic year was 1944 in which traffic exchanged with Southern Railway at Bordon and Liss totalled .. .. tons	601,895
This exchange represented an account with the Southern Railway of more than	£1,000,000

Railway Workshops, 1939–1946

Although it is difficult to give figures of output, the workshops were an exceedingly industrious department. In addition to maintenance of locomotives, rolling stock, etc., and training of workshop tradesmen, a great variety of experimental work was carried out on the loading of locomotives on transporters and craft, and in the design and manufacture of slinging gear and securing tackles. Steel bridges for Rhine ferries were built in the workshops, and the assembly and trial of mobile refrigerator units for use in the Far East was another task undertaken. In addition, 573 2-8-0, 79 2-10-0, and 75 0-6-0 locomotives were prepared for shipment, serviced, and despatched overseas. The number of other-rank tradesmen trained in workshop trades was 7,780.

Transportation Stores, 1942–1946

The Transportation Stores Depot at Longmoor originated in 1942 with strength of 154 personnel, with 1,500 tons of stores in one small depot. By D-Day in 1944 the total strength had risen to 1,500, staffing 9 sub-depots containing 170,000 tons of stores stacked on an area of 150 acres. Tonnage handled averaged 50,000 tons a month, and ten or eleven special freight trains were often required daily.

Over one million tons of stores were handled, and the average turnround of a wagon in the depot was 1¼ days.

The stores included items for Railway Construction, Maintenance and Operating, and for Port Construction Maintenance and Operating. As a typical example, one type of W.D. locomotive was represented by a holding of 7,000 tons of spare parts.

The old temporary Waterloo Bridge was reassembled at this depot and shipped to Holland for replacing a bridge at Arnhem.

EARLY BRITISH ENGINEERS

By John Garway

PEOPLE who gloss over their family's past generally do so through an uneasy doubt as to what it was, whereas in most cases the truth would not only reassure but be an actual source of pride, because all that is best in our country's character comes from an entirely different source to what is commonly believed. This is reflected in national history. For instance, anything pre-Roman is often looked upon as barbaric, which is a fallacy. Again, the English are usually considered as primarily Anglo-Saxon, an equally mistaken idea ; true it is we speak an Anglo-Saxon dialect, but as regards blood it is a physical impossibility for those invaders to have done much more than leave a veneer upon what is predominantly British stock. Indeed, the fact is that the Saxons, like their soldier descendants of today, finding themselves lonely in a foreign land, with one accord took British wives. Hence, so to speak, the milk in the coconut. However, it was fashionable to be Saxon, to belong to the ruling caste ; so, a few generations later, although it was known there had been skeletons in the cupboard, forgetfulness and a wishful imagination produced a pure Anglo-Saxon breed. Contributory to the whole stock also were the very many Britons who had been retained as serfs to do the spade work in farming the land, while their betters followed the more pleasurable pastimes of hunting and fighting. Thus it was that both for Danes and Normans the task of conquest was comparatively easy, for they appeared to some extent as " liberating " the British people from their unpopular alien landlords. Ultimately, internal rivalry among the successive conquerers left the country with an extensive widowhood of British mothers on the one hand, and a long line of bachelor ancestors on the other.

That is the source of our national character today, and it is from the British side where comes our deeper and nicer thinking. The stigma " barbarians " left by the Romans meant in reality no more than the equivalent of " gentiles," to Roman custom ; yet some of Roman custom was in itself barbaric, while the contemporary British ways were innately humane. It was through the mediæval revival of learning, when Greek and Latin became the hall-mark of education, that the popular ideas on history have developed from a Roman point of view. On the other hand the actual standard of British civilization at the time when the land came under Roman rule was remarkably high. As an example, the operation of trephining a skull with a flint knife had been carried out successfully ; nor is it the degree of manual skill in this which is so astonishing, but the mentality that had ever conceived it possible with such a crude instrument. Another example is contained in the British social philosophy, which was renowned throughout Europe ; its principles were the very ones we have been fighting to uphold today. The material civilization of Rome was the greater, but the moral civilization of Britain was the higher and the more courageous. So, in reviewing the engineer ability of our forbears, they are to be visualized as men who reasoned and planned as we do, although in terms of manual work and rude tools ; the quality they produced should not be lost sight of through the mechanical standards our eyes have become accustomed to.

That a body of engineers did exist is evident when the old defence works are given second thought, after a preliminary glance may have shown only unimposing remains. There is little enough to impress in the grass-grown earthworks which run across the countryside, distinguished chiefly by the old English lettering against them on maps ; yet when their siting is studied it becomes clear that a good deal of sound thought had been expended over them, and that military minds had argued out in prehistoric T.E.W.T's where they should be dug. The often expressed belief that the long lines of ditch were defended is wholly erroneous ; the numbers of men who could be gathered together suddenly, in the face of a raid, precluded any such usage ; on the contrary a running fight with the raiders in the open field beforehand, and a gradual withdrawal to collect more strength, ending in a determined counter-attack as the enemy retreated encumbered with spoil, were the tactics. All this is especially evident from the Welsh Border defence works, which can be seen to have had their origin in the earlier ones of southern England. Cattle raiding was one of the enemy's main objects ; the purpose of the earthworks was to hold up the animals and hinder him in his retreat, and they will be found sited well behind the frontiers, not on them, near the limits of raiding penetration. Thus these ditches were the counterpart of anti-tank obstacles, to confine enemy movement to the bottleneck of whatever breach had been made in them ; furthermore when the labour in breaking a way for animals across a deep ditch and high bank, with an overall slope of say 30 ft. at 1/1 is considered, it will be realized that with the kind of tools available it will have been a difficult proposition in a hurry. Dykes of this kind are one form of defence work, entrenched camps are another ; and the two will be found sited in connexion with one another, the camps often as outlying strongpoints into which the cattle could be driven and protected by the older men, while the younger kept up a skirmish as the raiders moved on past them. Both the perimeter dykes round camps and possibly those running across open country will have been further strengthened by timber stockades crowning their banks, or in a rock subsoil by the alternative of a dry stone wall. This leads to the third kind of defence work, the round stone towers that are a feature in north Scotland ; their construction testifies to the engineer skill of the times. Built of dry stone they show craftsmanship that has not been excelled since ; in one instance a tower 40 ft. high is still standing intact, after two thousand years, a degree of stability far in excess of the mortared masonry of Norman days. And the profile is definitely scientific. All of this is evidence of more than manual skill, it indicates the presence of military engineer minds directing the work.

Thus the question arises, who were these engineers ? The Chiltern Hills and Berkshire Downs seem to offer an answer. There, a series of earthworks covering two very old traffic routes, the Ridgeway and Icknield Way, bearing the name Grims-ditch or Grims-dyke, are the first for consideration. As regards the Ridgeway, it is more than just a trade route, it was also a military line of communication sited in conjunction with the earthwork protecting it ; incidentally, the defences were never finished, internal events extended the rule of the people who made it. For reasons which would be too long to enter into here they must have been built by a people called the Chatti, the same folk who have left their name to Chatham and Chattenden, one which still survives in the Clan Chatten of Scotland, Caithness, and in many other place names in England ; a material point is that their " lucky " badge was the box-tree, also still surviving in the name Boxley, the village near Maidstone, as well as elsewhere. They were a military folk, a clan whose name and emblems became general for the many other clans of the period, and from whom the Lion emblem of England is derived.

It is significant that the defence works now being considered are associated with the names Berk-shire and Berk-hampstead. Both come from the equivalent of the word Barrow—Barrow-shire and Barrow-hampstead—or Burrow, and this was a Celtic word, in contradistinction to the Saxon terms it stands for, ditch and dyke ; consequently it is to be understood as referring to the name of the folk who built the works, not to the features themselves. This folk, as explained later, were the " defence-work builders." The next point to be noted is that the name Grim, which is applied generally to the ditches, also appears in the name Grimes Graves for the flint mines in Norfolk ; it is easy to recognize from this that the men whose trade was to sink shafts and tunnel in chalk were chosen as ideal for excavating the chalk and flint soil of the earthworks. The ordinary Chatti farmers will have been accustomed only to tilling the light top soil of the land, and their tools have been suited only for that ; to get down to the depth needed for the deep dykes, and to organize shifting the spoil, will have been more of a specialist nature, just as today the Sapper is regarded as the specialist in what he himself may look upon as well within the capacity of unskilled labour. *En passant* it is worth remarking that the old time tunnelling included shoring up the galleries with pit props, and that the tools for mining were shovels made from the shoulder-blades of animals, and picks made from deer antlers ; the nature of these tools deserves bearing in mind when calculating the amount of work involved. Another name associated with the area is Icen, which seems to be derived from a word meaning sharp, and to have been applied to the flint knappers who mined and fashioned the flints, an earlier breed of men. All in all the picture is formed of a body of Chatti engineers directing the perhaps enforced labour of a conquered people, one of the latter's industries being the manufacture of flint tools ; these miners they nicknamed the Badgers, after the animal who is conspicuous for digging a burrow and defending it fiercely, the Celtic name for which is Broch. Thus the diggers and miners, or Sappers and Miners, were known as the Broch-folk.

The Saxons when they conquered the country adopted the name Brock for the badger into their own language ; but, as the Oxford English Dictionary observes, they confused it at times with the meaning beaver. The cause for this cannot have been the two creatures being mistaken for one another, nor could their proper Saxon names—badger and beaver—which are completely distinct ; but the Celtic words Broch and Berruc as different nicknames for an identical folk might well have become confused, which is what seems to have happened. That a Celtic clan with the name of Beaver used to exist in the neighbourhood is recorded by Cæsar ; and although it has been suggested that it gave its name to Berkshire, the people Cæsar referred to cannot have been in that place, because his army did not penetrate so far west ; the ones he mentioned must have been in the lower Thames valley in Middlesex. A timber pile village, in marshland by Watford, indicates one of their whereabouts, as it is wholly in conformity with the Celtic practice of allusive names that the folk who used to build themselves timber dwellings in water should be called the Beaver clan ; for the animal beaver is characterized by its skill in constructing dams of logs, stones, and clay, in order to make itself a home in the water. Indeed their actual methods of building may well have been copied from the animal, whose skill is conspicuous. The date of the clan's name is far antecedent to the days of the Celts arrival in Britain, and by the time now under description will have become synonymous with "builders," or more specifically "carpenters and builders." They are likely to have been employed on the defence works, for completing the obstacles across the valleys with timber stockades, and for similar work along the bank tops above the dykes. The remains of at least one group of huts on a Berkshire hill by the dyke, and apparently a construction camp, have a rubbish heap of oyster shells, suggesting that the occupants were not local men but came from the Thames estuary. Thus Beaver-folk and Badger-folk, Berruc and Broch, came to live side by side, and in due course the term "builders" was applied to both. And as craftsmen they spread ; so that when dry-stone defence towers came to be built, they were called after their engineers, Brochs.

Evidence that the Beaver-folk were Chatti is to be inferred from the mention by Asser the chronicler that box-trees were plentiful in Berkshire. It has already been remarked they were the "lucky" emblem of the clan ; and the reason for their abundance was that they were grown as hedges for the ritual mazes. The purpose of the mazes, and their association with the idea of luck can be guessed from the one that distinguished Woodstock, where King Henry used to entertain his Rosamund. *Honi soit qui mal y pense.*

The Broch towers are especially numerous in Chatti country, in and around the county of Caithness and in the "Cat" islands as the Shetlands used to be called. They formed the keeps of villages which themselves were surrounded by perimeter dykes crowned with stone walls, all of dry-stone construction excellently laid. They are miniature fortresses, and the weakest point in the defence must have been the awful smell from the fish middens, which in one instance has also lasted for 2,000 years. Their siting has one distinct characteristic, in that they are nearly always on the sea coast at places inaccessible from the sea ; it can be understood they were placed not to prevent raiders from landing, but as holts from which the enemy could be fought at a disadvantage when re-embarking. A surprise landing could not be stopped, but the enemy might be prevented from getting away with his loot.

These are a few reflections on some early engineering. That the defences were efficacious is recognizable from their adoption subsequently by both Romans and Saxons. The Romans caused a dyke to be made along their first frontier in southern Britain, and its construction brought about a revolt of the people on either side of it, when they saw themselves being cut off from their fellows. The Saxons used dykes extensively along the Welsh Border. When first thinking about the latter, the writer happened to remark to a clergyman antiquarian that the Saxons must have done a lot of work in making them, to which the clergyman replied " No, they were a lazy people " ; the writer said nothing, but could not understand the reason for his remark. It was not until many years later, when he was making a fuller study of the system, that he realized they had been dug with forced labour, and that the Saxon's aversion to the shovel, so faithfully preserved by the British infantryman of today, was inherent.

The main interest in these old works lies in their siting. The technical details of their construction, in so far as they are still discernible, show a really high standard of manual skill ; and their regular alignment and the amount of effort involved evidence considerable organization, as well as the presence of a strong authority able to have executed it, which in those very democratic days was unusual. But in their siting can be read the appreciations of military minds, that regarded defence not as static resistance but as a matter of field fighting, with camps and forts whose garrisons fought outside the defences rather than within, and with artificial obstacles designed to deny the enemy the power of manœuvre and to compromise him in his retreat. Such is the tale they tell ; and as a prelude to it there can be read, recorded in the metaphoric language of the times, the pre-war preparation of the ground by Berruc and Broch, the old firm of military engineers.

FOOTNOTE

Place Names.—Prof. Eckwall, *Concise Oxford Dict. of Place Names*, derives Berkshire from the Celtic barro ; Mr. McClure, *British Place Names in an Historical Setting*, had previously derived it from the name Bibroc, of which more will be said later ; both origins seem involved, and the Saxons confused Berruc, the contraction of Bibroc, with Broch.

Berkhampstead has its earliest recorded form as Birch-hampstead, though at a comparatively late date. The *Oxford English Dictionary* shows the words barrow and borough to have had a parallel development to the word birch-tree, all coming from an original meaning of mountain or height, and (the two former) eventually acquiring the meaning of protection ; the Saxon form of Berkhampstead seems to have been a mispronunciation of the root berg- similarly to its Dutch form berch.

There is, though, other evidence in support of Mr. McClure's derivation of Berkshire from Bibroc, latinized into Bivroc and Berruc, although the alternative origin barro has been chosen. A change from Bevroc into Berk exactly corresponds with the change from Laverock into Lark. Both might well have contributed to the ultimate name.

Grim, according to Prof. Eckwall, comes from the Norse Grimr meaning masked or some equivalent. Its application here is not clear, unless it meant nameless, an older people whose name had been forgotten. It is also accompanied by the Saxon word wrosen, worm, both in eastern England and in Herefordshire, as the Grimswrosen ditches. This also is difficult to explain. On a map the trace of the whole system might be resembled to a worm, but on the ground as far as a man's sight extends they are more or less straight, sometimes conspicuously so ; and that would have been their appearance in those days. Also, the supposition of a hybrid Norse Grim with a Saxon Wrosen is not satisfactory ; perhaps Grim has some other origin.

SOME NOTES ON ORDER CARDS FOR THE HANDLING OF DIVISIONAL ENGINEERS

By Lieut.-Col. A. F. Toogood, R.E.

I MAKE no apology, despite my inexperience as a Divisional C.R.E. in actual battle, in attempting to provoke a discussion which may prove interesting, especially if our war experienced Divisional C's, R.E., who may have now a little more leisure than hitherto, as well as a fresh memory and supporting documents, enter the fray.

I am strongly of the opinion that in the Corps this subject of R.E. Order cards has been unduly neglected. I can recall no modern example in the *Journal* or other technical or official papers. The causes of the neglect have been many ; for example in peace time Divisional C's, R.E. at home were given Works responsibilities, which absorbed most of their time and activities. R.E. officers alternated between Works and Units, but seldom, until they reached Lieutenant-Colonel's rank did they combine the two in one job. Consequently no really " professional," for want of a better word, research was ever made in the technique of handling Divisional R.E. in collective training and battle. Generalities were available, but generalities alone do not produce practical results, whereas clear orders can. The first attempt on paper was *Standing Orders for War, Divisional Engineers*, 1942, now being revised, but this omitted completely any suggestion for Order Cards, which was no doubt due to the lack of experience and data at that period.

It seems a curious fact that while Staffs and Infantry have found it necessary to have Order Cards, which are universal in application, and which, of course, were amended from time to time as weapons and organizations changed ; we, with, in fact, less basic changes of equipment, have had none. Modern war demands increased mobility and, therefore, requires increased rapidity of thought, action and reaction. Engineer influence has not declined, but rather increased. Surely, therefore, this apparent neglect is an extraordinary fact. It seems almost childish to exaggerate the necessity or reasons for a formal type of order in correct sequence. They are, of course, primarily so that the giver of the order, and its recipients, are helped to think logically, and, therefore, quickly and with clarity. Any omission during orders is subconsciously or consciously noted by them and thus not overlooked. Speed, clarity, and accuracy are thus achieved.

The writer, therefore, gives below a series of Order Cards based on much experience on the Divisional lever as an umpire, and as a Divisional C.R.E. at home, during the years of preparatory training before " D " Day.

Since the writer, at present, has not the leisure or time to discuss in detail these Order Cards, as he is serving overseas, he hopes, as suggested above, that others will give the benefit of their experience. Only a few special points of interest are therefore noted. Further an extension of this subject by a discussion on specimen Divisional Standing Orders would also be of great interest, such as Standing Orders for an Opposed River Crossing, where Signal communications, system of calling forward equipment, etc., are capable of standardization.

Bridging in an Opposed Crossing

The main point of interest, or controversy, in this particular order is that, contrary to the practice of a large number of C.'s, R.E., tasks are enumerated as a whole in the Method paragraph and the allotment of Companies to tasks follow later. There may be a small amount of duplication as a result, but the writer's experience in a complicated operation such as a river crossing shows that it pays. Since there are a large number of major and minor tasks, Company Commanders get a forewarning of what to expect. Further there is less chance of omissions or misunderstandings, and it is easier and clearer for the C.R.E. to bring out the important point of priorities, completion times, etc. These are apt to be overlooked when detailing a list of tasks to each company in turn.

It should be clear that the Intention paragraph is that of the C.R.E and not the Divisional Commander's intention, which is placed in the Information paragraph. This is a point often missed by Adjutants in issuing the written orders.

Order Card—Bridging

Information

(*a*) Enemy.
Sitrep. Minefds.
(*b*) Own Tps.
i Sitrep.
ii Comd's. Intention.
iii Comd's. Method.
(*a*) Fmn. Tasks and Objectives—Axis of Advance, Code Names.
(*b*) Fmn. Boundaries.
(*c*) Misc. Int.

Intention

(*a*) Initial Crossing.
(*b*) Brs. Number and Class.

Method

(*a*) Tasks, e.g., Class 9 at ——
(*b*) Priority. Time of completion.
(*c*) Attd. Tps. Under Comd. or in Sp.
(*d*) Allotment of Tps. to Tasks.
i Initial Crossing :
1 Tps.
2 Under Comd. or Sp. of
3 Inf. R.V. for Asst. Eqpt. and Timings.
ii Brs.
1 Tps.
2 Under Comd. or in Sp. of
3 Sites, including code names.
4 Responsibility for calling fwd. Eqpt.
5 Report Centre.
6 H.Q. of Coy.
7 H.Q. Reps. at Site.
8 H.Q. Traffic Control.
(*e*) Permissible Lighting : Sites and Vehs.
(*f*) A.A. Protection.
(*g*) Covering Parties.

(*h*) TRAFFIC CONTROL SYSTEM, incl. R.T. and Line: responsibility for lighting and marking sites to marshalling harbours, marshalling harbours to F.A.As.
(*j*) SYSTEM FOR CALLING FWD. TRAFFIC INITIALLY OVER BRIDGE.
(*k*) EQUIPMENT:
- i Allotments to Coys. Incl. Rafts, Bridges, Trackways and Med. Eqpt. and also to Inf.
- ii Sitrep.
- iii R.V. For Fd. Pk.
- iv R.V. For Fd. Coys.
- v F.A.A.
- vi Marshalling Harbours.
- vii Movements:
  - 1 Routes.
  - 2 Responsibility for Fwd. Move.
  - 3 Restrictions, e.g., Daylight Move.
  - 4 March Table.
- viii Return of Eqpt. R.V.
- ix Reserves.

(*l*) MAINT.
(*m*) REVERSION OF ATTD. TPS.
(*n*) SECURITY PRECAUTIONS.

Admin.

(*a*) AMN. AND EXPL.
(*b*) MEDICAL.
(*c*) PETROL.
(*d*) POST.
(*e*) SUPPLIES.

Intercomn.

(*a*) C.R.E. NET.
(*b*) C.R.E. ROVER.
(*c*) C.E. FLICK.
(*d*) C.R.E. H.Q.
(*e*) DIV. H.Q.
(*f*) TAC. H.Q. (*Note.*—Sometimes known as Br. Control Centre.)
(*g*) LIAISON OFFICERS.
(*h*) PROGRESS REPORTS.
(*j*) WIRELESS SILENCE.

ATTACK THROUGH STRONGLY DEFENDED MINEFIELDS

In this order, as in the Opposed Crossing, tasks, including the lanes, are enumerated as a whole. Owing to the complexity of the order for an operation of this type, it is the writer's definite experience that the order becomes very confused and the general picture is not presented unless this system is used.

The Administrative order is apt to be complicated, or not firm, for an operation of this nature, so the details have been left out. In general its sub-headings will be the same as for the Opposed Crossing.

ORDER CARD

ATTACK THROUGH MINEFIELDS

Information

(*a*) ENEMY:
Sitrep. Minefds.

(*b*) OWN TPS. :
- i Right. / Centre / Left } Fmns. in Line.
- ii Corps Comd's. Intention.
- iii Subsidiary Ops. by other Fmns.

(*c*) METHOD :
- i Corps Phases of Attack.
- ii Subsidiary Ops. by other Fmns.
- iii Div. Intention.
- iv Div. Plan.
  - (*a*) Under Comd. of Div.
  - (*b*) Phases (Incl. R.E. Main Effort).
  - (*c*) Preliminary Moves to F.A.A.
  - (*d*) Veh. Lighting during Move.

Intention

R.E. DIV. WILL CONSTRUCT LANES THROUGH MINEFD. { TK. LANES / WHD. LANES

Method :

(*a*) Tps. under Comd. or in Sp. of Div., R.E.

(*b*) MOVES
- i F.A.A. to start or check line.
- ii Timings.
- iii Tpt.
- iv Responsibility for calling fwd. R.E. to lanes.

(*c*) LANES :
- i Code Names.
- ii Posn.
- iii Tks. Whs. Spare, Reverse.
- iv Priority.
- v Alignment.
- vi Width.
- vii Responsibility for calling Traffic fwd.

(*d*) TASKS :
- i Tracks, responsibility from Rear Area to start or check line.
- ii Tracks, responsibility from start or check line to minefd. near edge.
- iii Lanes, Responsibility for marking, making and lighting.
- iv Tracks, handover.
- v Dets. for unlocated minefds. in Br. Head.

(*e*) COMPLETION OF LANES :
- i Rear Rally.
- ii Tasks on fwd. Moves under Comd. Fmns. incl. R.V. and Timings.
- iii Tasks on fwd. Move, Specific tasks (e.g., Clearance of a Rd.)
- iv Reversion of Tps. under Comd.

(*f*) STORES :
- i Mech. Eqpt.
- ii Trackways E Stores—Dump and Amount.
- iii Detector Allotment.

(*g*) TRACK AND LANES :
Maint. after completion, incl. lanes for Traffic for Rear Echelon.

(*h*) Lane Control :

i System.

ii R.E. under Comd. or Sp.

(*j*) Security Precautions :

i Maps and Orders.

ii Local Protection provided by other Arms.

(*k*) Reversion Attd. Tps.

Admin. :

Intercomn. :

(*a*) Wireless Silence.

(*b*) C.R.E. Adv. H.Qs (with Fmn. and Lane Control).

(*c*) H.Q., R.E.

(*d*) C.R.E., Rover.

(*e*) Wireless Comns. Fmns. to Coy., to Lanes, to T.C.

(*f*) Progress Reports.

Defence Order Card

This is on a Field Company level, since it is considered more normal for a Company to be in an isolated defensive position, rather than a complete Division, R.E.

Note the extensive internal reorganization necessary in order to organize a Field Company for an Infantry role in the Defence. R.E. are armed or equipped to work on an independent platoon/section basis and weapons, tools and ammunition are decentralized accordingly. Infantry are organized on a platoon/company basis on the other hand, so an R.E. Unit has to be reorganized when employed as such. Equipment must be centralized and redistributed according to platoon's needs. The problem of what to do with, and how to defend, the transport is a major one and must be very carefully considered. They cannot be in the Defence Area itself and it may be necessary to provide additional escort, as noted in Method Sub-para. (iv.), in order to provide additional strength for its defence, or to give the defence longer range in small arms, by providing riflemen, since drivers are all equipped with Stens.

Defence Order Card

Information

(*a*) Enemy

(*b*) Ourselves

Intention

Method

i Pl. Localities and Role. (Should include Counter Attack.)

ii Boundaries.

iii Tpt. Locality.

iv Tps. Additional for Tpt.

v Killing Ground.

vi Ground Vital to Def.

vii P.I.A.T.S.

(*a*) A/Tk. Role.

(*b*) C.S. Role.

viii 20 M.M. Guns :

(*a*) A/A Role.

(*b*) A/Tk. Role.

ix H.Q. Brens.
x Amn. Distribution :
(*a*) S.A.A.
(*b*) 20 MM.
(*c*) P.I.A.T.
(*d*) Grenades, 36, 77, 75.
(*e*) Booby Tp. Mechanism.
xi Digging Policy.
xii Vehs. Allowed in Def. Area, incl. those required for :
(*a*) Amn.
(*b*) Casualty Evacuation.
(*c*) Wireless.
(*d*) Carriers For L.M.G.
xiii Deception Plan.

Admin.

xiv Rations (Sp. Meals).
xv Petrol A.P.
xvi R.A.P.
xvii Stretcher Bearers.
xviii Amn. Res.
xix Tools Res.
xx P. of W.

Intercomn.

xxi H.Q. Coy. and Adv. H.Q.
xxii Wireless to incl. Comns. between Coy. and Tpt. Pk.

To conclude, it is hoped that the Order Cards that have been given may provide discussion or even provide some ammunition for some harassed C.R.E. who has to produce his orders in a tithe of the time necessary ; a common enough occurrence sometimes.

ROAD ABSTRACTS

(*Compiled by the Department of Scientific and Industrial Research* (*Road Research Laboratory*) *and the Ministry of Transport. February*, 1947).

116.—Reflections on Military Engineering : D. Torrance : Surveyor, Lond., 1946. A brief review is given of military engineering experience and its application to civilian practice is discussed. Topics dealt with include : plant ; haulage vehicles ; mobile workshops ; road construction in Italy—pressed asphalt block surfacing, surface-dressed, water-bound macadam, lava block surfacing ; use of relatively easy standard gradients on mountainous roads in Algeria and Italy ; concrete guide posts ; wet-mix sand asphalt for runway surfacing ; army track, Sommerfeld track, pierced steel planking ; "colloidal" concrete for roads and runways ; military bridging.

PLANNED CONTROL OF CONSUMPTION FROM A WATER STORAGE RESERVOIR IN BURMA

By Major R. S. Hawkins, R.E.

1. Introduction

THE author had cause to worry considerably over the available water in a certain storage tank in Burma. The problem was to estimate the safe domestic consumption that could be allowed. The solution was not to be found by just calculating the contents of the tank and estimating the permissible daily consumption to last out till the next monsoon. No! after consideration many factors had to be taken into account, and the conclusions arrived at were both unexpected and interesting.

The problem, therefore, was studied in more general terms, but covering a fairly limited set of conditions. The factors considered undoubtedly affect in a greater or less degree all water storage problems. The conditions were as follows :—

(*a*) Location to be in a monsoon country.
(*b*) Storage tank to be of natural or artificial earth construction.
(*c*) The whole to be above the dry weather water table level.
(*d*) Tank to be filled either by rain falling on the area of the tank or by streams from a definite catchment area.

Now the general problem was this: "Given a certain size of tank, a quantity of water in it at a certain time of year, and knowing the average rainfall figures—what is the permissible domestic consumption?" To solve this completely it was found that the following factors had to be taken into account :—

(*a*) The needs of domestic consumers for the ensuing years.
(*b*) The monthly variation in rainfall.
(*c*) The annual variation in rainfall.
(*d*) The possibility of rainfall arriving up to one month late.
(*e*) Losses due to absorption and evaporation, and their seasonal variations.
(*f*) Losses due to water overflowing in very wet years.
(*g*) Allowance for sludge and unusable water to be flushed off from the bottom of the tank.
(*h*) The maximum capacity of the tank to allow for :—
    (*i*) Monthly variation in rainfall, i.e., to store up water in wet months for dry months.
    (*ii*) Yearly variations in rainfall, i.e., to store up water in wet years for dry years.

2. Domestic Consumption

Water is such a vital necessity to any community that over consumption is a crime. The fact that a tank has lasted out for a whole year at a given consumption rate is no criterion that such a rate is permissible for all time. The average rainfall will always give figures for permissible consumption over a large number of years; but if figures for previous year's rainfall and consumption are not available, it is dangerous to assume that no over consumption has taken place or that the next season's rainfall will be anywhere near the average figure. In fairness to those who come after, consumption must be limited to a fair and proper figure.

3. Rainfall Figures

All our domestic supply of water comes from rain. We may catch it in rivers or streams, and a lot will be lost by evaporation, absorption and drainage away into underground channels. We may catch it in open tanks, and still we lose a lot by evaporations and absorption. But we never know accurately from month to month, or year to year, how much we are going to catch. Rainfall data for most countries for a number of years has been accumulated, but may not be available. From normally available data we can obtain :—

(*a*) Average monthly figures.
(*b*) Average yearly figures.
(*c*) The average and maximum of seasonal and annual variations.

It is the latter piece of information that complicates the problem so much. For the next few months and the next few years we can estimate within all too wide limits the future rainfall. But whether a tank will be filled to overflowing or run nearly dry we cannot know. Previous records of rainfall are invaluable for making a closer estimate. Unfortunately these are seldom available under active service conditions, and data is normally limited to annual and possibly monthly average figures. It has been found that annual rainfall varies as follows :—

(*a*) Maximum may be 140 per cent of average.
(*b*) Minimum may be 60 per cent of average.
(*c*) Average of three consecutive dry years may be 83 per cent.

Thus it will be seen that recorded figures for the last few months and years are invaluable ; for, instead of assuming for safety that the next year will be "dry" it may be possible, if previous years have been dry below average, to allow a more liberal consumption.

The possibility of rainfall arriving up to a month late in any year must be allowed for. This is best done by holding a month's reserve in the bottom of the tank ; in planning, this quantity must not be touched except in an emergency. It should be included with the "unusable" water referred to later.

4. Evaporation and Absorption

In hot countries, losses due to evaporation and absorption are major factors. For example, in the type of tank under consideration, such losses may be four times the domestic consumption in hot dry months. Evaporation is proportional to the surface area, and absorption to the wetted area. For shallow tanks, the most common type, surface and wetted areas remain fairly constant, and can be assumed so for relevant calculations. For reservoirs formed by damming a catchment area, these losses are nearly proportional to the surface area. Such a reservoir will approximate to a shallow cone ; when the water is low a greater distance must be covered by the water flowing in. Hence losses will be almost independent of the amount of water held, which can be assumed constant for this purpose. The water collected however, will undergo two sets of losses :—

(*a*) Due to run off and evaporation in the catchment area (varying from 60 per cent in wet seasons to 99 per cent in dry seasons).
(*b*) Due to absorption and evaporation in the reservoir (varying seasonally).

It is most convenient to express them as a decrease in net rainfall or "negative rainfall." This applies equally well, whether the rain is collected only in the area of the reservoir or on a large catchment area draining into it. Table 1, column (*b*) (see page 57), compiled from available data and interpolation, shows typical evaporation and absorption losses expressed as inches of "negative rainfall."

5. Losses During Very Wet Years

It is normally uneconomical to construct a tank to hold all the rain falling during a very wet year, i.e., when the quantity is over 120 per cent of the average. Any rainfall over the 120 per cent mark will not, therefore, be collected and stored, but will be allowed to overflow to waste. Assuming that a very wet year of 140 per cent average rainfall occurs once in seven years, then 20 per cent of the average will be wasted for that year. Assume then that average annual wastage due to overflow on this account is 20/7 = say 4 per cent.

6. Sludge and Unusable Water

This is an arbitrary allowance depending on the general condition of the catchment area and bottom of the reservoir. Silt and debris will inevitably collect on the bottom ; it must not be allowed to build up to such an extent that when the water is low, contaminated water is supplied for consumption. Such unusable water must be drained or pumped off periodically, and an allowance made in the annual draw off. Further a definite quantity of water must be held in the bottom of the tank which is not available for consumption.

7. Safe Draw Off and Capacity of Tank

All the foregoing factors must be taken into account to decide on the safe average consumption for a given maximum capacity of tank. The method suggested is summarized in the following headings :—

(*a*) Obtain data for annual and monthly average rainfall. If possible, obtain recorded data for the past few years.

(*b*) Obtain or estimate figures for monthly losses due to run off, absorption and evaporation.

(*c*) Estimate rainfall for the ensuing three years, using data in (*a*) or by making allowances for maxima and minima referred to in Section 3. If no back data is available, assume that for this three-year period actual rainfall will be 83 per cent of average.

(*d*) Allow say 4 per cent for wastage due to overflow and estimate the net rainfall during the period, i.e., total rainfall less wastage and losses. This, divided by three gives the annual amount available for draw-off (expressed as inches of net rainfall) provided the capacity of the tank is adequate.

(*e*) Allow for unusable water to be drawn off and so obtain permissible domestic consumption.

To check the adequacy of the tank proceed as follows :—

(*a*) Assume annual rainfalls differing greatly between maximum and minimum—say 100 per cent, 130 per cent and 60 per cent of average.

(*b*) Tabulate monthly figures for rainfall and losses, and get a running total for net rainfall month by month.

(*c*) Plot these on a graph with inches of net rainfall as abscissæ and months as ordinates.

(*d*) From inspection plot annual consumption (a straight line) as so many inches of net rainfall a year. This line must not cut through any of the troughs in the rainfall graph. Below this, plot a parallel line, at a vertical distance equivalent to one month's reserve plus unusable water held in the bottom of the tank. The line represents the bottom of the tank.

TABLE 1

MONTHLY EQUIVALENT NET RAINFALL FOR VARYING ANNUAL RAINFALLS (INCHES)

Month	Evapn. and absorbn. loss	100% R. fall	Net R. fall	60% R. fall	Net R. fall	80% R. fall	Net R. fall	110% R. fall	Net R. fall	130% R. fall	Net R. fall
(*a*)	(*b*)	(*c*)	(*b* & *c*)	(*d*)	(*b* & *d*)	(*e*)	(*b* & *e*)	(*f*)	(*b* & *f*)	(*g*)	(*b* & *g*)
Jan. ..	— 4·1	0·1	— 4·0	0·1	— 4·0	0·1	— 4·0	0·1	— 4·0	0·1	— 4·0
Feb. ..	— 5·1	0·3	— 4·8	0·2	— 4·9	0·2	— 4·9	0·3	— 4·8	0·4	— 4·7
Mar. ..	— 7·1	0·6	— 6·5	0·4	— 6·7	0·5	— 6·6	0·7	— 6·4	0·8	— 6·3
Apr. ..	—10·3	2·6	— 7·7	1·6	— 8·7	2·1	— 8·2	2·9	— 7·4	3·4	— 6·9
May ..	—18·3	12·4	— 5·9	7·4	—10·9	9·9	— 8·4	13·6	— 4·7	16·1	— 2·2
June ..	—14·3	42·7	+28·4	25·6	+11·3	34·2	+19·9	47·0	+32·7	55·3	+41·0
July ..	—13·5	49·9	+36·4	29·9	+16·4	39·9	+26·4	54·9	+41·4	64·9	+51·4
Aug. ..	—12·5	41·6	+29·1	25·0	+12·5	33·3	+20·8	45·8	+33·3	54·1	+41·6
Sept. ..	—11·5	18·7	+ 7·2	11·2	— 0·3	15·0	+ 3·5	20·6	+ 9·1	24·3	+12·8
Oct. ..	— 9·1	8·6	— 0·5	5·2	— 3·9	6·9	— 2·2	9·5	+ 0·4	11·2	+ 2·1
Nov. ..	— 7·1	5·1	— 2·0	3·1	— 4·0	4·1	— 3·0	5·6	— 1·5	6·6	— 0·5
Dec. ..	— 4·1	0·6	— 3·5	0·4	— 3·7	0·5	— 3·6	0·7	— 3·4	0·8	— 3·3
Total	—117·0	183·2	+66·2	110·1	— 6·9	146·7	+29·7	201·7	+84·7	238·0	+121·0

(*e*) Find the maximum vertical distance between the "bottom of tank" and the net rainfall graph. This represents the maximum required capacity of the tank, in inches of net rainfall. If a check is being made on an existing tank, this distance should not exceed the tank capacity. If it does, the rainfall graph must be adjusted for the period beyond this point, by "disallowing" so many inches of net rainfall, which have overflowed. This will cause a further adjustment of the safe "draw-off" line.

8. Example of Calculations

The problem set and dealt with here is typical of local conditions. Data is partly estimated and partly from records ; and must not be taken as exactly representing actual conditions. However, information from authoritative local inhabitants corroborates results to a welcome degree, and it appears, therefore, that data and calculations are reasonably accurate.

The Problem

A tank is taken over on 1st March ; it is 500 yds. by 500 yds., the bottom is dish shaped, approximating to a shallow cone with maximum depth of 30 ft. below ground level ; sides above ground are earth bunds of an effective height of 4 ft. above ground level : they are assumed vertical for calculation purposes; there is 23 ft. of water in the tank. No previous records of rainfall or consumption are available. Figures for average rainfall are available (Table 1, column (*c*)) (see page 57). Figures for monthly losses due to evaporation and absorption are taken as in Table 1, column (*b*). The tank is filled only by rainfall falling within the area of the bunds.

What is the permissible domestic consumption ?

(*a*) Over a large number of years ?
(*b*) For the months and few years in the immediate future ?

Solution to Problem (*a*)

Average annual rainfall $= 183{\cdot}2$ in.
Average evaporation, etc., loss $= 117{\cdot}0$ in.
Allow for overflow waste an annual loss of 4 per cent rainfall
$= {\cdot}04 \times 183{\cdot}2 = 7{\cdot}3$ in.
$\therefore$ The equivalent net rainfall collected annually in the tank
$= 183{\cdot}2 - 117{\cdot}0 - 7{\cdot}3 = 58{\cdot}9$ in.
Allow for unusable water flushed off, 3 per cent of this
$= {\cdot}03 \times 58{\cdot}9 = 1{\cdot}8$ in.
$\therefore$ Net rainfall available for draw-off $= 58{\cdot}9$ in.
$\therefore$ Net rainfall available for domestic consumption
$= 58{\cdot}9 - 1{\cdot}8 = 57{\cdot}1$ in.
This is collected over an area 500 yds. $\times$ 500 yds., and hence permissible consumption.

$$= \frac{57{\cdot}1}{12} \times \frac{500 \times 500 \times 9 \times 6{\cdot}25}{365}$$

$= 184{,}000$ gals. per day.

This consumption is permissible only over a large number of years, after the tank has been nursed back to form if over-consumption has taken place. There is still one further condition, and that is that the maximum capacity must be sufficient for storage over the dry months and years. This, however, is dealt with in problem (*b*).

Solution to Problem (b)

If a graph is drawn of net accumulated rainfall, minima occur at about the end of May. Therefore, for simplicity, a " year " is assumed to last from June to May of the following year. Let us call March to May of this year the end of year 0, and subsequent years numbers 1, 2 and 3 respectively.

As no back records are available, let us assume a 3-year period of consecutive dry years, averaging 83 per cent of average rainfall. Let us have also large differences between maximum and minimum annual rainfalls to check if the tank capacity is adequate. Actually these two sets of " worst " conditions cannot exist simultaneously, so

(*i*) For safe consumption figures, assume rainfalls as follows :—

Year 0	—	100 per cent of average	
Year 1	—	80 ,, ,, ,,	Average of 83 per cent
Year 2	—	110 ,, ,, ,,	
Year 3	—	60 ,, ,, ,,	

(*ii*) For maximum capacity check, assume rainfall as follows :—

Year 0	—	100 per cent of average
Year 1	—	100 ,, ,, ,,
Year 2	—	130 ,, ,, ,,
Year 3	—	60 ,, ,, ,,

Condition (i)

Graph III (see page 64) shows the relation between inches of net rainfall collected in the tank, and depth of water. As all rain falls within the area of the tank, it is easily found that 100 in. net rainfall is equivalent to 117×10^6 gals. From this graph it is found that 23 ft. of water = 54·1 net rainfall = $63{\cdot}5 \times 10^6$ gals.

Now one month's reserve $= \frac{1}{12} \times 58{\cdot}9$ in.
$= 4{\cdot}9$ in. net rainfall

Assume unusable water $= 10{\cdot}0$ in ,,

$\therefore$ 4·9 + 10·0 = say 15 in. must be held in the bottom of the tank, to be used only in an emergency.

Table 1 (see page 57) shows, for varying annual rainfalls, the monthly net rainfalls after deductions for evaporation and absorption losses. The running total of net rainfall accumulated is tabulated in Table 2 (see page 60), which is self explanatory. This is plotted on Graph I (see page 62) ; on this are also plotted by inspection, straight lines representing " safe draw off " and " bottom of tank." Note that point A on 1st March in year 0 at 15 in. By inspection point B is selected on 1st June in year 2 at 59·0 in.

$\therefore$ Safe draw off during these 15 months is
59·0 — 15 = 44·0 in. net rainfall.

The annual allowance for unusuable water flushed off is 1·8 in. Therefore, permissible domestic consumption per year

$$= \frac{44{\cdot}0 \times 12}{15} - 1{\cdot}8 = 35{\cdot}2 \text{ in. net rainfall.}$$

$$= \frac{35{\cdot}2}{100} \times \frac{117 \times 10^6}{365} = 113{,}000 \text{ gals. per day.}$$

Point C at the end of Year 3 is selected by inspection at 137·0 in.

$\therefore$ Permissible domestic consumption during Years 2 and 3 = 137·0 — 59·0 — 1·8 = 74·4 in. net rainfall = 120,000 gals. per day.

If Year 1 is a very dry year with only 60 per cent average rainfall, the situation will be acute and the tank may dry up in February or March. This can only occur if bad over-consumption has already occurred. It should be stated as a fairly safe forecast, therefore, that permissible consumption for the first two or three years will be 113,000–120,000 gals. per day ; after that, consumption may be 184,000 gals. per day.

Now the actual holding of the tank at any time is the vertical distance between the net rainfall graph and the " bottom of tank " line, 15·0 in. below the " safe draw-off line." Where this exceeds the maximum capacity of the tank expressed in inches of net rainfall, the tank will overflow.

The maximum holding of the tank during the period occurs about 1st October in Year 2, and it is 180·0 — 57·0 = 123·0 in. From Graph III (see page 64) the maximum capacity of the tank is 168 in. so it is adequate for conditions so far considered.

TABLE II

Monthly Running Total of Net Rainfall for 3 Years, Averaging 83 per cent of Average Rainfall

	Year 0		Year 1		Year 2		Year 3	
Month	100% R. fall	Running	80% R. fall	Running	110% R. fall	Running	60% R. fall	Running
	Net	Total	Net	Total	Net	Total	Net	Total
June ..			+19·9	53·8	+32·7	93·6	+11·3	159·6
July ..			+26·4	80·2	+41·4	137·7	+16·4	176·0
Aug. ..			+20·8	101·0	+33·3	171·0	+12·5	188·5
Sept. ..			+ 3·5	104·5	+ 9·1	180·1	— 0·3	188·2
Oct. ..			— 2·2	102·3	+ 0·4	180·5	— 3·9	184·3
Nov. ..			— 3·0	99·3	— 1·5	179·0	— 4·0	180·3
Dec. ..			— 3·6	95·7	— 3·4	175·6	— 3·7	176·6
Jan. ..			— 4·0	91·7	— 4·0	171·6	— 4·0	172·6
Feb. ..	—	54·0	— 4·9	86·8	— 4·8	166·8	— 4·9	167·7
Mar. ..	—6·5	47·5	— 6·6	80·2	— 6·4	160·4	— 6·7	161·0
Apr. ..	—7·7	39·8	— 8·2	72·0	— 7·4	153·0	— 8·7	152·3
May ..	—5·9	33·9	— 8·4	63·6	— 4·7	148·3	—10·9	141·4

Condition (ii)

Starting from conditions as at 1st June in Year 1 in Graph I (see page 62) net rainfall is plotted in Graph II for the rainfalls stated. In Year 1, assume that domestic consumption is limited to 117,000 gals. per day for safety. Assume that full consumption 184,000 gals. per day is permitted in Years 2 and 3, as Year 2 is going to be a very wet year. Reserve and unusable water is allowed for as before.

By inspection the tank is found to overflow at the end of August in Year 2 ; this state of affairs is plotted as shown, and overflow causes a net loss of 13·0 in. of rainfall. However, the capacity of the tank appears adequate to cope with any but abnormally wet years. As overflow waste has occurred, the net accumulated rainfall graph is adjusted by deducting 13·0 in. for the period after overflow stops.

Now if Year 4 is another dry year with say 80 per cent rainfall (and it may well be) maximum draw-off will cause the tank to use up far more than its one month's reserve. In fact the danger mark will be passed. Therefore, it is advisable to restrict consumption during Year 2 to a 90 per cent rainfall allowance.

Now 90 per cent rainfall = 90/100 × 183·2 = 164·9 in.
Evaporation and absorption losses = 117·0 in.
Unusable water draw-off = 1·8 in.
Annual overflow waste allowance need not be deducted here.

∴ Available for consumption = 164·9 — 117·0 — 1·8
= 46·1 in. net rainfall

$$\text{Permissible consumption} = \frac{46{\cdot}1}{100} \times \frac{117 \times 10^6}{365}$$
= 148,000 gals. per day.

The solution to the problem can be given in the form of a forecast only of permissible consumptions as follows :—

Year 1	113,000 gals. per day
Year 2	148,000 gals. per day
Year 3 and onwards ..	184,000 gals. per day

If, however, Year 1 is a very dry year with much less than 80 per cent rainfall, the tank will dry up due to previous over-consumption. Note the necessity of building up over a number of years a reserve store against future dry years.

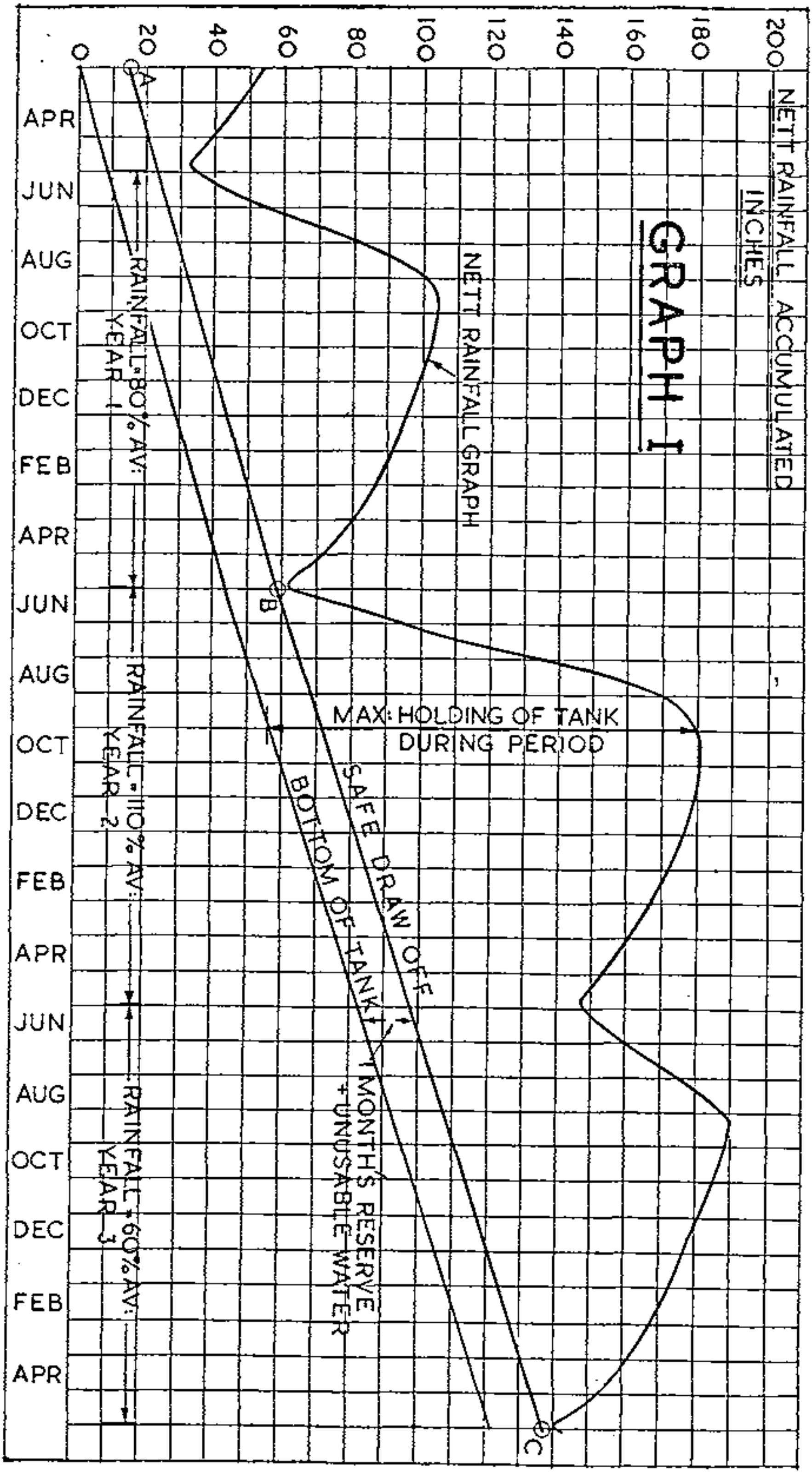
The Graphs also illustrate one or two points :—

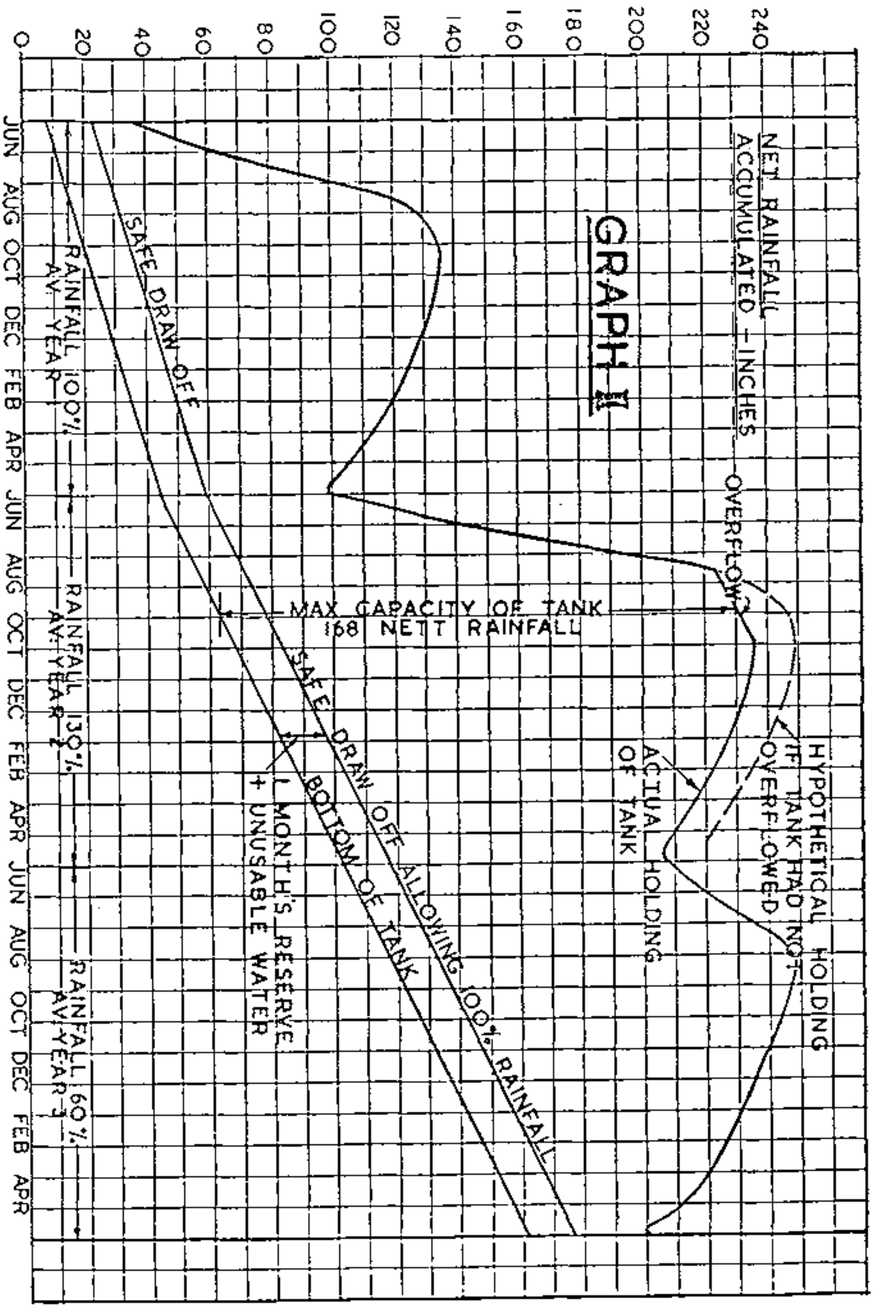
Graph I (see page 62)
At the end of Year 3, losses are three times the consumption rate.

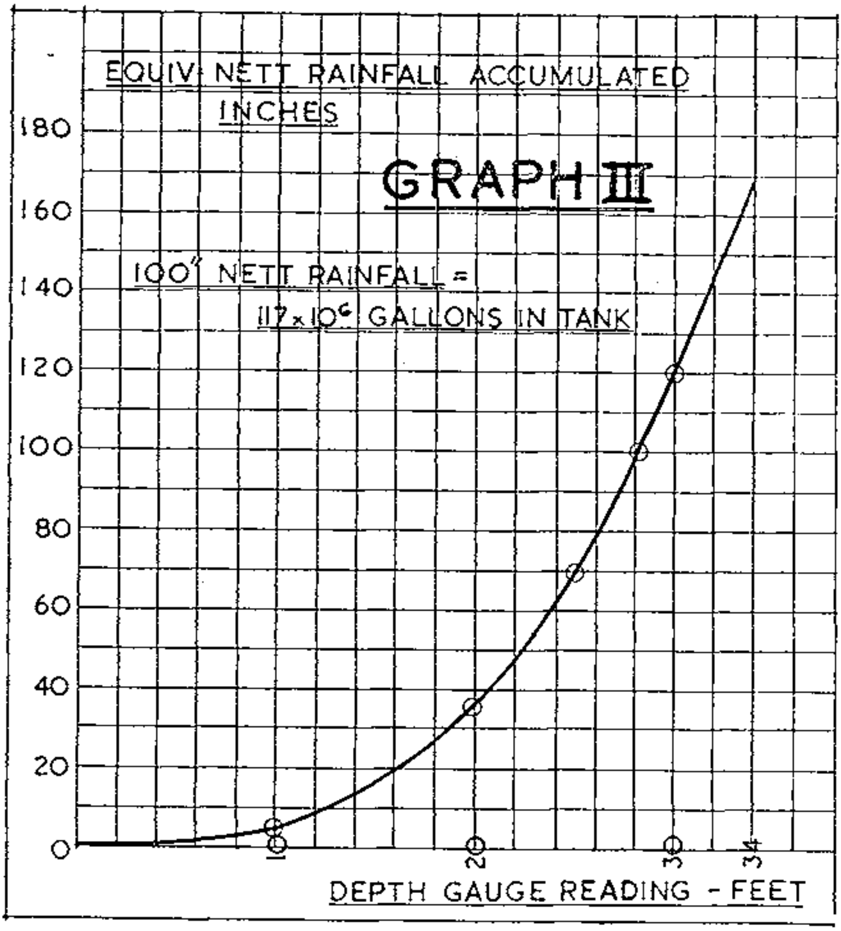
Graph II (see page 63)
(i) The maximum capacity of the tank is 2·9 times the full permissible annual consumption.
(ii) The minimum holding at the end of a wet year may be as much as the maximum holding during a dry year.

9. Conclusions

(i) The safe draw-off from a storage tank can be decided only after considering possible rainfall conditions up to 4 or 5 years after.
(ii) If back records of rainfall and consumption are not available a policy of safety must be followed. By carefully studying the problem, over safety can be avoided.
(iii) After enemy occupation and possible over-consumption the tank must be nursed back to form over a number of years, before maximum consumption is permissible.
(iv) Not a conclusion but a hope, in spite of what has been so laboriously written, a well informed local inhabitant should be found to " confirm results."


GRAPH I
NETT RAINFALL ACCUMULATED INCHES
0
20
40
60
80
100
120
140
160
180
200
APR
JUN
AUG
OCT
DEC
FEB
APR
JUN
AUG
OCT
DEC
FEB
APR
JUN
AUG
OCT
DEC
FEB
APR
A
B
C
NETT RAINFALL GRAPH
RAINFALL 80% AV: YEAR 1
RAINFALL 110% AV: YEAR 2
RAINFALL 60% AV: YEAR 3
MAX: HOLDING OF TANK DURING PERIOD
SAFE DRAW OFF
BOTTOM OF TANK
1 MONTH'S RESERVE + UNUSABLE WATER


GRAPH II
NET RAINFALL ACCUMULATED – INCHES
0
20
40
60
80
100
120
140
160
180
200
220
240
JUN AUG OCT DEC FEB APR JUN AUG OCT DEC FEB APR JUN AUG OCT DEC FEB APR
SAFE DRAW OFF
OVERFLOW
MAX CAPACITY OF TANK
168 NETT RAINFALL
SAFE DRAW OFF ALLOWING 100% RAINFALL
BOTTOM OF TANK
1 MONTH'S RESERVE
+ UNUSABLE WATER
HYPOTHETICAL HOLDING
IF TANK HAD NOT
OVERFLOWED
ACTUAL HOLDING
OF TANK
RAINFALL 100%
AV. YEAR 1
RAINFALL 130%
AV. YEAR 2
RAINFALL 60%
AV. YEAR 3


EQUIV. NETT RAINFALL ACCUMULATED
INCHES
GRAPH III
100" NETT RAINFALL =
117 x 10⁶ GALLONS IN TANK
180
160
140
120
100
80
60
40
20
0
10
20
30
34
DEPTH GAUGE READING - FEET

THE BILLING BLITZ

BY MAJOR D. A. BOYD, R.E.

ANY R.E. Officer who was in Works Services in Great Britain between 1939 and 1942 will hardly have forgotten the large amount of work that was then carried out on accommodation, gun sites and defences. This work was almost all done by civilian contractors and ordered, supervised, measured and billed by the staff of the D.C.R.E.

The vast and rapid expansion of Works Services meant the taking on of civilian employees quite inexperienced in W.D. procedure. Many of the technical staff had previously never measured up work in accordance with the W.D. Schedule.

Hence a situation presented itself in which the D.C.R.E. was being asked to handle a greatly increased volume of work with an inexperienced and inadequate staff. The result was that the Clerks of Works issued orders on contractors, mostly Term Contractors, and as there were always other new works to be ordered and supervised, little time was available for measuring up the completed work. Even when work was measured and booked there was no opportunity for squaring out, abstracting and billing.

Readjustment of areas meant that the D.C.R.E. sometimes had to take over sites on which part of the work was in progress, and part of it finished, some of which was measured and some not. Works orders, A.F's, K.1261, dimension books, and A.F's, K.1315 and M.1417 covering the work were sometimes available, but often incomplete.

Had it not been for the intervention of the Engineer-in-Chief during 1941 and the subsequent increased establishment for Works Services, which included a greatly increased civilian staff for the D.C.R.E., it is questionable if the work done during the busy period of 1939—1942 would have been measured up and billed today.

When the writer was appointed D.C.R.E. in December, 1941, he immediately concentrated on the clearing up of outstanding measuring. Nevertheless, although a very determined effort was made and considerable work was billed, it was found that at the beginning of March, 1942, the task remaining to be done in the thirty days, i.e., before April 1st, was to square out, check squaring, abstract and to check arithmetically and technically 234 dimension books covering 650 works orders the estimated value of which was £170,000.

The preparation of abstracts and the completion of bills is the responsibility of the contractors. The contractors' reduced staff, however, was too busy to do the work, and in some cases contractors who were not conversant with W.D. procedure could not do the work. This state of affairs led to a worry experienced by all works officers when a contractor asked for a payment on account for work finished and which had been valued by the Clerk of Works at a figure considerably less than that which the contractor demanded. The obvious solution of the problem was for the D.C.R.E. to accept the responsibility for abstracting and billing. This the writer decided to do.

The following is an explanation of how the very considerable amount of outstanding works were billed and paid for. There is no doubt that a similar system of abstracting could again be used. It is in the hope that others may be inclined to try out the method that this paper is written.

Task

As stated above the task was to square out, check the squaring, abstract and to check arithmetically and technically the abstracts of 234 dimension books covering 650 works orders the estimated value of which was £170,000.

Observations

A reasonably complete record of works orders existed, but it was necessary to make sure that those works orders which had been taken over from other D.C's, R.E., when areas were adjusted, and which, when outstanding, i.e., had not been billed, were entered in the " orders placed " column of the " Construction Account." It was found that in many cases this had not been done. The Clerk of Works had simply collected the works orders from another Clerk of Works and had placed them in a file, which lay on his own table until he had time to deal with them.

Control of Works Orders

In order to trace all works orders and to find out the exact position with regard to them a sheet was prepared thus :—

Part.	W.O.	Date.	If billed	If not billed, where measured	Transferred to D.C.R.E.

All works orders issued from my office, and all copies of works orders issued by other D.C's, R.E. on sites handed over to me, were entered on this sheet. Any works orders transferred to other D.C's, R.E. were noted in the right-hand column and no further action was taken. Thus a complete history of all works ordered was produced. Having this information it was known precisely what was to be billed.

After this was done all dimension books were withdrawn from contractors for abstracting by the D.C.R.E. Many of the dimension books contained very sketchy descriptions, as a lot of the measuring had been done by inexperienced men. Much time was also spent in obtaining time sheets for day work and invoices to support " star prices."

Abstracting

The next task was to set up an abstracting and billing team whose sole job would be to concentrate on the outstanding dimension books mentioned above. It was found that the following staff could be used for this work :—

6 Clerks of Works.
2 Foremen.
2 Grade III Clerks.
3 Finance Clerks.
1 Surveyors Clerk.

It was estimated that a Clerk of Works working steadily abstracted one dimension book in a day. It was obvious, therefore, that, if the task was to be completed in the time available, some method had to be found whereby this performance could be improved. Further, as almost all the Clerks of Works were more or less inexperienced in the work, a system of mass abstracting should be devised. If non-technical men could be used to do a part of the abstracting it would help very much.

It was usual for Clerks of Works to get their Schedule items in numerical order, i.e., from 1 to 1,000 and so on, by using a piece of paper of foolscap size and writing down the item numbers as they occur in the dimension books, low numbers on the left-hand side of the paper and high numbers on the right. By sorting them out it was possible to get the items into numerical order, in which order they always appear on the abstract.

The Skeleton Abstract

To obviate this haphazardous, slow and generally unsatisfactory method of working, a chart was prepared using large sheets of drawing paper, 6 ft. by 2 ft. 2 in., ruled in ink and headed as under :—

		1–49	50–99	100–149	150–199	200–249	Etc. up to 3800	
	0.							
	1.							
Etc.	2.							

The object of this chart was to arrange the item numbers in the sequence required for the abstract. Four men, comprising two teams were employed.

One man took the dimension book and called out the item number, page, and rate which the other man entered lightly, with lead pencil, on the chart. When this operation was finished the dimension book was set aside and one man took abstract sheets, while the other read off in rotation the item numbers, with the numbers of the pages and rates, rubbing out from the chart with an india-rubber each item as he called it out. The skeleton abstract on A.F.K.1291 was then finished, the columns in the abstract sheets appearing as follows :—

Item No.	
Rate	
Page numbers	

Note.—No descriptions or quantities, only Item No., Rate, and Page No. of Dim. Book.

The Finished Abstract

The dimension books and skeleton abstracts were then handed over to the Clerks of Works, of whom there were three teams of two men each. The descriptions were transferred, dimensions were entered against each page number on the abstract sheets and cancelled off in the dimension book, thus giving the finished abstract.

Technical Check and Final Billing

When the second process was completed the abstracts were ready to go to the Finance Clerks for check and final billing after technical check.

Remarks

The times spent on the three processes should be of interest. They were as follows :—

Skeleton Abstract .. 4 men—16 dimension books per day.
Finished Abstract .. 6 men—12 dimension books per day.
Check in Finance Office 3 men—6 dimension books per day.

The large accumulation of outstanding Works Orders was due to my office having taken over unmeasured Works Orders from six other D.C's, R.E.

The method employed is only of real use when there is a large amount of work done on the T.C. Where the T.C. is used for repairs and maintenance, and the work is recorded on A.F's K.1315 and M.1417, the measuring should be kept up to date. In the case which I have endeavoured to describe minor works of repair were ordered on A.F's K.1261, thus requiring the use of dimension books and abstract.

Much time was spent in getting invoices to support star prices and time sheets to cover day work. This should be done when the work is being measured and not months afterwards.

Finally had it not been for the loyal services of my Garrison Engineer, Lieut. W. Yule, now I am happy to say Major Yule, the billing could not have been finished in time. In fact the idea of the chart was originally his.

A WARTIME COURSE AT THE AMERICAN STAFF COLLEGE

By Lieut.-Col. W. H. Aylwin, R.E.

Students for the " 24th Class " at the Command and General Staff School were required to report to Fort Leavenworth, Kansas, U.S.A., on 26th May, 1945. Consequently, from all over the world, over a thousand officers were converging by train, road and air on that day towards this historic meeting point of the old-time " trails " in the geographic centre of the United States.

Amongst these thousand-odd prospective students there were no less than seventy-six representatives from foreign armies and air forces, viz., U.K., Canada, Australia, Brazil, Peru, Chile, France, Belgium, Ecuador, Poland, Uruguay, China and the Philippine Islands. The British provided eighteen of which eleven came from U.K., six from Canada and one from Australia.

Fort Leavenworth—one of the oldest military posts in the country—has been the home of the American Staff College since 1881 when " The School of Application for Infantry and Cavalry " was founded there by General William T. Sherman.

Nowadays the School is subdivided into three Sections—the Ground Section for " Combat Arms," the Air Section for Air Corps students and the Service Section for the remainder. The Ground Section is further subdivided into Infantry, Armoured and Anti-Aircraft.

For all three Sections the course lasts for ten weeks, but the remainder of this article must necessarily be confined to the Ground Section, since it was to that Section that the writer was assigned.

The ten weeks were divided into two halves. For the first five weeks, the organization, administration, staff duties and basic tactics of the American land, sea and air forces were taught in considerable detail, together with a good deal of rather elementary map-reading. The second half was almost entirely devoted to map exercises and map manœuvres, rising steadily from Regimental (i.e., Brigade) level up to Army Group and Combined Operations.

The prescribed syllabus was as follows :—

Instruction	Hours				
	Instr. to all	Specific instr. according to assignment			Totals
		Armd.	Inf.	AA	
BASIC :					
Organization, arms and services—					
(*a*) Organization	20	4	3	4	
(*b*) Staffs	9	—	—	—	
(*c*) Tactics of Arms and functions of services	23	—	—	—	
(*d*) Review	4	—	—	—	
Sub-totals ..	56	4	4	4	60
STAFF DUTIES :					
Detailed Staff organization, procedure and technique—					
(*a*) G-1 (i.e., our " A ")	22	—	—	—	
(*b*) G-2 (i.e., our " I ")	45	—	—	—	
(*c*) G-3 (i.e., our " G ")	30	24	24	24	
(*d*) G-4 (i.e., our " Q ")	12	14	14	14	
Sub-totals ..	109	38	38	38	147
OPERATIONS :					
Based on Command decisions to develop staff and operational technique for—					
(*a*) Operations of large formations, ground and air, stressing integration of staff and the application of staff technique	127	26	26	26	
(*b*) Combined staff organization procedures and operations ..	24	—	—	—	
(*c*) Map manœuvres	—	70	70	70	
Sub-totals ..	151	96	96	96	247
Grand Totals	316	138	138	138	454

From the British point of view, the strangest part of the course was the fact that, without any exception whatsoever, all instruction took place in the lecture room. Not once, even for map reading, schemes or the like, did one go out on the ground.

The incessant class-room work from 08.00 to 16.30 daily (followed by three hours private study), in a steady day and night temperature in the upper 90's, was hard going especially over the first five weeks when it was lecture, lecture all the way. Again, until one became " acclimated " to the accents of the speakers, more than normal concentration was required and the language difficulty was aggravated by the use of loud speakers—very necessary because of the enormous size of the class-rooms. The lecturer wore a small breast microphone clipped on to his shirt front, whereas you, if you wished to ask a question, stood up. Whereupon, a W.A.C. attendant ran up with a hand microphone on a wandering lead and you carried out a queer long distance conversation with a small impersonal lecturer in the far distance. Incidentally, the Commandant—Major-General Trusedell—has a box of tricks on his office table which enables him, by a trip of a switch, to listen in to any lecture hall at will. Rather a handicap to the nervous speaker.

The teachers had obviously been picked very carefully to give a well balanced view of a world-wide war and most of them were absolutely first class. There were, unfortunately, a few really bad ones which called forth some very outspoken comments from the American officers. There was one British instructor (Scots Guards) who was a great success. His performance in a staff play as the " typical Blimey officer " with accentuated flippancy, drawling voice, Eighth Army dress, Dachshund on a piece of string, but with underlying efficiency, had to be seen to be believed.

Anglo-American relations were rather interesting. We were received initially with great politeness by all students, but also with a certain amount of reserve. Our strange dress, jarring accent and refusal to knuckle under to considerable under-statement of the British Empire's share in the war tended, in the first few weeks, to widen the natural gap between us. Gradually, however, as American and British came to know one another better, relations improved by leaps and bounds and, once the ice was broken, our popularity soared to such heights that American hospitality—a wonderful thing—eventually almost swamped us.

In conclusion, a word about Leavenworth itself. Each of the sections has its own lecture-room—in most cases a converted riding school. There is one enormous building, known as Gruber I, which accommodates the whole student body for certain general lectures. Attached to each class-room is a coffee shop, which is a great boon in the ten minute intervals between lectures.

The students are housed in apartments accommodating nine or ten officers. Whether or not one gets a room to oneself depends on seniority, as the students vary from First Lieutenant to full Colonel.

Messing is on the " restaurant " as opposed to our " mess " principal. Students may choose whether they feed in a mess having table cloths and waitresses or at a help-yourself cafeteria. It was interesting to note that the British went 100 per cent for the former.

Amenities are on a scale unapproached and unapproachable in wartime England. An officer's club, a golf club (complete with first class swimming pool), a hunt (or country) club, air-conditioned cinema showing pre-release films, a young Harrods of a P.X., with all goods at cost price, dry cleaning shops, boot repair shops, laundries, etc., are but a selection of the facilities available.

Altogether, it was a very happy and interesting trip to a great country which is unfortunately " off the map " for most of the British Army.

BRIGADIER-GENERAL E. N. STOCKLEY, D.S.O.

ERNEST NORMAN STOCKLEY was the second son of the late Colonel George Watts Stockley, R.E., J.P., of West Malling, Kent. He was born at Gillingham on the 25th September, 1872, his father being at that time in command of the R.E. Detachment in *H.M.S. Hood*, a hulk moored off Gillingham for submarine mining experiments. Educated at Wellington College and the R.M.A., Woolwich, he was gazetted to the R.E. in July, 1891. On completion of the two years course at the S.M.E. he was ordered to India and joined the Military Works at Allahabad. In 1895, he was transferred to the Punjab Public Works as Assistant Engineer of the Kurram Valley and had the interesting experience of building Parachinar Cantonment, and reopening the Kurram Valley road from Thall for cart traffic.

In 1897, after a short spell in charge of the Peshawar District, he was transferred to the Tochi Valley for the construction of forts and barracks in the upper valley, and the road survey from Miranshah to Dattakhel. The attack made by Maddakhels on the Political Officer's escort at Maizar on the 10th June, 1897, set the frontier ablaze, and put an end to anything but field engineering. Stockley was mentioned for taking out reinforcements to cover the retirement to Dattakhel fort. His immediate work was the construction of a pack road up which the Tochi Field Force could advance, with a temporary wooden bridge across the river at Boya. This road was through by the time the troops arrived, and during the time of occupation gradually improved on the line of the cart road survey.

In 1898, after leave home, Stockley reverted to the Military Works and was posted to Secunderabad where the work was the ordinary routine of the Garrison Engineer.

In 1900 he was transferred to Simla for work in the office of the Director-General of Military Works, and for the next two years was employed chiefly on checking the large projects then in hand, mainly the completion of water-works in cantonments and the initiation of electric lighting and punkah-pulling proposals.

Reverting to home service, on promotion to Captain in 1902 he was employed at the War Office in the Barrack Design Branch of the I.Q.F's office, then very busy with extensive projects for new barracks at Tidworth, Colchester, Curragh, etc., under the Military Works loan. The essence of all this planning was embodied in the series of Standard Plans and a revised issue of the "Barrack Synopsis" in foolscap size, with an accompanying book *The Handbook of Design and Construction*. Stockley edited these and wrote the article on "Barracks" for the *Encyclopædia Britannica.*

His next appointment from 1906 to 1911 was at Chatham as Assistant Instructor in Construction. During this time, besides the usual S.M.E. Courses for junior officers, advanced classes were passing through for the officers who had missed their construction course owing to the South African War, so his work was of exceptional interest, and tours of Engineering Works were made a special feature of the course to supplement the lectures and projects. During the summer, Stockley had the opportunity of employing his hobby of sailing, especially dinghy sailing. He owned the first 12-ft. class dinghy on the Medway, and for some time acted as Secretary, R.E.Y.C., in the days of the *Fulmar*, *Hearty*, *Maia* and *Mignon*. He also went in for Scouting with King's School boys 1st Rochester Troop.

In 1911, on promotion to Major at twenty years service, Stockley was posted to Edinburgh and carried out the duties of Garrison Engineer for S.E. Scotland till war broke out in 1914, when he was called back to Chatham. He went to France in command of the 77 Fld. Coy., and in 1916 became C.R.E. 41 Div., with which he served in France, Flanders and Italy, coming back in 1918 to be C.E. XIX Corps in the final advance.

When the Germans made their great attack in March, 1918, a very critical situation arose near Bapaume where a gap occurred in the British Line between two divisions. Stockley, then C.R.E. 41 Div., collected his three field companies who were working on a rear line and took them up to hold the breach. Fighting as infantry these Sappers held the line against repeated attacks until he was finally ordered to withdraw. For his gallant action he was awarded a bar to the D.S.O. which had been awarded to him in January, 1917.

For his services in France he was also awarded the Legion of Honour and the French Croix de Guerre and was also made a brevet Lieutenant-Colonel in 1918 and a brevet Colonel in 1919.

After a spell in Cologne as C.E. VI Corps Stockley was posted to the War Office on the Training Manuals Revision Committee and wrote the post-war issue of *Engineer Training* and Vol. III *Military Bridging* as well as editing the *Field Works Manual*, *All Arms*, and other volumes of the Military Engineering Series. The work of *Military Bridging* during the Great War was also epitomized in an article for the *Encyclopædia Britannica*.

Stockley's next appointment from January, 1921, till September, 1922, was the command of the Depot Battalion in St. Mary's Barracks, then still full to overflowing with the stream of men for demobilization, and the centre for mobilization of all R.E. reservists for the coal strikes of 1921. St. Mary's also took the overflow of officers from Brompton, and the old casemates were put to their fullest use. Dining-halls and Regimental Institute with concert hall were provided.

The construction of a battalion recreation ground in the Black Lion Field gave useful employment and recreation, especially for the boys under trade training in the workshops.

In 1923 Stockley was appointed Deputy Chief Engineer in the Eastern Command: and in 1925 Chief Engineer in the Western Command, at Chester, which appointment he held till retirement at the age of 57 in 1929.

Stockley married in 1898 Elizabeth Shewell daughter of Lieutenant-Colonel H. F. Cooper, R.M.L.I., J.P., of Rochester and is survived by three sons: G. E. Stockley, Consul-General at Hankow, F. E. Stockley, Lieutenant-Colonel, the Essex Regt., G. H. Stockley, Lieutenant-Colonel, Royal Marines, and one daughter married to Major C. S. Bowen, M.C.

A brother officer who knew Stockley well writes: "He was one of the most modest and unassuming of men and the most kindly. I have never seen him ruffled or upset, but always patient, helpful and sympathetic and ready to do anything in his power to help anyone."

C.C.P.

Brigadier General Ernest N Stockley DSO

Major General Sir Louis Jackson KBE CB CMG

MAJOR-GENERAL SIR LOUIS JACKSON, K.B.E., C.B., C.M.G.

LOUIS CHARLES JACKSON was a member of a family, which for several generations had given cadets to the Public Service, notably in the Army and in India. His Father, Sir Louis (Stewart) Jackson, C.I.E., was a member of the Bengal Civil Service, who after employment in the Straits Settlements, China and India, was for the last eighteen years of his service a much respected judge of the Supreme Court at Calcutta. His mother was the daughter of Lieutenant-General Sir William Staveley, who was on Wellington's staff at Waterloo and died in 1854 when Commander-in-Chief of the Madras Army.

Jackson was born in England in March, 1856, but six months later, went to India, with his parents, while the Indian Mutiny was drawing to its end. He was educated at Somersetshire College, Bath, entered the R.M.A., Woolwich, in 1873 and was commissioned in the Royal Engineers in February, 1876, having lost a term through illness. On completion of his courses at the S.M.E. in the spring of 1878, he started a long course of Submarine Mining on the *Hood*, but this was not completed as he had volunteered for India and a war scare caused his embarkation for India in December, 1878. On arrival in India a war had broken out in Afghanistan and he at once went on to the front and joined a column which went up the Bazar Valley into the Khyber Pass. His travelling companion was Reginald Hart, and Jackson was present in the skirmish in the pass when Hart got his V.C. He eventually reached Jalalabad. On return to Peshawar, Jackson got an attack of fever and in August, 1879, he was invalided home. Early in 1881 he exchanged back to the Imperial list and was ordered to Newcastle-on-Tyne. In October, of the same year he joined the 1st Company, R.E. at Halifax, Nova Scotia, and nine months later the Company was ordered to Gibraltar, where he was employed on the emplacements for the two 100-ton guns just ordered for that station. A few months later he accepted the appointment of Secretary and A.D.C. to the Governor of the Leeward Islands, but after six months the Governor went sick and Jackson resigned to return home in September, 1883, to Chatham and then was ordered to Woolwich in charge of Works at the Arsenal. By this time he had had a good deal of contact with Coast defences of our ports and Colonies and this no doubt influenced him in determining to specialize in Permanent Fortification and Coast Defence and, with this in view, he applied for and obtained an Instructorship in Fortification at the "Shop," where he joined in January, 1885. He was promoted Captain in August, 1886. When he began to study the standard works on fortification, he realized that the course at Woolwich was still largely based on the experience of the Franco-German War and before he left the "Shop," four years later, he was instrumental in getting the course brought up-to-date.

The period of iron-fronted fortifications was giving place to earth and concrete with glacis parapets. There was also a new scheme for fortifications at many of our commercial ports and coaling stations.

On leaving Woolwich, Jackson's next station was Harwich where his principal job was the construction of the new batteries. At the end of 1890 he was ordered to St. Lucia, where a good harbour was being fortified as a coaling station for the Admiralty. The work, which had been started by his predecessor, included four new batteries and barracks for the increased garrison. The whole job was nearly completed when Jackson came home in the autumn of 1893, when he was appointed Staff Officer to the C.R.E., Northern Command. He was promoted Major in January, 1895, and at the end of the year was selected as Instructor in Fortification and Field Engineering at the S.M.E., Chatham. Owing to the South African War he held this appointment for six and a half years, which he describes as some of the most interesting of his life. In addition to his duties of Instructor, which included courses for Cavalry and Infantry classes as well as Senior and Junior officers of the Royal Engineers, he was an " ex-officio " member of the R.E. Committee and thus mainly responsible for all the patterns of equipment for the R.E. field units. During his time he reviewed all the patterns of tools and equipment used for field engineering, and also many of the methods which had got rather fixed, especially in mining and bridging. The latter was still concentrated on the combinations of round spars with cordage lashings. At this time the School of Military Engineering was the technical adviser of the War Office on all questions connected with the use of entrenchments and Jackson was called on to rewrite the Manual dealing with Field Defences.

Early in 1899 he went to Copenhagen to visit the new fortifications just completed by the Danes, but when the South African War started he naturally tried to join the Field Force to put to use the experience he had accumulated, but this was prevented partly by his own bad health and partly by the reluctance of the Commandant, S.M.E., to spare any of his senior Instructors. He was, however, kept very busy at the S.M.E. dealing with the many reports and suggestions which were put before the R.E. Committee and tried out in the Field Works School.

In September, 1900, he was detailed by the War Office to attend the Austrian Manœuvres, but in plain clothes. He found the Austrian pontooniers very good.

On 31st December, 1901, he was promoted Lieutenant-Colonel after twenty-five years service, but retained his appointment at the S.M.E. till May, 1902, to enable his successor to return from South Africa. He had been offered the post of Commissioner for the delimitation of the Barotseland boundary in South Africa between ourselves and the Portuguese, but at the last moment the Portuguese decided to go to arbitration, and a few days later Jackson was offered a similar job on the Yola-Chad boundary on the North-Eastern frontier of Nigeria.

British, French and German interests were all converging on this part of Nigeria. Jackson was the only British Commissioner but he was accompanied by three junior R.E. officers for survey work and an escort from the West African Frontier Forces. The work lasted from February, 1902, until May, 1903, and Jackson has left a very interesting account of his operations.

On return to military duty Jackson was ordered to Ireland as C.R.E., Dublin, and here he ended his regimental service on 31st December, 1906. He had been given the usual brevet Colonel in December, 1904, and he was now made Substantive Colonel. A few months later he was selected as Assistant Director, Fortification and Works, at the War Office and took up the work in the autumn of 1907.

During his absence in Africa, the Army and the War Office had been reorganized by the Esher Committee, the submarine mining defences had been transferred from the Corps to the Admiralty, new ideas on coast defences had been adopted, and Jackson found a big programme of reconstruction in hand.

In 1910 when Jackson was drawing near the end of his time at the War Office he was offered the appointment of Chief Engineer in Ireland with the rank of Brigadier-General. He was due for retirement, at the age of 57, in March, 1913, and as he had had slow promotion in the junior ranks he was too far down the list of Colonels to have any chance of further promotion. So he preferred the less important appointment of Chief Engineer, London District, and here he served till his retirement in 1913.

In March, 1914, he gave a lecture at the R.U.S.I. on "Defence against Aerial Attack," when he laid stress on the development of the Zeppelin and startled the experts by suggesting that London could not claim to be an undefended town and would thus be liable to attack from the air, a prophesy which was justified by the result.

He had for some time been one of the group of officers who foresaw the coming war and was anxious to get employment. When the War Office was completing the arrangements for mobilizing our first six divisions, he received the dormant appointment of his old job in the War Office, in place of Colonel A. M. Stuart who had been selected as Director of Works with the Expeditionary Force.

On the outbreak of the War in August, 1914, Jackson joined the War Office at once under Major-General Scott-Moncrieff, then D.F.W. His first job was a revision of the coast defences of Great Britain and also abroad.

When trench warfare started in France there was an urgent demand for various forms of weapons, notably hand grenades and trench mortars. In a lecture at Chatham in 1907, Jackson had suggested that such weapons would be necessary, but the General Staff up to the opening of the Great War were firmly determined that the War when it came would be a war of movement and could not last more than six or eight months. So no action had been taken. All such questions which reached the War Office came to Jackson's branch and he was soon busy with a mass of proposals, including mechanical excavators, pumps to drain the trenches, and bullet-proof plates. He also served on War Office Committees on siege trains, and the defence of London from the air. Another important question was that of explosives. The R.E. had for many years adopted guncotton as their main explosive, but the materials for its manufacture were also used for cordite for which the Admiralty had first claim. After some trials he selected Ammonal, of the Nitrate of Ammonia group, which being very hydroscopic was not liked by other branches. This was used successfully by the Royal Engineers during the War. He was also called to advise on the protection of Buckingham Palace and his suggestion of a double deck of two strong steel nets slung horizontally a few feet above the roof was adopted.

He was also busy with mining plant including listening sets, also flame throwers and when gas was used by the Germans, he had to study gas warfare. In January, 1915, Swinton reopened with him the question of tanks and the use of caterpillar tractors.

When the Ministry of Munitions was formed in May, 1915, Jackson was transferred to it as head of a department of Trench Warfare and continued his work on a larger scale and with a much augmented staff. Among weapons which became well known he fathered the Stokes Mortar. This had been offered to the War Office some time before by the inventor, but had been turned down owing to a defective type of fuse. Jackson saw its possibilities, put two of his assistants to devise a new fuse and method of charge and himself designed an improved gun, and produced the successful weapon which became so well known. When gas developed he did a good deal of work in the design of a shell to carry gas and in the production of Mustard Gas.

While in the War Office he had got on very good terms with Kitchener, who fully appreciated his work and had recommended his transfer to the Ministry of Munitions, but he never got on equally good terms with Lloyd George and the civilian heads of the Ministry, mainly because the politicians had not the technical knowledge to appreciate the difficulties of developing new inventions and their application to Military needs.

In September, 1916, he received a personal invitation from the Russians to visit Russia and discuss questions dealt with in his branch. This was approved officially and in October, 1916, he left via Norway, Sweden and Finland and in the course of eight weeks visited the fronts in Austria and Poland and also saw St. Petersburg and Moscow, lunched with the Emperor and met many of the leaders of the Russian Army. He returned via Archangel reaching London after a trying journey just before Xmas.

In June, 1917, the head of the French chemical section came over to England and was shown round and in September Jackson paid a return visit to Paris.

But meanwhile there had been many changes at Headquarters ; on the death of Lord Kitchener, Lloyd George had moved to the War Office and there were successive heads at the Ministry of Munitions, each new head having his own ideas as to procedure. In September, he was notified that a reorganization was in progress and that there would be no room for him in the new scheme. This was a great disappointment as the changes being made were what Jackson had consistently advocated, but room had to be found for new blood and he left the Ministry and reverted to the retired list in November, 1917. Most of his work had reached the practical stage of actual trial in the field, and little more was started after he left.

The next year, on the nonimation of Scott-Moncrieff, he was sent to Canada to deal with some questions of War Office property in Halifax, Nova Scotia, and also to advise the Canadian Government on defence questions. He left England in April, 1918, and returned six months later, having visited all the defended points on the east coast and spent June and July on the west coast.

While at Victoria, B.C., he explored the inlets between Vancouver Island and the mainland to advise on the selection of a Naval base. He returned via Washington having travelled in all over 8,000 miles.

He ended the War with a bad attack of 'flu which laid him up till February, 1919, when he accepted an appointment from one of our largest firms of contractors to act as their agent in foreign countries.

He found time in December, 1919, to give a lecture at the R.U.S.I. on the "Possibilities of the Next War" in which he anticipated many of the developments of the War just past, notably the large expansion of the Air Force and the growth of tanks. This produced much criticism from the advocates of "the War to end War" theory led by H. G. Wells, with whom Jackson later established a friendship.

Jackson settled down at home, mainly in London, where he took up his writing. During his first term at the War Office he had been asked by the Editor of the *Encyclopædia Britanica* to rewrite the article on "Fortification and Siege Craft" which was out of date. This he had done and he now prepared a supplement and also new articles on "Poison Gas" and "Military Mining."

He had a very keen and active brain and had now established a reputation as a progressive and practical thinker on military matters and always much enjoyed a correspondence in the Press on matters of general interest. Among other subjects he wrote a life of his grandfather Sir William Staveley and also an article in defence of General Gordon, whom he had often met at his uncle's quarters in the Royal Arsenal, Woolwich. He also compiled an Autobiography which is full of interesting detail and has been freely used in compiling this Memoir.

Jackson joined the " Senior " in 1893, soon after the club began admitting junior officers, and remained a member to the end of his life. He took a very active share in the control of the club and in 1937 he wrote a history of the Club at the request of the Council.

He was given the C.B. early in 1917 and was made K.B.E. in 1918, and on retirement received the honorary rank of Major-General. He was also made Commander of the Legion of Honour, and Knight of St. Stanislas of Russia (1st Class).

Jackson had enjoyed yachting on the Medway in his early days, and was a good shot. He was very interested in amateur theatricals and when at Chatham put on several excellent performances in the R.E. Theatre in which he was ably seconded by his wife whom he married in 1886. She was a daughter of Mr. William Vivian, a D.L. of London and died in 1938. They had three children of whom two survive, a daughter and a son, Cecil, who joined the Royal Engineers in 1906, and, after service in both world wars, retired in 1943 with the rank of Brigadier.

Jackson lived to see his 90th birthday and passed away in October, 1946, regretted by his many friends.

W.B.B.

BRIGADIER-GENERAL J. J. H. NATION, C.V.O., D.S.O.

JOHN JAMES HENRY NATION was born on the 5th December, 1874, and was the son of General Sir John L. Nation, K.C.B. After passing out of the "Shop" he was commissioned in the Royal Engineers on 1st April, 1895.

On completion of the usual course at the S.M.E. he was posted to the 12 Fld. Coy., R.E. at Shorncliffe in 1897 and went to South Africa with this Company at the beginning of the Boer War in 1899.

After the Boer War there was a big programme for the construction of new barracks and other works services, for which a special loan was raised, and Nation was posted to Lough Swilly in 1902 for work on barrack construction, etc., there. The following year he was posted to the "Shop" as an Instructor, and remained there till 1908 when he went to Aldershot and was attached to the 23 Fld. Coy., R.E.

In 1911 he was appointed a Staff Captain under the D.F.W. at the War Office and was there on the outbreak of war in 1914. The following year he was appointed Brigade-Major and Secretary at the S.M.E. and in 1916 went to France as A.A.G. at G.H.Q. He was given a Brevet of Lieutenant-Colonel in January, 1917, and in 1918 was promoted Brigadier-General at G.H.Q. and later was appointed D.A. and Q.M.G. on the British Mission with Marshal Foch's H.Q.

For his services in France he received the C.V.O. and D.S.O., both in 1917, and also received the following foreign decorations ; Commander, Legion of Honour, French Croix-de-Guerre, Officer of the Order of Leopold of Belgium and the Belgian Croix-de-Guerre and was mentioned in despatches six times.

In 1920 he was employed with a special financial mission to Persia and the following year was appointed D.A.A.G. in A.G.4 at the War Office, becoming A.A.G. of the same branch in April, 1923, when he was promoted full Colonel with an ante-date to 1st June, 1921.

He was placed on half-pay on 1st April, 1927 and in July of that year he was appointed Military Attaché at Rome. He accompanied the Italian military operations in Tripolitania and Cyrenaica in 1928, and later that year went on a military mission to Italian Somaliland, Eritrea and Abyssinia.

He retired with the rank of Brigadier-General in June, 1931, when he was elected as M.P. for West Hull, which he held till 1935. In 1936 he was a Member of the Overseas Settlement Board.

During the 1939–45 War he was a War Correspondent with the B.E.F. in France till April, 1940, and on the formation of the Home Guard, he became a Zone Commander and held this appointment until 1942.

In his younger days he was very good at billiards and represented the Corps on several occasions and had a reputation as one of the best amateur snooker players. He was also good at tennis and skating.

In 1932 he married Mrs. Olive Rubens the widow of Capt. W. Rubens.

C.C.P.

BRIGADIER R. H. THOMAS, C.S.I., D.S.O.

ROBERT HENRY THOMAS was born in April, 1877. He was educated at St. Edmund's College and St. Paul's School. At the "Shop" he won the Pollock Medal and was commissioned on 21st June, 1896. He was posted to the Indian establishment in 1898 and spent the first three years in India as an Assistant Engineer in the Military Works Department, during which time he was on deputation with the Malakand Field Force in 1899. He was transferred to civil employ in the Survey of India in 1901 and with the exception of the war years, 1914–19, he spent the whole of his service in that department, as indeed was usual with those who adopted survey in India as a career.

Prior to the 1914–18 war, Bob Thomas was employed in the Geodetic Branch, then known as the Trigonometrical Survey of India, and held charge of the Magnetic Party, with one short break, from 1903 to 1914. The Magnetic Survey in India had been started by D. A. H. Fraser in 1901, but the successful completion of this great undertaking in 1923 was largely due to Thomas' close study and knowledge of the subject.

On the outbreak of war Thomas was one of some eighty Sapper officers, mostly from civil employ in India, who sailed from Bombay in October, 1914, and who on arrival in England were nearly all posted to the newly-formed units of "Kitchener's Army." He was promoted to Major during the voyage and subsequently held command of 136 (A.T.) Coy. and 151 (Field) Coy. and was C.R.E. successively of 32 Div., of II Anzac Corps Troops in the Mediterranean theatre, and of XXII Corps Troops in France. He received the D.S.O. in June, 1918 and the French Croix de Guerre in August.

On reversion to the Survey of India in August, 1919, Thomas was in charge of Geodetic Parties for a year and was then transferred to charge of the Surveyor-General's office in Calcutta. This was a post in which he was able to display his marked facility for logical argument and expression and for lucidity in presenting all the aspects of a complicated subject. In 1924 he returned to the Geodetic Branch as its Director, after which he was Director of the Northern and Frontier Circles and of Map Publication until 1927 when he went home on long leave. During this leave he represented India at the Congress of the International Union of Geodesy and Geophysics, the Empire Surveyors Conference, and the International Geographical Congress. He was promoted Colonel in May, 1926, and succeeded Sir Edward Tandy as Surveyor General of India in December, 1928. He held this post, with the rank of Brigadier, until he retired on the 1st October, 1933, when he was made a C.S.I.

During Thomas' tenure of office as Surveyor General, the Department went through many vicissitudes and had the advantage of his great administrative ability at a very difficult time. Upon a period of general expansion and of more active co-operation with the Army in preparation for field service, the world slump of the 1930's supervened. The very existence of the Department was threatened. It was Thomas' most unenviable duty to have to carry out the reduction of all establishments and the discharge of personnel necessitated by the severe retrenchment imposed on all the Services in India, amounting in the case of the Survey to nearly half the budget.

In February, 1906, he married Evelyn Beatrice, daughter of Colonel W. L. C. Baddeley, R.E. There were two sons and two daughters. He died on the 17th October, 1946, after a short illness.

C.L.

BOOK REVIEWS

ARMAMENT AND HISTORY

By " J. F. C. Fuller "

(Published by Eyre and Spottiswoode, Price 12s. 6d.)

Major-General Fuller is too well known to British readers to need any introduction. We have learnt to expect from him evidence of an extensive knowledge of military history, deep thought and original ideas, served up in form requiring mastication and with mannerisms of style which some find unattractive. In the present work we have all the knowledge, thought and ideas in a condensed but most readable form. General Fuller tells indeed a gloomy story of man's folly and depravity, a story which moves like a Greek tragedy to its inevitable climax of horror and destruction : and he tells his story well.

In his study, General Fuller pursues a number of themes ; that " tools and weapons, if only the right ones can be discovered, form ninety-nine per cent of victory " ; that warlike developments since the beginning of the technological epoch tend continually towards the elimination of the human element in fighting ; that until the coming of the atomic weapon, war has been conditioned by the " constant tactical factor " that each new development is met by a counter-development which renders in turn each improvement obsolete. But perhaps his most challenging theme is that armaments and the requirements of their production and employment have been the over-riding factor in the social, industrial and economic development of society. We should have liked to have seen this theme more fully developed, but it is here that the present work suffers perhaps from having been written for serial publication in a military journal. These various and interlocked ideas General Fuller follows with a wealth of quotation and historical illustration—under which indeed they tend momentarily to be lost—through the Ages of " Valour," " Chivalry," " Gunpowder," " Steam " and " Oil." Here, in March, 1945, his thesis originally ended. He had then little hope that man would recognize the folly of warfare which consists in the mutual destruction of the whole apparatus of civilization. Noting that the Second World War seemed likely to end with three-quarters of the world's war potential in the hands of Soviet Russia, he quotes Stalin as saying that " it is inconceivable that the Soviet Republic should continue to exist side by side with imperialistic states. Ultimately one or the other must conquer. Pending this development a number of terrible clashes between Soviet Russia and the Bourgeois States must occur." The outlook could, therefore, hardly be regarded as bright.

General Fuller has been wise to add a final chapter, since the appearance in war of the atomic bomb has brought all his themes to a triumphant proof, although at the moment the working of the " constant tactical factor " seems to have been arrested. In writing of the Age of Atomic Energy, he finds himself, it seems, in two minds as to the future. While there is no direct protection against the electronicly guided atomic missile, he considers it even now unlikely that man will recognize the futility of mutual destruction and he foresees that the Great Powers will tend to fight for uranium as in the past they have fought for oil. Nevertheless, he considers that there is a pleasing possibility that atomic knowledge, including the power of transmuting the elements, may lead to an Age of Abundance which will liquidate all the apparatus of Capitalism " gold standards, loans, debts, foreign markets, embargoes," etc., which he regards—finding himself thus in the, for him, surprising company of Marx and Lenin—as the basic cause of war in the present " Age of Snatch and Grab."

Meanwhile what is the reply to the Atomic Missile ? General Fuller, conscious of having been a true military prophet in the past, makes a suggestion, the nature of which it is for the reader to discover.

This is a book well worth reading and, what is more rare, worth buying.

L.V.B.

HISTORICAL RECORDS OF THE SURVEY OF INDIA

VOLUME I. 18th CENTURY

Collected and compiled by COL. R. H. PHILLIMORE C.I.E., D.S.O.
(Late Royal Engineers and Survey of India)

(Published by order of the Surveyor General of India. Price Rs 30 or £2 7s. 3d.)

Mr. Ford is alleged to have said that all history was bunk. Those who agree with him forget that the processes of today have been distilled from the experiments of yesterday. One of the great values of history, as Trevelyan points out, is the light it throws on the present.

The Survey of India is to be congratulated on its decision to record its history. It is most appropriate that its achievements should be made known, especially now when the part England has played in India is so often decried. This history should prove extremely valuable not only to those who will continue the Survey of India but also to those who have to carry out survey work in the Empire.

Colonel Phillimore, who has compiled this volume, hopes to be able to complete up to 1883. His task is enormous as he estimates that three volumes will be required to cover up to 1830 alone. We congratulate him on the publication of this first volume in spite of delays caused by the war and we hope that other events will not interfere with the rest of his programme.

The original policy of the East India Company had been peaceful trade. Except for the land required for its factories it desired no possessions. The wars with France and French intrigues at the native states that arose after the dissolution of the Mogul Empire forced the Company to abandon its policy. At the end of the eighteenth century it was in virtual control of Southern India and of Bengal, Bihar and Orissa. The Company dealt direct with each of the three Presidencies although at the end of the period it had given the Governor-General of Bengal nominal powers over the Governors of Bombay and Madras.

It was natural that the Company should want maps to follow the military operations, to show their possessions and to help in assessing the revenues likely to accrue from them. How these early maps were made is told in this volume.

The period was too early for a proper appreciation of the value of triangulation. Each Presidency carried out its own surveys so that it was difficult to get any concerted use of triangulation and it was left for Lambton to show the way in the next century.

We find an increasing use made of astronomical control for the surveys and route traverses. Lunar distances and the eclipses of Jupiter's satellites were the only methods available for establishing longitude. Consequently, although latitudes were always adequately observed, longitude presented some difficulty. The measurement of a degree of longitude and of latitude by chaining carried out by Reuben Burrow was a fine performance although the results were never used in deducing a Figure of the Earth. Another noteworthy achievement was the setting up of the Madras Observatory in 1791 by Topping aided by his assistant Goldingham.

Field surveys were mostly measured by perambulator which was a wheel, usually about 7 ft. in diameter, with a cyclometer gearing to read miles and furlongs. Considering the climate and the conditions of the time the determination of the surveyors must have been magnificent for them to have achieved the progress and results they obtained. Space here only allows a passing reference to the outstanding surveys by Rennell in Bengal and Reynolds in Bombay.

In Madras, Topping was responsible for the opening of a Surveying School in 1794 to teach youths the elements of survey. Goldingham was placed in charge of some dozen boys from 11 to 15 years old. After training they were sent out at what seems now an incredibly early age as two of them could not have been much over 16 years old at their death in the field.

No general scale was adopted for any of the maps drawn from these surveys even in the same Presidency, although in 1771 the Company laid down that general maps should be drawn at 3 in. to the degree and particular surveys at 6 or 12 ins. to the degree. This ruling was never obeyed and the atlases produced by Rennell, Kelly, Call and Colebrook were all at differing scales.

This volume tells the story of these early surveys in full with many extracts from letters and despatches. In addition there are details of the surveys carried out by the Jesuits and French, of early maps and of the Civil Establishment, pay and allowances of the surveyors. At the end of the book there are nearly a 100 pages of biographical notes of surveyors, both English and French which form a very useful summary of their lives.

The book would have been much easier to read if it had included a brief statement of the general political and historical background to provide some continuity for the patchwork pattern of the early surveys. It might have been improved if each Presidency had been treated entirely separately; as it is, the present arrangement gives an impression of restlessness which does not do justice to the great care that has gone into this production.

A number of errors are listed but there are many more which should be corrected in the next edition. The index excludes all surveyors who are included in the biographical notes. This makes it somewhat difficult to refer quickly to the text and it is recommended that the index should be enlarged to include these details in the remaining volumes which we hope will rapidly follow.

K.M.P.

THUNDERBOLTS

By Maj.-Gen. J. F. C. Fuller

(Published by Skeffington and Co., Price 12s. 6d.)

Like his previous book *Whirlwinds*, this is a collection of fifty articles most of which have appeared in the Press at various times during the recent war. They range from *Mechanization 2,000 Years Ago* to *The War Rocket*. General Fuller's writings are always readable and thought provoking, but to those who have been abroad, or for other reasons have failed to follow the author's comments on events, and musings on the future, during the war, this collection is particularly interesting and intriguing.

Reprinted articles divorced from their circumstances measured in time are often dull reading, but General Fuller's approach to his subject always possesses a freshness which remains and renders his articles readable even after a considerable lapse of time. It is pleasant to find that with all his penetrating thoughtfulness he has not lost his puckishness, and that there are among his " Thunderbolts " a number of " Chinese Crackers." These keep the reader on his toes so as not to be lead astray unconsciously by apparently weighty arguments which on close examination prove to be somewhat light-hearted conclusions based on featherweight premises. His penchant for noise is illustrated in one of the essays in this book, in which General Fuller suggests that the secret weapon of the future may be noise, ultra-assonic or otherwise.

While many of the articles, critical of our conduct of the war and our preparations for it, Continental Policy, Bombing, the Italian campaign, the " Bogging up on the Rhine," the stressing of unconditional surrender, etc., have been largely approved or answered by subsequent events, the majority of the articles have longer range bearing, and still provide valuable food for thought. Chief among the latter are those which deal with the effects of the war, or of our handling of its problems, on the peace or the subsequent period of turmoil to which it has been the introduction. The effect of internal liberation armies, the desolation from bombing, the upset in vital statistics, and many similar problems are examined in turn. But laying down the book and looking back, the subjects on which the author appears to have expended the most thought and ink are our bombing strategy, and the failure of our economic and financial system. General Fuller seems definitely of the opinion that our so-called strategical bombing of industrial towns was in the long run wrong psychologically, and from the point of view of the peace, a misapplication of effort. He states his case clearly and one can leave the reader, with his post-war knowledge, to balance his arguments with those of " Bomber " Harris.

On the financial side the opinions expressed are very much in line with those of the Economic Reform League and a growing circle which condemns the present dominance of High Finance with the adhesion of the latter to the Gold Standard, and our consequent " enslavement " by the Bretton Woods agreement.

Naturally, as one must expect from General Fuller, a considerable amount of space is devoted to the mechanical side of war, the tank, aircraft, flying bombs and rockets ; but underlying all consideration of these, he stresses even more that in his earlier works the human and psychological element in war.

Time and events have shown that some of General Fuller's statements, and hence possibly his conclusions are at least doubtful. He speaks of Rommel being "throughout vastly inferior" in aircraft. Evidence available seems to show that in 1941 with his commitments in Greece and elsewhere, Wavell was inferior in the air, and in the German offensive in 1942, while the Allies had air superiority, it was not of the measure suggested. Again General Fuller accepts the principle that "artillery conquers, infantry occupies," and in artillery he includes the tactical bombing aircraft, and instances El Alamein, Mareth, Tunis, Sicily, etc. At the same time he condemns the bombing of Cassino, but this may be only a matter of degree.

Reading these essays written at intervals over the last six years, one feels many of the problems discussed are still unsolved, or possibly one should say unresolved. Therefore, the book deserves careful study, and is one that should be bought, thought over, and put away in a handy bookshelf to be pulled out again from time to time to see how we are getting on, if at all.

R.P.P-W.

MATHEMATICS FOR T.C. MITS

By H. G. and L. R. Lieber

(Published by George Allen and Unwin, Ltd., 40, Museum Street, W.C.1., Price 7s. 6d.)

T.C. Mits stands for "The Celebrated Man in the Street" whose outlook on life is often confused by the contradictory slogans with which he is assailed on all sides. This little book sets out to remedy the situation by providing a Mathematical approach to the basic problems of mundane existence.

It is divided into two main parts ; the first, "the Old," deals with the Classical Mathematics of Euclid and Newton, and its application to practical affairs. A very clear picture is given of the interrelationship between mathematicians, scientists and engineers. The second part, "the New," takes a brief excursion into modern Mathematics, where no truth is admitted as self-evident and twice two has ceased to be four. It describes and gives the implications of new algebras and geometries in which all laws but those of logic may be set at defiance, and it ends with a distant glimpse of the hyperbolic co-ordinates of the relativists.

Like a swimming bath, the book gets deeper as you go further into it. The non-mathematical reader is rudely ducked in the shallow end by three familiar puzzle questions, designed to get him into a respectful frame of mind ; he is thereafter buoyed up when out of his depth by the extremely lucid arguments and explanations of the writers, and their accompanying diagrams. At every stage the underlying moral is drawn ; there is a summary at the end of Part I, and a list of conclusions at the end of the book.

Though serious in purpose, the book is written in a very lighthearted and rather chromium plated American style ; the manner in which the text is broken up, so that in spite of a disclaimer it might be taken as blank verse, makes it exceptionally easy to assimilate. This system could profitably be adopted by other writers on obscure subjects. The volume is decorated with a number of cheerfully surrealistic drawings which add greatly to its entertainment value, and, where intelligibly relevant, point a moral as well as adorning the tale. But two of them at least would, I think, look better the other way up.

W.M.B.

ONWARD FROM D-DAY

By Major-General H. Rowan-Robinson, C.B., C.M.G., D.S.O.

(Published by Hutchinson and Co., Ltd. London. Price 16s. 0d.)

This is not an easy book and the reader is advised to study the Preface first. Many will disagree with some of the conclusions drawn and comments made by the author, but they may well be led on to ponder over some of the problems themselves. Much of the historical portion of the book will require revision as further authentic facts come to light ; some of the statements made as to Command and Commanders strike one as being made as simple statements of fact, whereas that was often far from being the case and history may not confirm all that the author has written.

It is difficult to follow the " plan " of this book. The first five chapters are concerned with N.W. Europe and take us from D-Day to VE day ; then follow three extremely brief chapters on the Navy, Air Force and Airborne Forces ; there follow another five chapters which bring Russia to Vienna and Berlin, whilst the last year of War in Italy is accorded but one solitary chapter. The next chapter (XV) deals with Guerilla Warfare and Resistance Movements, the reader is taken round the world at great speed ; then follow five chapters on the Far East, three of these being allotted to S.E.A.C. and two to the Pacific. This is all hard going and is compressed into twenty chapters of but 120 pages which take the reader breathlessly through not only the final assault in Europe and the downfall of Hitler, but the attack against Japan in Burma and the Pacific, which led to the total surrender of the Japanese Nation.

The last six chapters of forty-eight pages cover such immense and diverse subjects as Tactics, Strategy, the Scientist, the Atomic Bomb, Security and the Instrument, of all these perhaps the first half of page 141 is the most important for future generations ; here we find a passage taken from " Report of Select Committee on National Expenditure on Research and Development, June 1945," this passage starts off with the pregnant sentence :—

" Research Had to Starve."

Let us hope that the Nation may remember this. The book ends with an Appendix of oddly assorted and incomplete sets of statistics which it is felt could well have been omitted.

The object of war being to enable one Nation to impose its will upon another, battles are fought with the object of destroying the enemies' forces so as to hasten on the achievement of that object. Compared to 1914–18, the war of 1939–45 has been one of vast manœuvre and mobility ; no longer is the land battle one for particular square feet of territory, it has taken on a much more Naval aspect. Both services must work with the Air, the Navy eventually had its aircraft carriers, the Army frequently had to fight its land battles with the object of acquiring existing airfields or terrain suitable for rapid conversion into air strips so that the R.A.F. would have the facilities from which to co-operate in the Army's next move forward. That vast logistical problem with its engineering repercussions, entailed in the constant and continuous preparation of air-strips together with all that is involved in maintaining the mobility of a victorious and ever advancing Army, gets but scant mention in this book ; it is not suggested that this problem is the only wheel in the machine, but it certainly comprised a great number of the cogs and to ignore it does not enhance the value of the book. The author finds space for the P.I.A.T. and the Sten gun, but the Bailey Bridge gets no mention whatsoever. However as morale, which accounts for a great number of the cogs too, is also very scantily dealt with, it is not so surprising perhaps that the logistic side of war is glossed over.

Nevertheless, this book is essentially readable and valuable, but it is suggested that it is easiest if taken in small doses. With the aid of a good atlas for reference, it might be best to read one campaign only and then turn to the final six chapters ; after a suitable period for thought and mental digestion, another campaign could be tackled in the same way.

B.K.Y.

THE PRESENTATION OF ENGINEERING EVIDENCE

(Published by the Institution of Civil Engineers. Price 3s.)

A record of four lectures delivered at the Institution of Civil Engineers, June–July, 1946 (4to., 49 pp. 3s. 0d.).

These lectures by the Right Hon. Lord Macmillan of Aberfeldy, Geoffrey Bell (two) and C. W. Knight, M.I.C.E. (late A.D.Tn., W.O.) are proof that our normal training as soldiers and military engineers in the writing and making of appreciations and reports are in line with the current opinion of " The Civils." The record of Lord Macmillan's lecture is well worth reading for its authoritative and concise instruction. Although entitled " The Giving of Evidence before a Parliamentary Committee in the High Court and before an Arbitrator " much of the advice and criticism have direct application to the Sapper discussing a project with his Commander (High Court) or explaining what has happened to his C.E. (Arbitrator). Moreover, the Sapper with his training in Military Law will appreciate and get much entertainment from the examples and asides in the text. Attendance with their principals as expert witnesses sometimes falls to the lot of those on an E. and M. course—a valuable experience. Those who have had it and those who expect it will be specially interested in what Lord Macmillan says.

Now that so many officers keep cine-camera records of their projects, Geoffrey Bell's two lectures provide food for thought in how best to turn the record into a story. Mr. Bell of Film Centre, Ltd., is an expert maker of scientific films with a detailed knowledge of their production and distribution. His two lectures were illustrated by the showing of films and although the record has only three photographs there is much in it to interest the Sapper cine-camera man.

Those of us who still have the old Chatham habit of providing our formal reports with a jacket will be interested in Col. Knight's criticism of H.M.S.O.'s cover to General Eisenhower's report. How would you set out " Report by the Supreme Commander to the Combined Chiefs of Staff on the Operations in Europe of the Allied Expeditionary Force, 6th June, 1944–8th May, 1945 ? For answer turn to page 39 of the Record.

W.H.G.C.

THE CONTRACT SYSTEM IN CIVIL ENGINEERING

REPORT NO. VII.

(Published by the Institution of Civil Engineers. Price 2s. 6d.)

This Report, one of a series on Post-War National Development, is divided into six main sections, with twenty-five sub-headings, and deals in detail with all aspects of Civil Engineering Contracts. It is essential at the outset to realize that the Report covers Civil Engineering Contracts only, the procedure being in many respects quite different from that in Building Contracts. The Report, as stated in the preface, has been prepared as a corollary to the Report on the Placing and Management of Building Contracts issued by the Central Council for Works and Buildings of the Ministry of Works (price 1s. 0d., H.M.S.O.), and the main object is to emphasize the difference between Building and Civil Engineering Contracts.

The Report deals with the History of the Contract System, the Chief Parties Concerned in a Contract, the Civil Engineering Contract, the Adjudication of Tenders, the Composition of a Contract Price, and Engineering Administration. The sections of most interest to R.E. officers are those which deal with the Civil Engineering Contract, the Adjudication of Tenders, and the Composition of the Contract Price, which are dealt with in detail under Sub-Headings Nos. 7–20.

The section headed the Civil Engineering Contract deals with the Contract, the Conditions of Contract, Types of Contract, Comparative Merits of Various Types of Contract, Rise and Fall Clauses, Contract Documents and Sub-Contracts. Six types of Contract are reviewed. That placed on the basis of Bills of Quantities is the most strongly recommended, Cost Reimbursement Contracts being deprecated except in circumstances which make them unavoidable. One peculiarity of Engineering Contracts placed on Bills of Quantities is that the whole work is measured and executed and priced at the Contract rates. It is difficult to understand why this is the practice, because if the Bills of Quantities have been properly prepared, it should be necessary to measure variations or provisional quantities only, as in the case of Building Contracts. A strong plea is made for proper and complete planning before a Contract is placed.

The section headed the Adjudication of Tenders deals with the Invitation to Tender, Comparison of Tenders, and Comparison with Estimates of Direct Labour Costs. A warning is given against work being done by Direct Labour without full consideration being given to all the factors involved.

The section headed the Composition of a Contract Price deals with Price and Cost, Constituents of a Contract Price, Promoter's Requirements affecting Contract Price, and Other Factors affecting Contract Price, and deals generally with the contractual liabilities and factors which have an affect on the Contract Price, most of which are the concern of the Contractor and not of the Promoter.

The Report closes with notes on administration and deals with the relationship between the Engineer and the Contractor.

J.B.M

THE SEINE! THE SEINE!

By Lieut.-Col. T. Lloyd, D.S.O., M.C., R.E.

(Published by Sifton, Praed and Co., Ltd., St. James's Street, S.W.1., Price 2s. 0d.)

This small pamphlet, which has a preface by Sir Donald Bailey, Kt., O.B.E., the inventor of the Bailey Bridge, gives a vivid description of the bridging of the Seine on the British front.

The narrative starts with the first warning order to Lieut.-Col. Lloyd about the bridging of the Seine, which he received on 16th August, 1944, when still only four miles inland from the Normandy beaches and the Seine seemed very far off. Events then moved very rapidly and it was only a matter of a few days before the Seine was reached and bridging work commenced.

Col. Lloyd describes very vividly the experiences of the troops who were responsible for building a class 40 Bailey Pontoon bridge. The pamphlet gives a good picture of the work entailed in collecting the necessary bridging equipment, getting it to the site, making the necessary reconnaissances under enemy fire to select the best site and to calculate the width of the gap and, finally, the actual bridging work itself.

Many Sapper officers will have had similar experiences in the recent war, but for those who have not, this little book gives a good picture, in simple words, of the various vicissitudes and hitches which are liable to occur in such an operation.

C.C.P.

ROAD RESEARCH SPECIAL REPORT NO. 3—ROADSTONE: GEOLOGICAL ASPECTS AND PHYSICAL TESTS

(Published for the Department of Scientific and Industrial Research by H.M.S.O., Price 9d.)

The report is the result of collaboration between two organizations of D.S.I.R.—the Geological Survey of Great Britain and the Road Research Laboratory.

In the report the essential facts concerning the geology and petrography of roadstones are concisely stated. The fundamental differences between the main classes of rocks are described and the bearing of the nature of the rock and of the geological structure on the development of quarrying operations is explained. The mineral composition, texture and general characteristics of the principal rock types are considered.

The section on physical tests includes brief descriptions of the British Standard tests on roadstone. The results of tests on about 1,200 samples of roadstone are analysed and used as the basis of a discussion on the following aspects of physical testing: (*a*) Reproducibility of results. (*b*) Correlation between the results of different tests, between the results of physical tests and petrographical examination, and between test results and service behaviour of the aggregates. The properties desirable in aggregates for particular forms of construction (concrete, bituminous, etc.) are discussed.

MAGAZINE REVIEWS

GEOGRAPHICAL JOURNAL

(Published by The Royal Geographical Society, London)

March–April, 1946.—This number includes the address of the President, Lord Rennell, at the Annual General Meeting. It deals mostly with plans for expanding the activities of the Society.

There are three articles of great interest dealing with the Arctic flights, made in May, 1945, in the R.A.F. Lancaster *Aries*. The first by the Commander of the expedition, Wing-Commander D. C. McKinley, gives a general account of the flights, in which the Geographical Pole was crossed, and valuable evidence obtained as to the position of the Magnetic Pole. The second, by Wing-Commander K. C. McClure, deals with the technical aspects of the flights, and in particular describes the Greenwich grid system of navigation, which was suggested by this officer in 1941 for polar air navigation, and was tested on this expedition and found to be highly satisfactory. It is interesting to note that Wing-Commander McClure is a descendant of Sir Robert McClure, who in 1853 was one of the first to traverse the North-West Passage. The third article, by Wing-Commander R. Winfield, treats of the medical side.

There is a chatty description by Witold Rajkowski of a visit to Southern Kurdistan ; and an account of viticulture, or grape-growing, in Belgium, by S. W. E. Vince.

C. A. Cotton gives a vivid description of the 1945 eruption of Ruapehu, the highest peak of the North Island of New Zealand, illustrated by fine photographs ; and there is a very pleasing account of Russia, being an extract from Giles Fletcher's *Of the Russe Commonwealth* from Hakluyt.

May–June, 1946.—This number opens with the 11th Asia Lecture, given by Sir Leonard Woolley, on " Syria as the Gateway between East and West." It is full of interest, geographical, historical and archæological, and is well illustrated.

G. C. L. Bertram discusses " Population Trends and the World's Resources," being an account of increases of population compared with means of subsistence. The paper, with the discussion which follows, leaves one feeling that the outlook is somewhat gloomy.

Maj.-Gen. Cheetham gives a description of the new medium and small scale maps of the Ordnance Survey, and of the National Grid, with illustrations of its use. The discussion which arose from the paper shows views which are as interesting as they are diverse.

T. Crombie writes an account of two climbing expeditions in the Central Andes, illustrated by magnificent mountain photographs.

H. E. Adler, gives a short but interesting account of " Turkistan in Transition," where recent developments, due to Soviet initiative, in irrigation and communications are introducing startling changes in this primitive land.

There is a combined note, by P. C. Spink and J. A. Stevens, on " The Magadi Section of the Eastern Rift Valley," the northern part of which is little known.

E.M.J

JOURNAL OF THE UNITED SERVICE INSTITUTION OF INDIA

(Published by the Civil and Military Gazette Press, Lahore)

July, 1946.—The number begins with an eulogy on Field-Marshal Sir Claude Auchinleck, the thirteenth field-marshal the I.A. has produced.

The Fourth Christmas.—1942 was spent by the author in a P.o.W. camp in Changi. He looked back on his last three, 1939 in almost peace conditions in Shillong, 1940 amid sniping and snows in Waziristan, 1941 in retreat through rubber plantations in Malaya. Wherever he was, he had a flair for vivid descriptions of his surroundings.

Army Farmers in Eastern Bengal relates how vegetables were grown, fish caught, and pigs and ducks reared for consumption by the forces in Burma. There is nothing the Army may not have to do!

March to Freedom is the diary of six days of a P.o.W's life. His party was marched away from Rangoon when the recapture of that place by the British seemed inevitable. The first four days were under a Jap escort who killed every man who fell out. The last day was spent in a village in No man's land under air attack from our own planes.

Rebuilding a Navy.—The R.I.N. on the outbreak of war had to start almost from scratch. The article deals largely with dockyard conditions; these at Bombay were terribly congested and the buildings old and unsuited for modern warfare. Personnel had to be multiplied twenty-fold.

Destructive Combat or Subversive War.—The author points out that, in the future, an aggressor nation may hesitate to use atomic bombs and similar deadly weapons, for the reason that the victor would find the territory of the vanquished a worthless acquisition. Propaganda is a much more likely weapon whereby the "agin the Government" section of the population would be strengthened until it was able to take over the rule, and then accede to the instigating Power's will. The remedy is to educate the people, at the same time improving living conditions until discontent becomes a negligible quantity.

Japanese Animals is a readable article. In spite of elaborate feeding tables in Siam, the Jap usually neglected his beasts. A British Remount Officer showed Jap P.o.W's by personal example how to groom a horse, after which the standard improved greatly. The B.O's action, by the way, caused considerable comment among the prisoners, as it was inconceivable that a Jap officer should so demean himself as to instruct, let alone groom a horse!

A Year as a C.L.O. (Civil Liaison Officer) shows what useful work can be done by B.O's going round country districts visiting pensioners and their families, and getting at their grievances. One retired I.O., aged 103, walked three miles to see the author! Tribute is paid to the work done by B.O's and their wives, as well as by missionaries. There are valuable suggestions, and a note on the evil effects of bribery and corruption by petty officials.

Dopoguerra is a rather depressing account of post-war India. The author sounds tired and disillusioned, but has fortunately kept his sense of humour. Impartial leadership, which was prominent during the war, is wanted more than ever during peace. A pensioned risaldar complains bitterly that no one listens to the retired Indian soldier.

The N.W. Frontier Problem is again discussed, this time with a valuable suggestion, based on the experience of the author at the Malakand, where he codified the unwritten laws of the tribesmen. Could this be done by a sympathetic commission in all transfrontier territories, the tribesman would feel that he was something of a civilized being, with at any rate a system of laws. The old feeling of distrust of the Government might go; but this must be done quickly.

Those who have had a hand in raising a new unit will appreciate *Raising a Regiment.* A battalion had to be formed from a nucleus of two companies of the I.T.F., largely from a class labelled as " non-martial." The battalion met and defeated the Japs, and now forms part of the Bihar Regiment.

Engineers in India's Modern Army discusses methods of training officer personnel for the scientific branches of the I.A., and plumps for a Military Science College, where candidates for R.I.E., Signals, I.E.M.E. and certain branches of the Artillery could do a course after qualifying at the Indian National War Memorial Academy.

Post-war Infantryman's Individual Training contains many valuable suggestions ; jungle warfare, in which we are now the world's adepts, must not be forgotten, and every recruit must do his bit of training in a real, not makeshift, jungle.

India's War Wealth and National Planning treats of the agenda before the country is self-sufficient. There is a lot to be done, and what if the population goes on increasing at its present rate ?

Taking Over a Company.—Very practical.

The Right Type and Some Thoughts on Indianization.—The best way of teaching Indians to take over the I.A., with its magnificent traditions, is discussed.

Officer Production and Nationalization is discussed ; it covers much of the same ground as the foregoing. The author points out forcibly that Indians do not yet realize, as far as defence goes, the implications of self-government. Until they do so, is it hopeless to expect the right type of prospective commissioned officer to come forward.

F.C.M.

THE MILITARY ENGINEER

(Published by the Society of American Military Engineers).

August, 1946.—*Outlawing the Use of the Atomic Bomb.* Another interesting editorial on the future control of the Atomic Bomb. Outlawing of both bombing and atom bombing are held to be covered already by the Hague Convention Declarations of 18th October, 1907. In the future as in the past it will not be possible to enforce this prohibition unless there is an enforcing agency strong enough to regulate warfare. Such an agency would be strong enough to prevent war. The League of Nations was an impotent enforcing agency. The hope is expressed that the United Nations Organization will be more effective by being strong enough to make wars unendurable by threat of the use of the Atomic Bomb. Until U.N.O. is strong enough to take over, the responsibility must remain that of the United States. The manufacture and use of the Atomic Bomb must be controlled, not by entering into international agreements which are certain to be violated, but by guarding the secrets of manufacture and by obtaining a monopoly of the materials used in its production. Should Americans agree to use only weapons of the pre-air-atomic era they will have given away a birthright which might have been used to preserve the peace of the world.

Operation Crossroads by Lieut.-Col. Leigh C. Fairbank, Jr. The second of this series of articles on the Atomic Bomb test at Bikini. The article was written just prior to the explosion of the first bomb ; gives details of the technical aspects of the test ; and covers plans for Security, Safety, Instrumentation, Photography, Oceanography Survey, Re-entry Plan, Salvage, Reboarding and Inspection.

September, 1946.—*Exchanging Military Secrets.*—The proposal to exchange military secrets with other nations is analyzed and rejected in this editorial on the grounds that it is not sound on equitable considerations. America would obtain very little in exchange for what she gave. To attempt to generate some international good will by this method is considered too like the policy of appeasement which has been proved in the past fifty years to be so signal a failure. The success of America in technological fields is attributed not to any superiority of individual American scientists so much as to organizing ability, supported by enormous allocations of funds which when applied effectively through groups of research engineers and scientists produced American military secrets from fundamental knowledge common to men of science all over the world.

Operation Crossroads. Results of Test ABLE, the Air Burst, by Major Philip G. Kreuger.—The third article on the test at Bikini and deals with the results of Test "Able," an air burst of an atomic bomb over a concentrated fleet of ships at 09.00 hrs. on 1st July, 1946. The weather was satisfactory and the point of detonation of this fourth atomic bomb is described as being 1,500 to 2,000 ft. astern of the *Nevada*, the bull's eye of the target, and over a somewhat open area entirely west of the tight-packed group of capital ships in the centre of the target. The visible effects were what is already known as the typical effects of a standard-type atomic bomb ; flash of light, ball of fire, turbulent cloud as at Alamogordo, Hiroshima and Nagasaki. Although the efficiency of the detonation depends on what portion of the fissionable material reacts in quick chain fashion before the material is blown apart, it is noteworthy that in the four atom bombs so far detonated there have been no duds and each explosion has approximately equalled that of 20,000 tons of T.N.T. The author's eye-witness description of the explosion is excellently illustrated by photographs : the initial flash ; the mushroom-shaped head spreading out at 10,000 ft. ; and the so-called ice-cap forming at a much higher altitude. Some ten minutes after the detonation a big explosion was seen among the target ships, believed to be the aircraft carrier *Independence*. Drone planes flying through the atom bomb cloud were found later to be "hot" with radio-activity. When inspection ships entered the lagoon in the early afternoon fires were burning in the *Independence*, *Saratoga*, *Arkansas*, *Sakawa* and other smaller ships. The President's Evaluation Commission reported that those ships within one mile of the explosion were sunk or suffered damage varying with the distance from the point of detonation and with the type of ship, and also that there was little damage more than a mile from the blast. The Joint Chief of Staff Evaluation Board reported there was relatively little damage at distances greater than three quarters of a mile from the blast but that ships within that distance suffered such damage to hulls and superstructure as to require "extensive repairs at a naval base." Another opinion is given that within 1,000 ft. of the point of detonation any ship would sink, light ships would sink within 1,500 ft. and that the more vulnerable destroyers would be sunk at 2,200 ft. and, that further, heavy to moderate damage could be expected on vessels within 2,000 ft., and light damage from 2,000 to 3,000 ft. A close inspection of the ships remaining within a half mile of the point of detonation revealed that they all suffered some or all of the following types of damage : hulls, decks and/or bulkheads warped, buckled or ripped from distortion due to blast or pressure ; boilers blown out or crumbled by blast ; lightly constructed superstructure destroyed, torn loose or deformed ; moderate to light fire damage except in odd cases ; stacks, masts, radar and radio gear bent or broken ; deck equipment, including airplanes, rafts and other gear and Army equipment displayed there burned and battered. In addition heavy personnel casualties could have been expected from blast, pressure, burn or radio-activity. Five ships sunk due to direct causes. It would have been impossible to save these ships under normal battle conditions. Six ships suffered major damage. After more detailed description of the damage to individual ships the author sums up: "The main lesson which everyone can learn from the test is that all eggs should not be put in one basket. Dispersion is an effective method of passive defense against the atomic bomb."

October 1946.—*Operation Crossroads. Results of Test BAKER, the Underwater Burst, by Major Philip G. Kruger.*—The fourth and final article of the series deals with the results of the fifth atomic bomb, the first to be exploded under water. This was detonated on 25th July, 1946, beneath a concentrated group of eighty ships. The exact location and depth of the bomb are withheld for security reasons. The author describes the explosion as viewed by him from the air at a distance of fifteen miles and a height of 5,000 ft. A large incandescent bubble appeared to burst out of the centre of the target area. The dome-shaped shock wave expanded outwards from the point of detonation. Quickly a steamy cloud formed over the entire target array, and as quickly dissipated. From the surface of the lagoon an immense water spout 2,200 ft. in diameter at the base erupted, at first a pure foamy white, then a dark mass to a height of more than a mile. As the water started to fall back on the target vessels, a cloud poured forth from the top of the water column, this time a miniature version of the normal atomic bomb mushroom cloud. Below on the surface of the water, rolling steam clouds foamed out from the centre in an ever widening circle to engulf most of the target fleet. About this time, the sound of the blast, which in the airplane sounded like the crack of a small calibre pistol, was heard. No particular shock was felt at fifteen miles. Waves 80 to 100 ft. high near the burst swept out, but they subsided to 7 to 10 ft. by the time they reached Bikini Island, several miles away. Overhead the radio-active cloud rose to about 9,000 ft. and then comparatively quickly dissipated and drifted away. In 15 minutes it was all over and the target fleet became visible. It appeared that a giant fist had cleared the centre of the target. Ships apparently loose from their anchors seemed to have shifted outward from the centre. The battleship *Arkansas*, 500 ft. from the blast, and four smaller ships were missing. The aircraft carrier *Saratoga* was in a hopeless condition with her stern low in the water and listing badly with her flight deck superstructure severely damaged. She sank seven and one half hours after the blast. The original well defined pattern of the target fleet had been completely altered and ships were drifting aimlessly in all directions. The Japanese battleship *Nagato* sank five days later, still too radio-active to be boarded. Three submerged submarines sank immediately. Seventeen ships, two battleships, two cruisers, one aircraft carrier, three destroyers, six transports, one submarine, and two L.S.Ts suffered minor, moderate or major damage from the blast. The author finds it impossible to draw detailed conclusions on the basis of preliminary reports so far made on the test, but considers the effect of an underwater atomic bomb comparable to that produced by many thousands of standard depth charges. In addition the fission products of the bomb, poison with radio-active particles a huge volume of water and this radio-activity is more effective as a casualty producer than had been anticipated. The writer suggests that the answer is not to outlaw the use of this bomb but to outlaw war by fear of the use of the bomb.

N.W.

THE ENGINEERING JOURNAL

(Published monthly by *The Engineering Institute of Canada*)

May 1946.—The first article describes the installation and operation of *A Modern Electric Boiler Installation at Arvida.* The installation comprises two electric boilers having a maximum continuous rating of 40,000 K.W. each at 6,600 volts, with an output of about 130,000 lbs of steam per hour at 250 lbs. per sq. in. Aluminium air cell heat insulation is used and its many advantages are explained.

The Construction of Buried Cable in Canada for Long Distance Communication is explained in the next paper. Overhead lines are being replaced by cable as soon as possible to obviate interruptions due to the weather. Ploughing equipment is used for laying the cable.

The Foreman's Status in the Organisation is discussed regarding the position in the United States and Canada. Should the foreman identify himself with the Management or the Trade Union ?

June, 1946.—*The Technical Aspects of the Future of Aluminium* forms the subject of the first paper. The extraction of the metal from bauxite is described and its physical, mechanical and chemical properties are compared with those of magnesium and ferrous metals. The versatility of aluminium and its alloys, both wrought and cast, is well brought out.

Industrial Earthquake Hazards in Eastern Canada. An attempt is made in this article, by analysing the records of earthquakes in Canada during the past 400 years, to estimate the incidence and severity of earthquakes to be anticipated in the future. The precautions to be taken in the siting and design of structures to minimize damage are considered.

The Engineer and his Relation to Human Progress. This is an interesting and thoughtful address by an eminent British engineer who has spent forty years in the Electrical Manufacturing Industry. He stresses the importance of studying the human problems and looks forward to a revolution in our system of technical education to ensure a proper blending of techniques with the humanities.

July, 1946.—*Present Achievements and Future Developments in Aircraft Gas Turbine Engines.* This is a highly technical article of some 1,600 words with thirty-two diagrams. The characteristics of the simple jet, the ducted fan and the propeller turbine are considered in some detail. The simple jet engine is evidently best for the ideal fighter at high speeds, approaching the speed of sound, but the propeller turbine is most suitable for long range duties.

Vertical Lift Bridge Across the Lachine Canal. The construction and operation of this bridge are explained and the reasons for its choice in preference to a swing bridge.

War Time Production of Precision Optics in Canada. This new industry in Canada is dealt with in four instalments, the first having been reviewed in the April issue. The second instalment, in May, deals with the grinding and polishing of lenses, prisms, etc., and blocking methods, the third, in June, continues with prism centering, anti-reflection films, mirrors and engraving and the fourth, in July, describes the various abrasives used and explains the personnel factors and production control.

August, 1946.—*Pre-compressed Concrete Design.*—Numerical examples are given to illustrate the principles involved and practical applications are reviewed.

The Application of the Gas Turbine to Railway Locomotives.—The first gas-turbine-electric locomotive (2,200 h.p., manufactured by Brown, Boveri and Co.) was introduced on the Swiss Federal Railways in 1941. Operating experience with this equipment is described. Its relative advantages and disadvantages compared with Steam and Diesel-Electric drives are dealt with in some detail.

Operating Experience on " Loran."—The word " Loran " designates a navigational system employing the pulse transmission of signals. This system was developed during the war and is now used on Trans-Canada Air Lines.

The Architect, Engineer and Landscape Architect in City and Regional Planning.—An address given in New York by an American planning consultant with twenty-five years' experience of the subject.

September, 1946.—*Proposed Rapid Transit System for Toronto.*—The City of Toronto with a population approaching a million has had no major street improvements for three decades. This article describes proposals to relieve the traffic congestion by the construction of an underground electric railway system.

Modern Methods of Conditioning Boiler Water Externally.—A discussion of the various types of water softening equipment, both base exchange and chemical precipitation. Modern improvements in technique are described.

The Winter Temperature Cycle of the St. Lawrence Waters.—This is a discussion on a paper which appeared in the January issue of the *Engineering Journal.*

Air Conditioning a Windowless Textile Mill.—The subject matter is of particular interest to Military Engineers in view of the greater attention now being paid to air conditioning and the probability of large underground installations in the future.

October, 1946.—*Repair of War-damaged Buildings in the London Area.*—In this paper, the responsible Consulting Engineers describe the organization and supervision of the work in the Borough of Lewisham which has an area of about 10 sq. miles. The heavy damage sustained will be realized from the fact that, out of a total of 50,000 houses in the borough, 370 only were undamaged by enemy action. The difficulties regarding materials, labour, transport, etc., are clearly explained.

Pre-stressed Reinforcement of Timber Trusses.—This article explains the causes of failure and the methods adopted to reinforce with 0·3 in. dia. high tensile steel wire, a large number of Warren trusses in the roofs of Aeroplane hangars built during the war from inferior timber.

Searching for Petroleum in the Maritimes.—Canada produces about 15 per cent only of her crude oil requirements. A good deal of prospecting is going on in New Brunswick, Nova Scotia and Prince Edward Island but the results are not very promising.

Education for Management.—The importance now attached to this subject is explained and the facilities afforded to study it in British Universities and Colleges.

W.M.

POMANDER
16th Century

VINAIGRETTE
17th Century

THE EVOLUTION OF THE BEAUTY BOX

PATCH BOX
18th Century

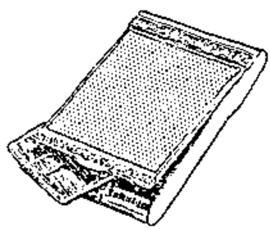
IN Tudor days dames of fashion carried the pomander—*pomme* (apple) denoting the shape and *ambre* (perfume)—a ball of perfume.

When in the XVII century liquid perfumes superseded the solid, the pomander gave place to the vinaigrette.

Yet another aid to legitimate vanity was the patch box of the days of powdered hair. The XVIII century specimen shown above bears the motto

Have communion with few
be familiar with one
deal justly with all
& speak evil of none.

These vanities were the forerunners of the modern flapjack Vanity Case — Eve's essential travelling companion.



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