THE ROYAL ENGINEERS JOURNAL—DECEMBER 1957 VOL. LXXI. No. 4

THE ROYAL ENGINEERS JOURNAL

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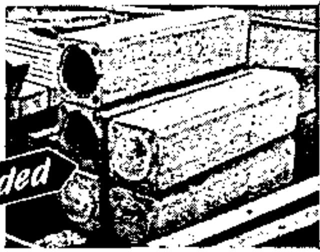

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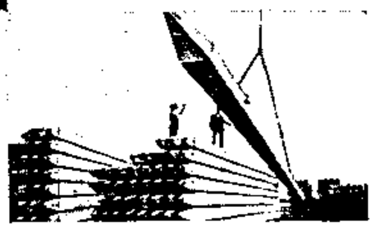

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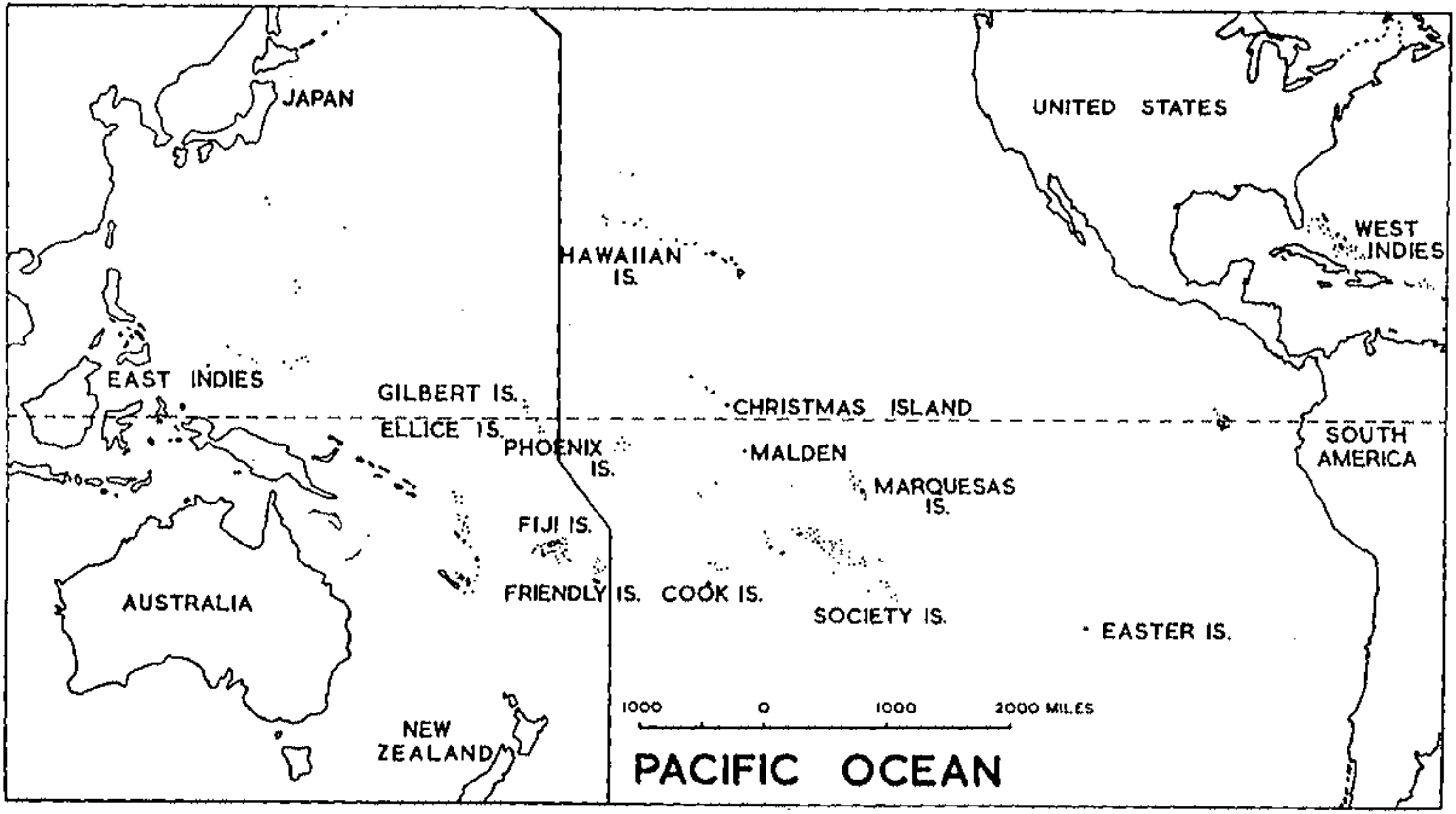
MAP 1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NEW ZEALAND
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0
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2000 MILES
PACIFIC OCEAN

The Christmas Island Trials Base

By Colonel J. C. Woollett, O.B.E., M.C.

Introduction

In 1955 it was decided that a British megaton weapon would be ready for testing in the spring of 1957, and a search began for suitable areas and ways of doing this. Reconnaissance was carried out in extreme secrecy and late in the year plans began to be made to drop the weapon from an aircraft based on Christmas Island. An important part of any trial of this type is the recording base, on which the scientists set up instruments to record the effects of the explosion. Malden Island, some 400 miles away was selected for this role.

This article deals with the Army's share in the operation and more specifically that of the Corps. Although the task was full of technical interest I shall mention only the more unusual problems, for reasons of space. I will, however, try and show how the operational requirements and administrative difficulties affected the engineer task, and how the engineer plan was developed and executed within those limitations.

Geography

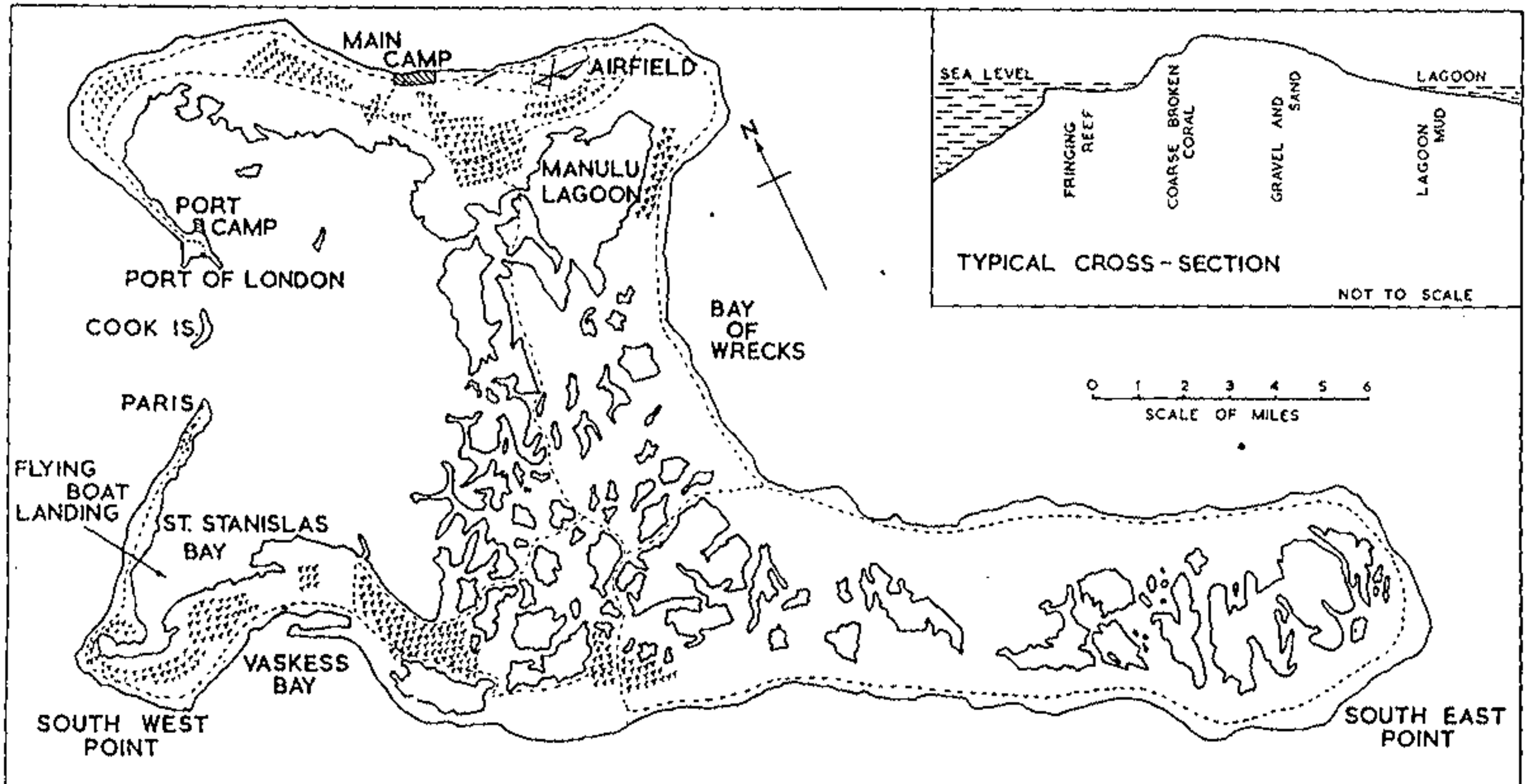
Christmas Island is in the middle of the Pacific, 1,200 miles south of Hawaii, 3,500 miles from San Francisco, 4,000 miles from Wellington, 4,300 miles from Brisbane and 5,400 miles from Japan. It is the largest atoll in the world, with a coastline 104 miles long enclosing 342 square miles, of which 104 square miles are land and the rest lagoon. Because of the uncertain rainfall, it has never been able to support human life, and there is no indigenous population. The Island is planted in parts with coconut palms, and the copra is cut by Gilbertese labourers imported under contract from elsewhere in the colony. The District Officer of the Line Islands District of the Gilbert and Ellice Island Colony has his residence at Christmas, and is also manager of the plantation.

Malden Island, 400 miles to the south-west is a much smaller atoll in a later stage of development. It is 5 miles by 2 miles, and the lagoon is completely enclosed and largely dry, forming quite a small proportion of the surface area. No one has lived there since the company that had worked the guano deposits for sixty years went into liquidation in 1926.

Map 1 shows the position of these islands in the Pacific.

All atolls in this part of the Pacific Ocean are similar, and are surrounded by a fringing reef some 100 yards or less in extent which is almost dry at low tide and is covered two feet at high water. Beyond the reef the sea bed drops away steeply and anchoring is difficult. Shorewards the island consists of coral debris broken from the reef, varying from lumps of 6 in. or more down to coarse gravel and sand. As the lagoon is approached the debris becomes finer until areas of lagoon mud are reached. The latter is the dried silt from the bottom of dried out patches of lagoon, and is a useful construction material. The islands are flat and low, but here and there sand dunes up to 40 ft. or more are found on Christmas. Map 2 shows Christmas Island with a typical cross section of an atoll in an inset.

MAP 2



CHRISTMAS ISLAND

The wind blows from the east for most of the year, from twenty to four knots. Rain is most likely to occur between March and June and anything between 5 and 190 in. has been recorded. At other times only an occasional light shower occurs. Heavy surf may be expected during the northern hemisphere winter months, but at other times it is moderate. Both islands are covered with a sparse coarse grass, but whilst Christmas has numerous clumps of bushes, on Malden there are only four or five clumps of stunted trees. Sea birds are abundant, and land crabs abound. Other wild life consists of a few harmless insects, little jerboa rats and field mice. Flies are apt to be a nuisance but there are no snakes.

In 1944 Christmas Island had been occupied by the United States forces, who dredged a channel, built a wharf and established an airfield with unsurfaced coral runways which in 1955 were overgrown. A few huts were also left in an uncertain state of repair on the airfield site.

Initial Planning

In November, 1955, an engineer planning team was set up at the War Office. I was brought in in January, 1956, and began to plan the reorganization of the Regiment, keeping in touch with the Engineer Planning by means of weekly visits to the War Office. The extreme secrecy made progress very difficult and as no firm political decision that the trial should take place had yet been taken, no expenditure could be incurred. In addition no Task Force Commander or staff had yet been appointed, and planning was taking place on a basis of estimates from the Air Ministry and Admiralty branches interested as to what would be required. The first "Q" brief was in fact written in the E.-in-C.'s branch. Finally in February a decision was taken and a Task Force H.Q. set up. It was necessary to go out to contract at once for hutting and many other items which were not available from Engineer Stores, and the Task Force had to take over the Engineer Plan as it stood. Later amendments were made, and the scope was greatly increased, but it is a great tribute to the E.-in-C.'s branch and the Planning Team that this plan formed a successful basis for the operation.

The Task

The Engineer Task consisted of the repair of the port facilities, the provision of accommodation ashore, including light and water, rehabilitation of roads and the reconstruction of the airfield to take modern jet bombers, and the erection of special buildings required by the Atomic Weapon Research Establishment (A.W.R.E.). Time was so short that only minimum standards on an austerity scale could be provided, and this was accepted by the Task Force Commander, Air Vice-Marshal Oulton, when he was appointed in February.

It was decided to have tented camps with hutted cookhouses, messes, canteens, and offices. Tents would have electric light and cookhouses would be oil fired with low pressure steam boilers and hot plates.

The airfield was to be built to LCN 35, 7,000 ft. long, the centre 100 ft. to be of $1\frac{1}{2}$ in. hot rolled asphalt with concrete turning and running up pads at each end. Taxiways, standings and technical buildings were also required.

The A.W.R.E. buildings mostly involved air cooling and air conditioning, and in some cases gantry cranes for heavy equipment. An elaborate laboratory with compressed air, coal gas, cooled water, stabilized power, and D.C. was another requirement.

After the Task Force H.Q. had been appointed, requirements began to snowball alarmingly, and in March I had to inform the Task Force Commander that the works as planned could not be completed by the target date of 15th February, 1957. This was not acceptable for political reasons and we had then to see how men could be got to the island earlier, and what would have to be sacrificed to do this.

Regimental Organization

In 1955, 28 Field Engineer Regiment had returned from Korea, where they had been the Divisional Engineers of the Commonwealth Division, leaving behind 55 Field Squadron, which was reorganized as an Independent Field Squadron. We were stationed at Erlestoke Camp, Devizes, as the Divisional Engineers of the embryo 1st Infantry Division. The Regiment consisted of 12 Field Squadron and 64 Field Park Squadron, and in January, 1956, had been joined by 71 Field Squadron who took the place of the Canadian Field Squadron that had been part of the Regiment in Korea. Although we were now 10 per cent under lower establishment the bulk of the officers and senior N.C.O.s remained the same, and there was, therefore, a firm framework on which to build.

55 Field Squadron

At the outset it was intended that 55 Field Squadron, who were due to return in the spring, should join us at Erlestoke, and after leave and reorganization go out with the Regiment in August. The need to speed up the work meant that they would now have to move direct from Korea, and in March I flew out to warn them of this and to outline their tasks. They took the news manfully, and with a good deal of hearty laughter, as the day before they had been permitted to purchase their Korean winter kit.

Both the Commonwealth Division and H.Q. British Commonwealth Forces in Korea were extremely helpful, although the premature removal of the bulk of their Sappers was a great inconvenience. In particular the C.R.E., B.C.F.K., Lieut.-Colonel S. A. Fletcher, O.B.E., R.A.E., did all he could to see that they were equipped and trained for their tasks, and his previous experience of operations in the Pacific was invaluable. Amongst other things he designed and made up portable camp structures to cope with the initial landings, until semi-permanent structures could be erected.

The Establishment

The task fell roughly into two parts, the work on the airfield and the construction of the camp and A.W.R.E. buildings. I therefore decided to have 12 and 55 Field Squadrons organized on the lines of Army Field Squadrons with a minimum of transport. There were three large specialized commitments comprising Plant, E. and M. and the camp administration, which was an Army commitment. 71 Field Squadron was reorganized into an E. and M. Troop, a Plant Troop and an Administrative Troop, whilst 64 Field Park Squadron had its stores and workshop troops increased to the size of those of a workshop and park squadron. The Plant Troop that they had lost to 71 Field Squadron was replaced by a Transport Troop, in which all the working transport of the Regiment was centralized.

In addition the Regiment was supported by a Special Engineer Workshops R.E.M.E. some fifty strong, with an attached Ordnance Section which also ran a laundry. Fuel and supplies were looked after by an R.A.S.C. detachment which operated DUKWs and a bakery as well, and an Air Formation Signals Troop was provided. A detachment of 51 Port Squadron operated NL pontoons and provided stevedores. In all the Army force consisted of 1,200 officers and men, with 150 vehicles and 190 pieces of mobile and static plant.

Training

Time did not permit of any unit training for the task, and so the principle was adopted of keeping sub units together as far as possible, and either reinforcing them with suitable tradesmen or sending men to firms or establishments to get experience. Much invaluable help was given by the S.M.E., by M.E.X.E., by individual firms and the Engineer Training Centre at Ripon. The entire output of the training machine was taken to provide sufficient plant operators, and in addition experienced operators were posted in from Germany. Special courses were run for engine hands and electricians by the E. and M. School. I was most concerned that some training should be obtained in asphalt work and on bolted tank construction, since we had no experience of these tasks. The Civil Engineering School trained some men on mixing plant and on layer and finisher operating, and later M.E.X.E. were able to let us have some practice by troops, but there was little doubt that we would have mostly to learn by ourselves on the job. We were also able to practise bolted tank erection at M.E.X.E., and this proved invaluable later on. Civil firms were most co-operative in giving selected tradesmen instruction in erecting the various types of building they were providing, and most valuable of all, two asphalt firms allowed us to attach Barber-Greene operators to gain experience on the job.

Since the joint force was only just being assembled, and most of them would be unable even to meet until arrival on the island, I felt that it was essential that those concerned with the first landings should get together and study the problem. Accordingly, on 14th and 15th May, 1956, a two-day study period was held at Erlestoke Camp, which was attended by all squadron and specialist troop commanders and by Royal Naval, Royal Marine and R.A.F. officers concerned with the initial landings. O.C. 55 Field Squadron, who had been flown back from Korea to be briefed, was able to attend as well. The first day was devoted to a study of the Engineer Plan, which was presented by the Planning Team, and the second to a study of the landings and initial operations. Many problems were ironed out, but the time was far too short, and had a week been available, it could well have been spent in this way.

As a result of this study I was able to present the final engineer plan to the Task Force Commander and the senior officers of each service on the following day. It was already apparent that we were slightly overloaded with work, and it was agreed that the R.A.F. would provide working parties for the simpler tasks, such as tent erection.

Logistics

Christmas Island was as near an administrative desert as any place could be, and it was also nearly as far from its main support area as anything could be. The work done was governed by the rate at which stores could be delivered and discharged, and this in turn governed the facilities provided

Photo 1.—Layout of port and oil tank farm.

The Christmas Island Trials Base 1

and the rate of build up of the force. We were fortunate in having an experienced staff officer as Chief Logistic Planner at H.Q. Task Force, as the co-ordination of inter-service priorities was far from easy.

Engineer stores formed the bulk of the stores required, and the R.E. Planning Team had given priorities based on the expected progress of the work. It was never possible to keep to this except in the broadest of terms, and changes had to be made continually to fit in with delivery dates, ship capacity, requirements of other services and so on. This affected the order in which work had to be done.

It was of the utmost importance that no unnecessary men or stores were taken to the island, and that there should be no over-insurance of any kind. It was equally important that everything should work when it arrived. The shortage of time meant that there would be little chance of checking stores before shipment, and any idea of assembling everything at No. 2 E.S.D. Liphook to do so had to be abandoned. Upon reflection it was remarkable how well the engineer stores organization did us, and how few mistakes there were, considering that the total tonnage of engineer stores was over 16,000. Nothing vital was omitted, though a few minor deficiencies caused an irritation out of all proportion to their consequence.

Command and Control

The H.Q. of the Task Force was situated in London and liaşon with A.W.R.E. was maintained by means of weekly meetings at Aldermaston. It was not intended that the Task Force H.Q. should come out until shortly before the trial was due to take place, when the base was ready to receive its full quota of scientific staff and operational aircraft. In the meantime the direction of all three service components of the Task Force in the Pacific was given to an officer designated the Senior Officer "Grapple" Area. During the construction phase, up to February, 1957, the C.R.E. was so designated and I found this of the greatest assistance in ensuring that all operations were directed to the support of the construction force. I do not mean to imply that there was any lack of co-operation from the other services, but in such a complex operation it was necessary to stick closely to the Task Force Commander's directive, and the best way of achieving that was to ensure that the officer responsible for directing each phase had over-all control.

It thus became necessary to split Regimental H.Q. functionally and to provide what was, in effect, a small C.R.E. and Garrison H.Q. This was composed of myself and the Adjutant, whilst the command of the Regiment and other Army units as far as administration and discipline was concerned devolved on the Second-in-Command, This organization is shown diagramatically at Appendix A.

The works programme had been provisionally prepared before we went out, and tasks had been allotted to squadrons so that they could prepare for the work. For reasons given above it was not possible to keep exactly to this programme, and I therefore held weekly co-ordinating conferences at which firm orders were given as far ahead as possible. Based on these decisions the D.C.R.E. and Works Section (which the R.E. Planning Team had now become) issued works orders to the squadrons together with the AB43s to enable them to draw the stores from the Stores Troop. At the same time they were given an appropriate allocation of plant and E. and M. tradesmen, Thus 71 Field Squadron in effect "hired out" its plant and E. and M. tradesmen whilst retaining responsibility for maintenance and standards of work, a form of centralization which I consider essential to efficiency. Tasks on which only plant was used, such as road construction, or wholly E. and M. tasks such as power line or tank erection, were the complete responsibility of this squadron.

Progress was reported weekly by means of job tables, the serial numbers and percentage or other applicable report being signalled to London.

Port Organization

From the anchorage to the wharf was about one mile, and about a hundred feet of the wharf was still usable. The layout of the port can be seen in Photo 1, in its final condition, with a ship in the extreme north of the anchorage beyond. DUKWs used to operate from a sand spit beyond the left of the photograph, on which L.C.M.s could beach as well. Stores and vehicles had to be brought in by L.C.M., by N.L. pontoon, or by DUKW, and a water barge was used for water supply.

The first task was to clear the wharf of the rubbish and wreckage, establish the two N.L. pontoon finger berths to the south of it, and lay P.S.P. for the L.C.M. and DUKW landings on the sand spit. We were very nearly in serious difficulties early on because the L.S.T. *Reginald Kerr*, which had brought the equipment for the initial landings from Singapore had been wrongly loaded. The other ships had not been tactically loaded at all, and the delay in getting cranes ashore was only overcome by improvisation. So if anyone thinks that training Sappers in the construction and operation of a sheer legs is out of date in this day and age I can assure him that he is wrong.

The port organization that had been agreed was a mixture of that laid down for a beach landing and for a port, i.e. control was vested in a port committee with the Senior Naval Officer as chairman and with all organizations working in the port and user units represented. It was really too cumbersome a machine for so small a port and further problems were posed because the port camp contained a hotch-potch of all units and services working in the port area, with only an improvised administrative organization. It would have been much more efficient to have had a port squadron H.Q. in control of the shore side of all port activities, both operationally and administratively.

The First Arrivals

On 19th June, 1956, an advance party consisting of Commodore Gretton, the Deputy Task Force Commander, myself, and a Wing-Commander in charge of the R.A.F. detachment, with sundry helpers, arrived in two Shackleton aircraft, and landed on the old American airstrip, which had been cleared by the District Officer with Gilbertese labour. We had five days to confirm plans made from air photographs, before the *Devonshire* arrived with 55 Field Squadron who had embarked at Singapore and a troop of 12 Field Squadron, the stevedores, Plant and E. and M. personnel, DUKW detachment, sailors and marines for landing craft, R.A.F. staging post and a host of other persons who had flown out to Suva in Fiji and embarked there. With the L.S.T. *Reginald Kerr*, the heavy lift ship *Ben Wyvis*, and the R.F.A. *Fort Beauharnois* bringing the landing craft and food there was soon quite a fleet in the anchorage.

For the first three days men worked ashore unloading stores, returning to the *Devonshire* at night, but on the fourth day the whole force of 500 came ashore and the *Devonshire* sailed. It had been hoped to have our mobile camp structures up by then, but due to the incorrect loading of the *Reginald Kerr* they were still buried under lower priority items. Thus conditions for the first few days were rather primitive. It came as something of a surprise to those accustomed to field unit life to find how those who are not so trained considered the conditions a great hardship. However, all turned to with a will and started to put their tents up with a certain amount of ribald advice from the Sappers. The film unit, it is true, complained that their contract specified first class accommodation, but they were shown the parts of a tent and told that they could sleep in it or on it—it was up to them. They slept in it. On the whole it was a pity that so many who were not strictly necessary at first were landed so early, but the need to make full use of transport capacity made this essential.

At first the whole force concentrated in getting stores ashore and into dumps by categories. A careful organization had been worked out and a whole troop of 55 Field Squadron was employed as checkers and storemen. When the initial rush of discharging three ships at once was over the movements organization were able to cope unaided, and this troop was withdrawn. Advantage was then taken of a lull in ship arrivals to move most stores 10 miles up country near the site of the main camp, and thereafter the majority of stores were moved up as soon as they had been unloaded. I am sure that the elaborate arrangements made, which included card indexing all consignments by F.S.O. numbers were absolutely necessary to avoid confusion, especially as the force had never trained or worked together before. After three weeks, satisfied that the operation was well under way, Commodore Gretton returned to London and the construction phase began.

The Temporary Phase

The Engineer Plan for this phase envisaged the setting up of camps with temporary cooking, washing and latrine facilities, and with field lighting from cables laid on the ground. An old American airstrip, about a mile away from the site of the main airfield was to be cleared and levelled to take the weekly Hastings flight to and from Honolulu, bringing our mail and fresh fruit and vegetables. Work could then begin on the main airfield.

As soon as 55 Field Squadron had finished their work at the port they were moved up country to the site of the main camp. It had originally been intended to site this in a coconut plantation for shade, but an unobstructed breeze proved a better cooling agent, and I therefore resited it on the coast.

On 28th July, 1956, the *Charlton Star*, arrived with Regimental H.Q., 64 Field Park Squadron, less the Workshop Troop, and 71 Field Squadron, less the E. and M. Troop. This at once provided a more effective working organization, as well as very necessary reinforcement. 55 Field Squadron had borne the brunt of the early part of the operation and were beginning to feel the strain.

It was not until 12 Field Squadron with the missing Workshop and E. and M. Troops arrived on the *Cheshire* on 13th September, however, that the construction force was complete. This rate of arrival was by no means ideal, but was forced on us by the availability and capacity of the ships, and the need to give special training to those concerned with asphalt work and

Photo 2.—The airfield.

The Christmas Island Trials Base 2

bolted tank construction. Two and a half months was too long for the construction force to be fully built up, and I would have much preferred to have started with a smaller party and then expand rapidly.

The Airfield

A soils laboratory and a 60-ton test roller had been brought out, and tests on the old American airstrip confirmed the reports of the reconnaissance of 1955. A good source of coral stone was found on the beach at the north-east point, some three miles away, where years of wave action had produced a good dense material. Two Parker, 20-ton per hour, rockcrushers were set up here, and the coral was dozed into stockpiles from which it was loaded into the crusher hoppers by face shovel. Outputs of 15 tons per hour from each of the two machines was achieved after some teething troubles, and stockpiling began. In the meantime the main runway was surveyed, and variations of up to a foot in levels discovered. The whole surface was then roughly levelled and scarified, and covered with a minimum of 2 in. of lagoon mud, which was then well watered, compacted with rubbered tyred rollers, finish graded and rolled again.

The 8-in. concrete pads at the ends were laid first. Two Blaw Knox, Batchmaster, weigh batching plants (14 MP-NT) were set up at each end, and the concrete placed by means of 1-yd. Benford dumpers. Holman vibrating beams were used for compaction. The specification called for 2,500 lb. per sq. in. at twenty-eight days, and some difficulties were found in achieving this at first because coral is porous, and it is hard to control the water cement ratio. This was finally overcome by continually hosing down the stock piles, so that the coral was fed into the mixers thoroughly saturated. Strengths of up to 4,000 lb. per sq. in. were ultimately achieved.

Asphalt work started ten days behind schedule, due to the late arrival of the *Cheshire*, combined with a breakdown of our solitary Hastings, which stranded the Barber Greene operators in Honolulu. A battery of three Parker, Starmix 8, mixers was set up near the airfield, and stone was fed to the hoppers by means of Jumbo mobile cranes with clamshell attachment. Bitumen was supplied in 40-gallon drums, and was melted into a battery of 250-gallon kettles, from which it was pumped over into 1,000-gallon mobile heaters, which were towed round to feed the mixers. A 60/70 straight run bitumen supplied by Shell was used. As I explained earlier, the men operating these machines had had no opportunity of practising continuous working. The machines are complicated and every mistake brings a train of troubles. Output at first was disappointingly slow, but there was a steady improvement. It was soon apparent that we would be unlikely to meet our target date of 1st November, and as the first charter aircraft bringing the first of the R.A.F. build up was due to arrive from England on the 4th, this was a matter of some moment. On 1st October I decided to stop work on the concrete standing for the Valiant aircraft, and to use the labour so freed for asphalting, working in two shifts of six hours, to make full use of daylight.

The Barber Greene operators had been well trained and soon achieved a high standard of work. During October output crept up and up, with each shift vying with the other for record output. The best ever was 300 tons a day, and finally on 31st October at midday, the last run joined up with the concrete pad. The arrival of the first aircraft was watched with great interest by all concerned, and the end of Phase I of the operation was celebrated by a holiday and firework display on 5th November.

Photo 3.—The camp area.

The Christmas Island Trials Base 3

Coral makes excellent asphalt, and Marshall Test numbers of 3,000 were easily achieved. In all some 6,000 tons were laid on the runway, and the shoulders levelled with lagoon mud and surface dressed with a cut back 150/200 Bitumen. The same surface dressing was used for the standings, with a finer grade of stone. It proved barely adequate and needed continual patching. Asphalt was laid for all taxiways. A general view of the finished airfield is given in Photo 2.

Camp Construction

There is no real tropical scale for temporary camps as conditions vary so much. In general, Malayan scales were used and adapted locally. Sufficient E.P.I.P.* tents for the original force were shipped from Malaya, but as the numbers were eventually doubled, the balance had to be made up from 160 lb. tents from the U.K. The E.P.I.P. tents were excellent, but the material was rather poor and soon rotted.

Power was distributed from three phase, National Brush, 120 kVA. generators by overhead line on normal poles, and distribution to tents by Enfield overhead cable. This proved reasonably satisfactory although the salt laden atmosphere, caused by the spray from the surf on the reef, caused troubles at junction boxes, and the U.K. type insulators were too small, for the same reason.

Cookhouses and mess anterooms were all in Thorns hutting, a prefabricated type which was chosen for speed of delivery. It was by no means ideal for the tropics as far as kitchens were concerned, but was satisfactory in other aspects. Oil fired ranges were installed and low pressure steam heating for hot plates and boilers. The latter was very satisfactory, but the oil-fired ranges gave a very fierce heat which the cooks found difficult to control. Water supply was from three sources. By digging down a few feet a low salinity water (about 1 per cent) can be found almost anywhere, and this was pumped up to a tank and distributed around the camp by a victaulic ring main for washing purposes and showers. Although not very pleasant, soap will lather in it, and it is adequate. In certain parts of the island fresh water lies on top of the salt in the sub-soil in the form of a lens. We improved an existing water hole by digging a long shallow trench and were able to pump eventually some 16,000 gallons a day 4 miles to the main camp. This source was supplemented by diesel burning distillers operated by the Royal Navy. They were of an obsolete pattern, and very troublesome and unreliable. Fresh water consumption averaged 10 gallons per man per day and initially was much less. Strict control was necessary, and we had to employ one sergeant whole time inspecting and checking fittings and consumption.

The plumbing of the cookhouses and messes was necessarily elaborate, and proved to be a major bottleneck. I am sure that plastic plumbing would have saved a lot of construction time in work of this nature.

A Romney hut was lined and partitioned to make a N.A.A.F.I. and W.V.S. Club, and an open air cinema constructed. Both C. of E. and R.C. churches were built of timber and palm thatch by the respective padres using volunteer labour from their flocks.

For latrines, Elsan closets were provided and the waste was disposed of by pumping it over the reef down wind and current of the camp. It was

* European Privates Indian Pattern.

very successful and no fly borne sickness occurred, although flies were everywhere. I do not consider that ordinary buckets would have been sufficiently flyproof, and deep trench latrines were ruled out by the high water table. Flies bred in the carcases of the thousands of crabs that lived and died all over the island, and though they could be kept down by spraying, they could not be eliminated.

Cookhouse and shower drainage was by means of large soak-pits, but although the grease traps and the size of the pits were always being enlarged, they were always troublesome. In all, collecting tanks and pumping out to sea would have been a better solution, and would probably have meant less effort over-all. A general view of the main camp is in Photo 3.

Fuel Storage

Both jet aircraft and the distilling plant used enormous quantities of fuel, and storage for one million gallons had to be provided, comprising Avgas, Avtur and Dieso. A pipeline from a tanker berth to the airfield was considered, but was ruled out on considerations of construction time and expense. It was decided to bring in fuel by barge from the tanker in the anchorage and deliver to the tank farm at the port, from which it was taken by bowser to a smaller farm at the airfield, the re-fuellers could move easily to and from the aircraft. The bolted tanks, which were of the standard pattern developed by M.E.X.E. were put up in three weeks by a team of fifty who had been previously trained. The main tank farm can be seen on the right in Photo 1. For simplicity three separate delivery pipes, one for each fuel, were laid from the barge discharging point. This avoided the problem of contamination and disposal of the contaminated fuel. When constructed the tanks were water tested and all save one stood up to the acceptable leakage rate of under one eighth of an inch in twenty-four hours. That one proved to have a line of bolts in the base untightened in spite of careful checking procedure. The tightening is done by torque spanners and it is important to test them before using. Ours proved to pull off at very varying pressures and a new set had to be flown out from England in a hurry. Those who saw Charles Chaplin in *Modern Times* will realize the state that the men got into after tightening so many bolts, and they had to be stood off for a few days before they were fit for anything else.

Two months after the tanks had been filled, a great scare developed because samples taken and sent to Australia for testing proved to have an excessive gum content. This was found to be due to the samples having been mislaid for two months in a tropical heat, and the only contamination found finally was coral dust and rust, which was expected. Proper boards had been held before handing over the farms to the R.A.S.C. and R.A.F. respectively and this proved of value in avoiding subsequent recrimination. There is no doubt, however, that the filtration arrangements should be improved for the very high standard now required for aviation fuel, and provision for recirculation is necessary. A minor gap in inter-service responsibilities was noted when the airfield tank farm was handed over to the R.A.F., as they have no trades similar to the R.A.S.C. petroleum fitter, and we had to train them to use the installation.

Refrigeration

It had been originally intended that all food should be supplied from a Victualling Supply Issuing Ship (V.S.I.S.), except for a short period in

Work on the island continued throughout until March, and the first A.W.R.E. representatives arrived in February to help site their installations. Finally, the island settled down to its final population of a hundred, half A.W.R.E. personnel and half Sappers, with a R.A.F. controller to bring in the daily aircraft. The drill for dismantling the camp and storing machines in protective earthworks was carefully worked out so that the island could be prepared for a trial and restored in two days.

Other Islands

Small detachments were also established at Jarvis Island, to operate "Decca", and at Penrhyn in the Northern Cook Group, where a metereo-logical station was also set up. All these involved small but significant drains on the engineer effort, and proved bigger jobs than had been thought in the first place. Penrhyn was a lovely island and very unspoilt, and with trading schooners, pearl shell fishing and friendly native population was much more like a story book South Sea island than the barren Christmas, Malden, and Jarvis islands.

A.W.R.E. Tasks

Work on the A.W.R.E. installations began after Christmas. In all, about 30 per cent of the engineer effort went into these buildings and facilities, but for security reasons I shall not enlarge upon them here. In addition, some sixty Sappers were attached as tradesmen to the A.W.R.E. teams, and their work was highly commended by those in charge.

Administration

It was necessary to work a full six day week in order to get the work done in time, but I tried very hard to avoid exceeding this because of the ultimate loss of efficiency, and Sunday was made a complete change, with the morning left free for Church and games. Troop officers were encouraged to get their men out of camp as much as possible on Sundays, and fishing and boating on the lagoon was very popular.

Besides the N.A.A.F.I. the cinema was well attended and put on three programmes a week, and our two W.V.S. did sterling work with their club. But on the whole it was a life with few attractions for young men over a long period, especially as no form of leave could be given. For a limited period of up to a year this was acceptable, but for a longer period it would have affected morale.

Clothing was normal jungle green, and proved adequate and suitable. The sun was very fierce, and at first dangerous, but after two or three weeks men were able to work in jungle hat, shorts and boots, and became nearly as brown as the Gilbertese. On the whole health was surprisingly good and the sick parade, including works injuries, was under one per cent. Food was a problem at first, until methods of cooking had been improved, and also storage facilities, when it was adequate but somewhat monotonous. Potatoes are remarkably difficult to keep in the Pacific, and I was able to trace a definite connection between a failure of the fresh potato supply and each crop of grumbles.

The mail service was excellent, and averaged five days to and from the U.K. It was also possible to get compassionate cases home in about the same time.

October when it would have to leave to restock. Fifty tons storage ashore was considered adequate for this and five 10-ton portable stores were provided. Unfortunately the scope of the operation increased so that this ship, the *Fort Beauharnois*, had to be away more frequently delivering stores to other islands, and fetching stores, so that our 50 tons was often overloaded. The 10-ton stores are easy and quick to erect, but the Jap engines gave trouble under the conditions of almost continuous running required in the heat. Later they were replaced by 5 h.p. electric motors which proved satisfactory. Other refrigeration was of a domestic nature and varied from 50 cu. ft. in cookhouse to 15 cu. ft. in the smaller messes. These gave little trouble. The A.W.R.E. buildings also had air cooling and air conditioning equipment.

Power Supply

For speed, low voltage distribution was used throughout, although it was most uneconomical in labour. In all, there were nine power stations capable of generating some 2,000 kVA., and at peak periods, some seventy men were required to man them continuously. For the more important power stations, generators were triple banked, but generally 100 per cent reserve generating capacity was sufficient.

Malden

At the beginning of October I reconnoitred this island in H.M.S. *Messina* which remained off the island for four days and landed plant and stores. Soil samples were taken, and sites for the camp, the airfield and the measurement groups were fixed. Landing conditions proved easier than expected and a beach roadway was left ready for the construction force which was to land in December.

On 7th December the main construction force sailed with some more stores, but this time the surf was very bad and they found the beach roadway destroyed. H.M.S. *Messina* damaged herself trying to beach, a DUKW was lost, and a L.C.M. was also damaged. In bad conditions it was necessary to employ up to three dozers on the beach to tow out stores from L.C.M.s and to prevent them broaching to, but the Royal Navy and the Royal Marines carried on with great determination and all stores were landed. The DUKWs did very good work indeed here and proved capable of landing through the surf when the L.C.M.s could not be used. After the loss of one by broaching to, however, it became the practice to bring a dozer winch rope with a snap hook to the edge of the surf and hook on as soon as the DUKW touched down.

One of the problems at Malden was that the camp would have to be completely dismantled before each trial and re-erected. Accommodation was therefore wholly tented, except for the cookhouse, showers and latrines, which were made to take to pieces. Elephant shelters were provided to store the camp and furniture.

Work on the airstrip began early on, and the site was soon stripped and levelled. Very large quantities of water were then pumped onto the coral gravel which was vibrated and rolled. Lagoon mud was not easy to come by on Malden, and borrow pits were soon worked out. In addition large coral heads were found in the mud, which made the extraction by scraper very difficult. By 15th January the strip was 800 yards long and ready to take Dakotas, but unfortunately the Dakota flight had been delayed by bad weather. However, a very skilled and sporting Hastings captain landed his aircraft to drop and collect mail, much to the admiration of the Sappers.

There was an almost complete absence of petty crime, although there were two or three cases of stealing, which could fortunately be tried on the island as I held a warrant. On the whole morale was amazingly high, and everyone felt that they had a worth-while job to do in a limited time, and were determined to hit the target.

The Operational Phase

At the end of February, 1957, the work was virtually finished and the R.A.F. and A.W.R.E. build up was well under way. There remained certain additional tasks—taxi ways, and standings on the airfield, which 12 Field Squadron was carrying out, but in other ways our tasks were reduced to maintenance and administration. 71 Field Squadron had been reorganized to carry out these tasks, and had been reinforced from other squadrons. The whole Army force came under Garrison H.Q. Christmas Island, which had been raised on 1st January, 1957, to comply with the provisions of the 1955 Army Act, as it is not possible now to command a unit and hold a court martial warrant. The Regiment sailed for home on the *Captain Hobson* on 3rd March, with 12 Field Squadron following by air at the end of the month.

March saw the beginning of the rainy season, with heavy rain every two or three days. On the whole it proved to be a wetter year than average. This caused us a good deal of trouble on the roads which was not unexpected, and plans had been made to have duplicate roads, where possible, so that one could be closed for maintenance. For the dry season, which covers most of the year, the best roads are made of lagoon mud which, if sufficiently thick, and on a moist sub-grade retains its cohesion and provides a level dust free surface. By using alignments near the edge of the lagoon quite good roads can easily be made by dozing or using a dragline to build a low embankment, allowing it to dry, and then grading and compacting with rubber tyred rollers. This type of road is really a crust of hardened lagoon mud, and in wet weather it is liable to soften, pothole, and finally dissolve into mush. Alternative roads were sited near the coast on coral gravel sub-grades. These roads were simply graded to shape and compacted by traffic. In wet weather they stood up well, but in dry conditions they were very dusty and corrugated badly. Thus by ringing the changes on the two sets of road reasonably satisfactory communications were possible under all conditions except the heaviest rain.

Drainage of the airfield also presented some problems due to the very flat nature of the island. Except when the rate of rainfall exceeded the rate at which the runway could shed it at its specified cross-gradient of 1 in 200, the runway was never closed. Occasionally in heavy showers it had to be closed for up to half an hour. A good deal of inconvenience was caused by flooding at the back of the standings and in the equipment section, which had spread far beyond its original planned area.

Excellent liaison was maintained with the flying and engineering sections of the R.A.F. wing, and nearly all the Sappers were given flights to look at the airfield they had built, whilst much mutual help went on. All officers, most of the senior N.C.O.s, and numbers of the rank and file were able to witness the explosions from ships or from "grandstand" aircraft, and so see the operation through to the finish.

Lessons and Reflections

Most comments on the operation boil down to the fact that it would have been easier, or better, with more time, more stores, or more men, and since none of these things, except possibly the latter could have been made available there is little point in mentioning them.

In fact a very large amount of work was carried out in a very short time, and on the final count some 43 per cent more than had been planned was done. This large additional amount was only possible because we were extremely lucky with the weather and accidents, and needed to use hardly any of our 30 per cent reserve. The remaining time was gained by retaining 12 Field Squadron for an extra month and flying them back to the U.K.

Working for the other two services is not very different from supporting other Army units, although there are sometimes "language" difficulties and the former are not so well educated in the problems of engineer work. But they are, after all, used to sailing ships or despatching aircraft with sufficient fuel for the journey plus an adequate reserve, and once they grasped the fact that exactly the same considerations apply to engineer work things were much easier.

The training in engineering given to R.E. officers has often been criticized as unnecessary in view of the simplicity of most field tasks. I have always felt that this was wrong and am more than ever convinced that it is so now. In January, 1956, we were planning to train up as a field engineer regiment with our division. By November of that year we had completed a runway for modern jet bombers on a desert island 9,000 miles away. This would have been quite impossible without sound engineering knowledge at the back of the majority of officers. Work with his own sappers on good engineering tasks against time is immensely interesting for a young officer—or any R.E. officer—and is the finest training he can have. The main deficiency noted was poor organization of work, but this lesson can only be learnt on the job, and was quickly acquired.

The W.O.s and Senior N.C.O.s training showed up well, particularly those in the Establishment for Engineer Services. The one or two weak spots in the latter were men who were not really good N.C.O.s, although technically proficient. It is to be hoped that first class N.C.O.s will continue to be put into the E. for E.S.; we could not have done the job without them.

As regards the Junior N.C.O.s and Sappers, their response to a real job and heavy responsibility was amazingly good, as it always is, and their morale and cheerful hard work won the admiration of the other two services. The standard of tradesmen was not so good, and it was disappointing to find many men with "paper" trades. In fact, it became necessary to have all the more advanced tradesmen interviewed by the E. and M.O. before accepting them for the operation.

Although the Regiment had been considerably enlarged and reorganized, it was basically the same Regiment, and I am sure that this was a major factor in the success of the operation. No *ad hoc* assembly of squadrons and specialists could have stood up to the pressure and the strains, and the pride of all ranks in the Regiment, with its background of Korean service was immense. I hope regimental trooping will continue. It is a major factor in the happiness and morale of the Sapper. The support given to us by the Corps as a whole was very encouraging. The War Office and Records got into action well ahead of official instructions, and all units sending us men gave us their best. I do not recall one single case of "unloading". Having a high priority task is splendid for the unit with the high priority, but one realizes only too well what it must mean for others in losing their best men and having all their plans upset.

I only hope that tasks of this nature will become more widespread in the future so that more units can share in them. They are the most excellent training, and many officers join the Corps in the hopes that they may have such work to do. As an indication of the scope of the task, I have included a summary similar to that given to the Press.

There are few more satisfying things than to finish a job of this sort against time, and to know that the Corps has once more played a vital part in such an important operation. The excellent support given to us by the other Army units must not be forgotten, particularly our Engineer Workshop, R.E.M.E., who met every call made on them, and with whom we worked so well that the R.E. Workshop element remaining in the maintenance phase was, in fact, integrated with them.

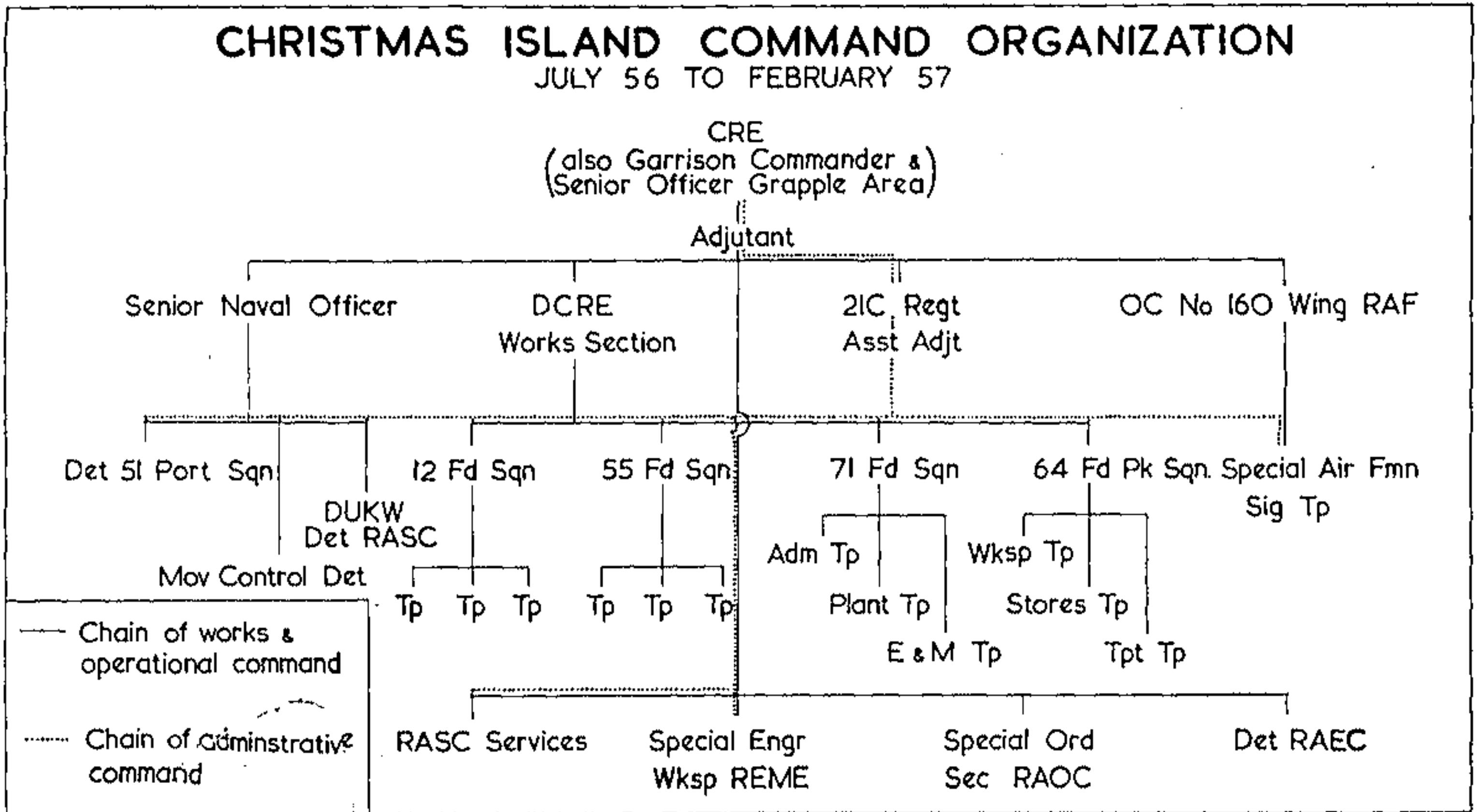
I would like to conclude by reproducing the signal that the Scientific Director of the trial, Mr. W. R. J. Cook, C.B., sent to the D.C.I.G.S. when he arrived out to take charge.

"Am very pleased with the arrangements made here by War Office units. A.W.R.E. Scientific Groups are well satisfied with accommodation, offices, laboratories. They did not expect conditions to be so good. This is having very marked effect not only on morale but on ease and efficiency of working. The help received by A.W.R.E. Groups from Army is tremendous. Army co-operation extremely good and difficult work goes on regardless of hours and weather."

SUMMARY OF WORKS

Buildings Constructed	*Number*
Camps and services	37
Airfield	15 buildings + 25 rehabilitated
A.W.R.E.	20
J.O.C.	6
Tents	290 marquees
	691 other tents
Asphalt	27 acres, 1½ in thick
Surface dressing	37 acres
Concrete	5 acres, 8 in thick
Stone crushed	50,000 tons
Lagoon mud placed	120,000 tons
Roads	37 miles rehabilitated
	8 miles new
Fuel	17 tanks of 1,350,000 gallon capacity
Water supply	100,000 gallons in tanks
	5 miles of mains
Electrical work	8 power stations of 2,000 kVA. total capacity
	5 miles of power mains
Cold storage	50 tons of cold storage
	1,500 cu. ft. in refrigerators

APPENDIX A


CHRISTMAS ISLAND COMMAND ORGANIZATION
JULY 56 TO FEBRUARY 57
CRE
(also Garrison Commander & Senior Officer Grapple Area)
Adjutant
Senior Naval Officer
DCRE
Works Section
2IC Regt
Asst Adjt
OC No 160 Wing RAF
Det 51 Port Sqn
DUKW
Det RASC
Mov Control Det
12 Fd Sqn
55 Fd Sqn
71 Fd Sqn
64 Fd Pk Sqn.
Special Air Fmn
Sig Tp
Tp
Tp
Tp
Tp
Tp
Tp
Adm Tp
Plant Tp
E & M Tp
Wksp Tp
Stores Tp
Tpt Tp
RASC Services
Special Engr
Wksp REME
Special Ord
Sec RAOC
Det RAEC
Chain of works & operational command
Chain of administrative command

Operation "Mosaic"

By Major R. N. B. Holmes, R.E.

On 29th December, 1955, H.M.S. *Narvik*, a L.S.T. of ancient vintage, steamed out of Portsmouth Harbour, almost unnoticed, into the teeth of a wintry gale. She was heading for Australia and the lagoon of the Montebello Islands to play her part in two more atomic experiments. She carried a curious load; L.C.M.s, cutters, pinnaces and odd steel structures on her foredeck. Her tank deck, obstructed by newly constructed compartments to act as laboratories, was crammed full with Engineer Plant and Stores, as well as enormous crates of scientific equipment.

Her complement too was strange. A Commodore in command and about 250 officers and ratings. Amongst these were to be found an officer and twenty Marines to man the Landing Craft and six Sappers. Four of the Sappers were to maintain the engineer plant during the voyage and the other two were volunteers to run the laundry. (A strange task for Sappers and the less said about their inclusion the better.)

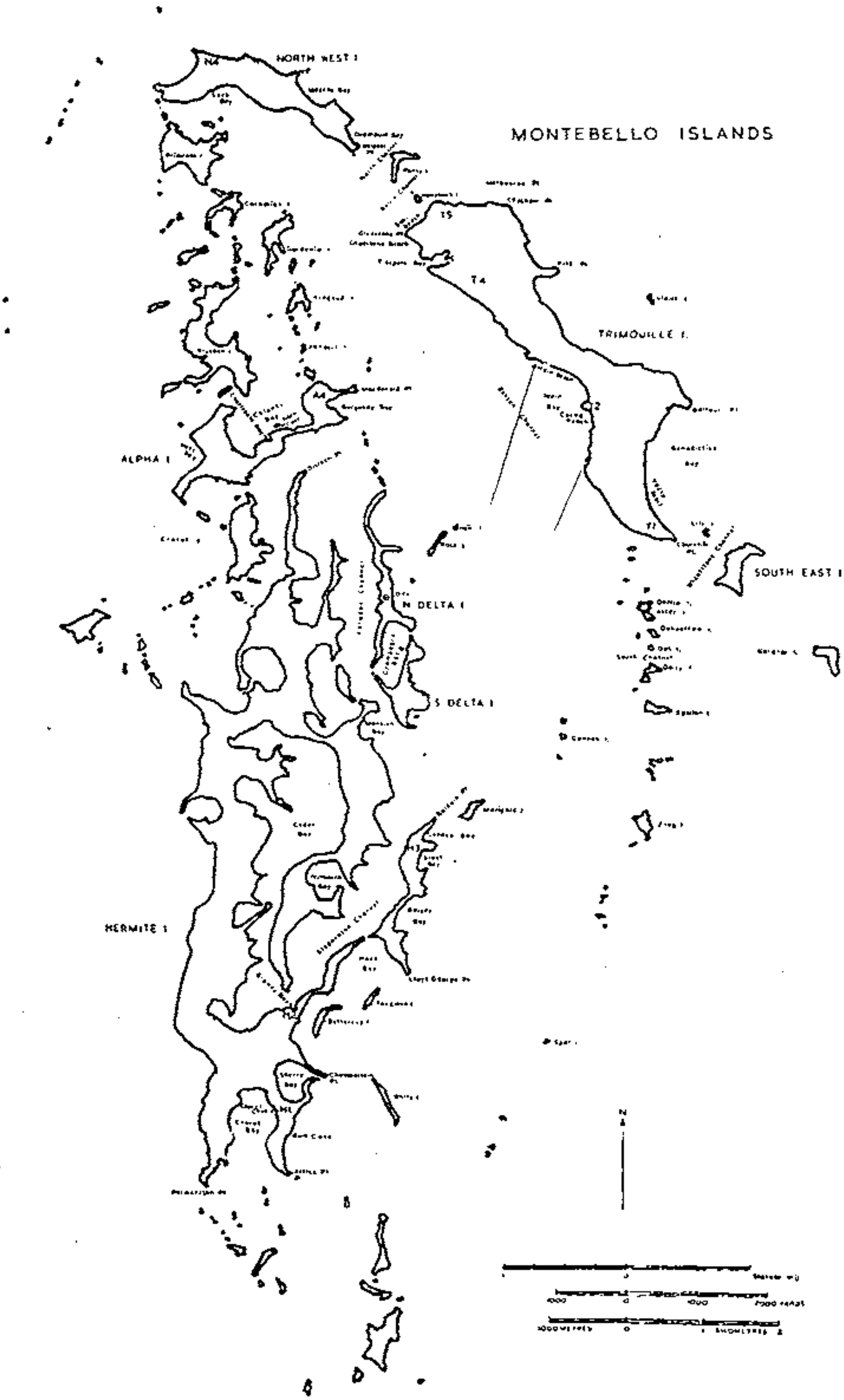
The sailing of this ship signified that a truly combined operation involving all three Services was at last under way after five months of intensive planning and preparation. As the tests were to be carried out in remote islands off the Australian coast, Naval and R.A.F. support was essential, and as the weapons were to be fired from high towers the Sappers could not be left out.

Whilst *Narvik* endeavoured to maintain 10 knots on her way, the main Sapper party of sixty were able to put in a few weeks' training for the tasks that lay ahead before embarking, in mid-February, 1956, in a Qantas Super Constellation that A.W.R.E. had chartered for us. The journey out was very swift and luxurious for all. For the night's stop at Singapore we were all accommodated at the Seaview Hotel, which pleased the Sappers, especially the two who found a couple of Chinese beauties sleeping in the rooms allotted to them. This was rectified before any damage was done or pleasure enjoyed—apparently.

The main R.A.F. Force, consisting of Canberras for recce and cloud sampling, Hastings and Varsities for logistic support, Shackletons for weather reporting and search, and Helicopters, had travelled out in January. So when the Sapper plane touched down in Perth on 23rd February, the same day as *Narvik* docked at Fremantle, the whole combined task force was concentrated.

Planning and Preparation in U.K.

Before running on with the story, a brief account of the preparations leading up to this concentration of the forces must be given. (A description of the islands has already been given in Lieut.-Colonel A. P. Smith's article in *The R.E. Journal* for September, 1953.)



MONTEBELLO ISLANDS
NORTH WEST I
TRIMOUILLE I.
ALPHA I
N DELTA I
S DELTA I
SOUTH EAST I
HERMITE I

Preliminary planning by A.W.R.E. had been started early in 1955 and the various ministries had been approached for assistance. The main atomic programme ("Op. Buffalo") for 1956 had been started and an executive had been formed. The same executive was used as an authority for these extra tests that were deemed essential before "Op. Buffalo" took place. The only suitable site was in the Montebello Islands and therefore this meant a combined operation with the Navy being responsible for the logistic support. The Commander would have to be a naval officer and accordingly Commodore Martell was duly appointed at the end of June, 1955, and at the same time the Sapper and R.A.F. Commanders were selected.

The Commodore decided at once that the major planning must be carried out at A.W.R.E. Aldermaston. This was very wise as we all got to know each other well from the start. Our job was to assist the scientists in every possible way, and we had access to all the staffs and offices concerned, so that problems could be thrashed out (amicably) at once.

The original conception was of a small force of scientists and Sappers to be transported to the islands in one L.S.T. to fire one weapon. Later it was decided to fire two; *Narvik* had to have special compartments made, restricting her hold space; the original estimates of engineer stores by A.W.R.E. were too conservative; meteorological problems arose and generally things started to "snowball".

The final set up then was that, apart from the R.A.F. and Sappers already mentioned, the force consisted of the following:—

H.M.S. *Narvik*. H.Q. and control ship.
H.M.S. *Alert* (C.-in-C. Far East Despatch vessel). Accommodation for extra scientists.
Two R.A.N. ocean going minesweepers.
Two lighters (refrigerator and water).
Boom defence vessel.
Weather ship. Provided in turn by a flotilla of destroyers from Singapore.

Chatham dockyard did a marvellous job on the refitting of *Narvik* which was brought there from the Holy Loch, where she had been mothballed since the days of "Op. Hurricane". Her refit was complete in time for her trials in mid-November and she was successfully loaded at Marchwood by 6th December.

The Sapper problems were many in the early stages (and throughout) and started from the moment the joint planning staff met for the first time in early July, 1955. A complete list of all plant and equipment to be taken was necessary so that the dockyard work on *Narvik* would not be held up. This was a fast ball, as a decision on how to carry out the work had to be made without a ground recce. The Geneva Conference was on and all visits to the islands were prohibited for fear of giving the game away, although the Russians enjoyed carrying out their tests whilst the conference was sitting!

There was nothing for it but to settle down and produce an "Appreciation of the situation", gathering all the information one could from the previous operation and subsequent scientific visits. A job list, followed by a detailed works table, was produced at once and this led to a pretty comprehensive list of plant and equipment along with an increased demand for men in order to complete the programme produced for us—a modest forty days to complete everything. This sounded a long time to do a few Sapper tasks, but not so when the works table was produced. The main items to be considered were:—

(*a*) Unloading of ships and number of round trips per day that each L.C.M. could do.

(*b*) Concreting material—impossibility of operating a quarry as time was so short that we had to start concreting the tower bases within five days of our arrival in the islands.

(*c*) Weapon towers. Complicated aluminium structures. Time of erection was very difficult to assess and in the end the figure arrived at was made to fit in to the works table. This was quite irregular, but as no job is quite impossible it is foolish to go round saying it is, as on an operation like this you would lose your job and miss the fun. As it was we made it, but only just.

(*d*) Maintenance of plant so scattered around the islands. The journey from ship to the control hut on S. Hermite took 1½ hours, whilst to the two target areas twenty to thirty minutes.

(*e*) Rock excavation. Had it not been for the recce more compressors and explosives would have been taken. As it was the first tower site was on sand.

The impossibility of a site recce really was disturbing and did not give us much confidence. In the end, however, the Prime Minister relented and I was able to make a very rapid journey out to Australia. An interesting trip amongst drunken cattle ranchers down the west coast from Darwin ended at Onslow, where the R.A.N. took me on board a survey sloop for a five-day recce. Lieut.-Colonel A. P. Smith's regiment on "Op. Hurricane" had done a good job, as the hardstandings and beach exits were perfect (see Photo 2) and they also left behind a good deal of useful material. The control hut was in perfect order, howbeit the electrical circuits bore no relation to any of the three designs I had studied! After this a trip to Perth and then on to Melbourne to organize some supplies.

At the very beginning it was realized that there was no hope of quarrying material for concreting. To meet the works programme I reckoned on having to lay the foundations of the towers within a week of landing and the only way to achieve this was to have the aggregate delivered. This was done to the tune of 450 tons, which in the end left little to spare. The cost? The small freighter would only operate for a minimum of 1,000 tons at £12 per ton. The remaining cargo space was filled with generators, a remarkable Australian crane (see Photo 5), scientific equipment, and cement (100 tons) that *Narvik* could not carry.

So I returned much pleased after being away only twenty-two days. Our requirements were slashed and there was a lot more confidence in completing our tasks. Tower sites were shifted to ease our work, as well as that of the scientists. This brought us now to the end of October and the troop had only been collected a short while before my return. The stores and equipment had also just arrived. We did have a bonus though. The troop was to be raised mainly from 25 Regiment and they kindly loaned twelve men to watch and help four civilian erectors build a prototype tower at Foulness. We then felt we had about four able erectors from this gang who had learnt a few tricks of the trade. This particular tower took several months to complete; there was a hold up in production of parts and many errors in manufacture that gave little hope that two more towers would be ready by the end of November. They were, but only just, and when delivered on to the quay at Marchwood most of the bindings had broken, giving the appearance of a stack of matches emptied out of a box. No loading list or even a list of parts. A good deal of blasphemy and long distance calls to the firm in the North of England resulted in lists being produced (these were promised a week before after urgent pleas). We had counted the parts, but had to load them before the lists arrived, revealing apparent discrepancies which I could not allow and extras were provided.

These points are produced for the help of others who might be similarly embroiled. These firms must be watched—some can be trusted (as the one who produced the camera tower) but others cannot and must have inspections seeing to the minutest detail.

Now for a few points on plant and equipment taken. The great advantage of working for an organization like A.W.R.E. is the power of local purchase invested in the heads of various departments—so unusual for officers brought up under the shadow of command secretaries.

Cranes. For unloading L.C.M.s and general stores shifting, the RB.19 was selected, with grab and hook attachments. Tracks were considered essential in the soft sand, although this clogged the tracks on slewing. At a recent exhibition at Olympia new cranes (wheeled or tracked) were seen that made one's mouth water (60–80 ft. jibs lifting 1–6 tons) which would have made our work so easy.

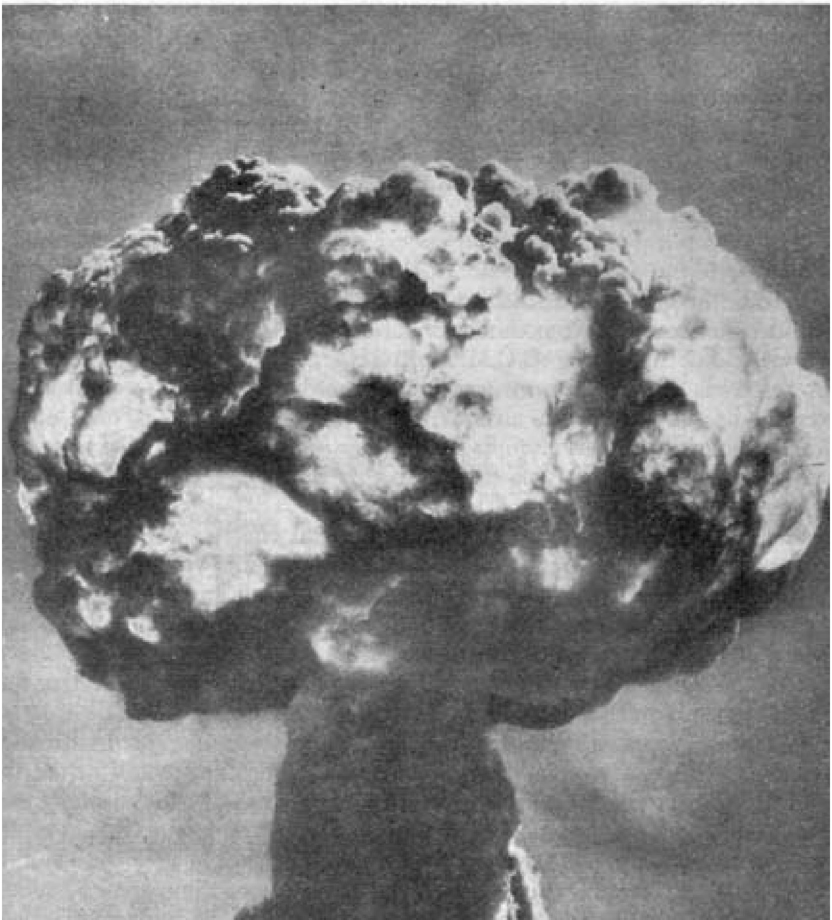
The Australian crane mounted on a Federal chassis was a dangerous looking weapon. As its rear end with counter weight was only about six inches off the deck it was the devil to get on to or off an L.C.M. It did play its part in helping to erect the camera tower; loading three tonners and then chasing after them to unload them was amusing but effective.

Weighbatchers. These were considered essential for rapid concreting and were bought (two) from Road Machines, West Drayton.

Monorail equipment. Whilst at the above firm I was intrigued with their monorail. With this we could save space in the ship and could do all our concreting on the beach and transport the concrete in skips to the site. There were a few accidents, but the equipment stood up well to the task. A motor unit and trailer skip (i.e., two skips of 10 cu. ft.) should go up a slope of 1 : 18, but 1 : 22 is nearer the mark. Very quick to erect and no drivers needed. These machines replaced four dumpers, which on looking back would never have found a parking place in the hold of *Narvik* anyway.

Concrete mixers. Goodwin Bensby 10/7. Excellent machines for operating when *in situ*. Rubber tyred wheels were specified. But these machines only had two wheels, which for this type of operation were hopeless. On flat ground they are almost impossible to manhandle as it takes six men to lift the tow bar. In and out of L.C.M.s was also a ghastly performance as the towing assembly fouled the ramps. If a crane is always available to lift them in and out and a dozer or tractor can position them, all well and good. But with stock piles and cement drums restricting manœuvre final adjustments have to be done by hand. Anyway, my recommendation is to go for four wheels.

Before going on to tell a few anecdotes about work on the islands there are one or two pointers on loading a ship.



Operation Mosaic 1

Photo 2.—View from top of first weapon tower showing pier and P.S.P. hardstanding left by the 1952 expedition.

Photo 3.—Completed weapon tower.

Operation Mosaic 2 , 3

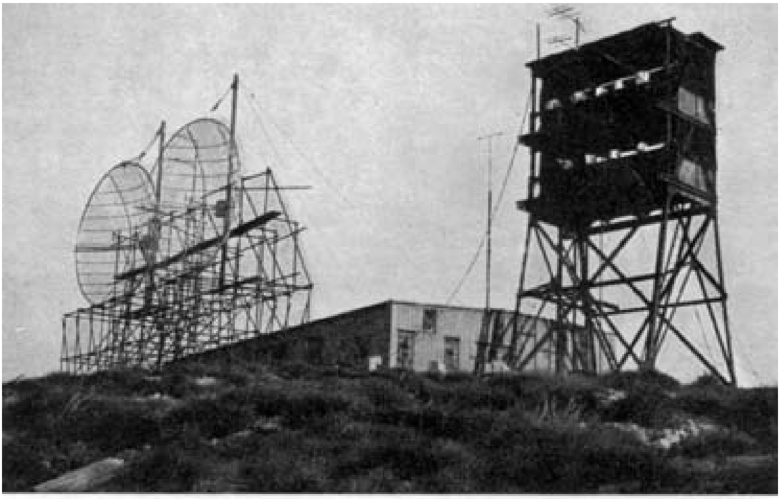


Photo 4.—Control hut H1 camera tower paraboloids.

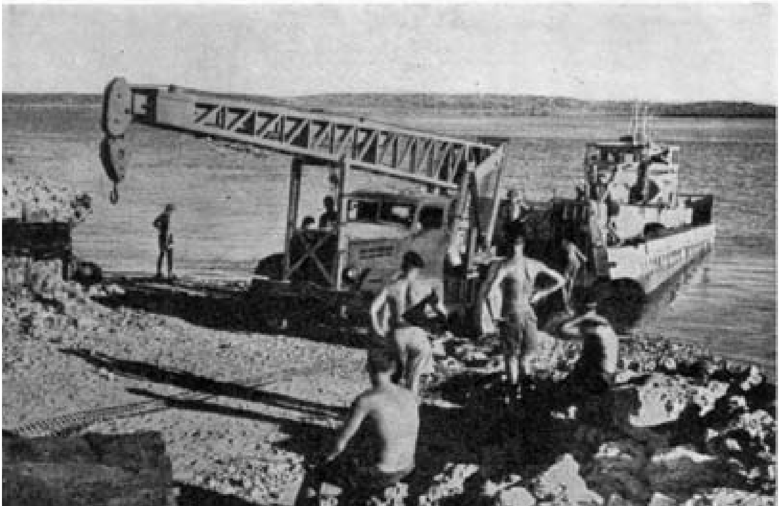


Photo 5.—Australian crane mounted on a Federal chassis

Operation Mosaic 4 , 5

The idea was to load at Marchwood using our troop and *Narvik*'s complement under supervision of the Dock Superintendent (Major Durante). After a day's work Major Durante tactfully suggested that the Navy should stand aside and the stevedores of the Port Trg. Regt. should do it all. This was the only way—they are the experts and should be employed from the start.

The next point concerns packaging of equipment. A.W.R.E. were asked to produce their crates in sizes and weights that could be manhandled. In any case, the heavier pieces should not exceed 1 ton, i.e. the capacity of an RB.19 at full reach. I doubt whether a single item of scientific equipment was capable of being manhandled in the end.

WORK ON THE ISLANDS

A cyclone raging down the west coast of Australia prevented us from sailing from Fremantle for five days. The programme was not altered—we just had to make up those days. A little hard and we were well behind by the time the main scientific party arrived.

The tasks that were set us were as follows:—

Unloading plant, stores and material from ships to sites on shore of approx. 1,000 tons.

Erect two aluminium weapon towers on concrete bases (see Photo 3).

Erect one steel camera tower (see Photo 4).

Weld and position 8 ft. steel cube below ground level.

Erect seven special prevented huts.

Survey and position numerous blast measurement and radiation stakes.

Erect tented camp.

Erect tubular scaffold tower to carry two 18 ft. dia. paraboloids (see Photo 4).

Install and maintain fifteen generators.

Health centre.

Access roads.

We started off on our tasks almost before *Narvik* dropped anchor in Parting Pool outside the lagoon. Two cutters were launched, one for the navigator to check on the leading marks and buoys and the other for a small recce party of sappers. In this party was one scientist who was to decide on the danger of residual radio-activity in the north of Trimouille Island, where we were to erect the first tower. On his decision depended the need for erecting a proper health centre, showers and the like. This, needless to say, we were anxious to avoid as we had enough to do. In the end we erected a marquee and a 180 lb. tent to act as changing rooms and store for our dirty clothes. We washed in the sea before returning to ship. Far the best and simplest idea.

With regard to our major tasks it would be best to deal with each in turn, bringing out points of interest and advice for others tackling similar problems to avoid the same mistakes.

Unloading. *Narvik* arrived on a Thursday night, S.S. *Comara*, the freighter with our aggregate, cement and generators, etc., was due on the following Monday. It was our intention to spread the unloading of the ships over a period to phase in with the construction work ashore. This was not to be as *Comara* was charging £450 per day demurrage and it was considered desirable to clear everything out of *Narvik.* Plant and stores from *Narvik* presented little difficulty. The weather was perfect and L.C.M.s were able to use the bow doors throughout the period. The unloading from the after part of the hold was done by means of a Union purchase rig. *Narvik* had two derricks, 30 ton and 9 ton. Both very slow at slewing, as guys had to be manhandled by scores of sailors. Therefore, one derrick plumbed the hold whilst the other plumbed the L.C.M. alongside and lifting tackles were connected.

Comara also unloaded quickly when her crew decided to work (i.e. they started two hours after us, but were content to work to midnight, which did not suit us, all for £45 a week).

The aggregate was loaded into L.C.M. by grab and unloaded on the beach by RB.19, also using a grab. This was slow work but quickened up as the operator trained himself.

The only really difficult load was the water distiller. Two of these were unloaded on the ramp at Hermite made by 180 Regiment. The crated distiller weighed 4½ tons which was the maximum that the RB. could lift at 10 ft. radius. Our first attempts were not very successful, even with an extra counterweight on the crane. The crane had to sit on the L.C.M.'s ramp and as the load was raised so the L.C.M. floated, the ramp went down at the hinges and the crane tipped forward. The answer was easy—to let the L.C.M. dry out. As the bottom was firm there was no difficulty in launching the L.C.M. afterwards by giving it a push with a dozer. The distiller was then put on to a steel sledge made by our predecessors and towed to its position in the camp, 1½ miles away.

Weapon towers (see Photo 3). These were our main worry as we had only two Sappers who claimed to be steel erectors. Of these, one was good as such and the other made a very indifferent "tea" man. However, the few who worked on the prototype at Foulness picked up a lot of valuable tips and showed plenty of guts. By the end we had half a dozen expert erectors who could tackle most jobs.

The first lift was 30 ft., and the four main legs were put in with the 19 RB. The next lift was 45 ft., which was tricky but overcome by adding a 25 ft. spar on to the crane's jib. After that the lifts were 20 ft. which meant a 25 ft. spar aloft as a derrick. The two tower parties used different methods for putting in the last four legs, which weighed about two hundredweights each. The more successful method was to mount the derrick centrally on planks, spanning a 12 ft. gap, and luffing over to each corner in turn.

The high winds experienced in April made work aloft rather dangerous but we did not lose many days through this. The 15 cwt. hoist beam was a devil to place. Had the designer reduced its length by 12 in. we could have fixed it in about twenty minutes; as it was several hours were spent wrestling with it. We used a combination of a powered erection winch and a Tirfor Pulllift Jack. The former made by A.C.E. was a menace as it worked on the principle that the hoist drum was shifted, by lever, from the brake linings to a friction drive. The distance moved was not great, but if you jammed a load on the petrol engine might stall, and if you hesitated the hoist unwound in the neutral position. Therefore, when you stopped a hoist, on restarting a loss of 18 in. occurred—an unpleasant business when lowering a leg into position. The Tirfor, on the other hand, was excellent, neat and easy to work, taking a load of 1 ton.

There were a lot of inaccuracies in the manufacture of the tower parts, necessitating a great deal of drilling and hacksaw work, which was a nuisance, especially up aloft.

Camera tower (see Photo 4). There was not much difficulty here. The design was better and the federal crane was able to lift all the legs into position. We were very short of labour and the erection team consisted of Captain Mitchell, a plumber and one Sapper. It was completed in ten days, which all told was excellent.

Steel cube. Here again this was not a difficult task. It was sited in a sandy place and a dozer did most of the excavation. The crane was necessary for lifting each side and also positioning the cube (less lid) in the hole. The load being about four tons meant a bit of juggling with the crane, which did not like slewing in the sand. The instruments were lowered into place and then the lid was bolted and welded. The tunnel into the door at the back was not made strong enough and collapsed under the blast pressure. For operating the instruments we had a Coventry Climax 6 K.V.A. set on a trailer, which was placed to one side behind a small sandbag wall. Although less than a mile from the explosion it suffered no damage and was still running several hours afterwards when the recce team arrived. As far as the works programme was concerned, the estimate for man days for this job was hopelessly out, but as only about five men were concerned it did not matter.

Blast measurement and radiation stakes. The B.M. Group assisted us enormously and did all their own survey and fixing of stakes. A couple of Sappers and a Landrover were allotted to them and I was absolved from any further worry.

There were fifty stakes for film to be surveyed in and up to 10,000 feet from the target, which was rather a trial. We had no surveyors with us and I had decided to do it myself. After fixing half the stakes I instructed the two infantry officers, attached to the A.W.R.E. Radiological Group, in the rudiments of chain survey and asked them to complete the job, saving me a great deal of time. I considered the accuracy they would achieve was well within the limitations required. We could not tie in the end of the line and adjust the survey but checks were made up to 36th peg. The results of the Radiological Group were very satisfactory and agreed with other groups, so all was well.

Paraboloid aerials (see Photo 4). The 18-in. dia. aerials erected at the control hut on Hermite were rather awkward items to fix. They were not very prettily erected but they worked adequately. Originally the requirement was for them to be mounted on a 45 ft. tower which would have taken many manhours that could not be spared. This was argued out at Aldermaston and finally the electronics team agreed to have them at a modest 12 ft. up. The scientist obviously wants the best conditions for his work and he will not easily submit to a minimum requirement, as we always have to in the Army.

Access roads. Thanks to our predecessors in the islands, our work on roads and tracks was greatly reduced. However, a track had to be cut alongside the line of the various gauges on Trimouille. This was all in sand, easily accomplished by a dozer, but it had to be surfaced with P.S.P. and P.B.s over a good deal of the length. This work was carried out entirely by a P.O. and ten ratings from *Narvik*, a very valuable bit of assistance.

For the second weapon on Alpha Island the fixing of the stakes was a little more complicated. To cover the required distances the line chosen was on the northern promontory of Hermite Island. The stakes were placed at roughly the right distances apart, measured by tape and then the exact positions were surveyed in from a base line on Alpha. All that was required was the exact distance of each stake from the weapon and we were not concerned with direction—it was not possible anyway to place them in a straight line.

Work on Hermite Island, the most distant site from the ship, went along almost as planned. The main items were the camera and paraboloid towers, rewiring of the control hut, erection of tented camp and several instrument stations. After these were completed and handed over, the Sapper party were never idle, there were sports fields, bathing pools, rearranging of scientific stations, apart from the general maintenance of the camp. It was quite a comfortable place with a well organized cookhouse. Two months was considered too long to feed off stews and fried foods cooked on a hydro-burner. A magnificent electric oven was accordingly bought in Perth and flown to the islands where it was connected to a Morrison generator which had to supply it with 6 kW. As there were three large refrigerators in the camp this poor old generator had to keep going night and day. It was finally replaced by two Coventry Climaxes, one being allotted to the oven alone, but this gave up the unequal struggle. The cookhouse was the one which was used in the 1952 expedition, but the trombone type oven was removed and reverently buried.

So much for the construction tasks. Now a word or two about the maintenance of plant. Our total force was small so, although we had many pieces of plant, I felt we could not expect to be given a large maintenance staff. The team we had consisted of a R.E.M.E. Staff Sergeant, one vehicle mechanic and one M.T. fitter. To this drifted a corporal who had spent a lot of time on plant and the M.T. N.C.O. I had hoped that the plant being reconditioned, if not new, would be in a good state to last out a couple of months without heavy repairs. Within a very few days "nonsenses" were occurring and the "black gang" were working night and day; spares were flown up from Perth. What Staff Sergeant Amphlett achieved with his two fitters was almost a miracle. Dozers were stripped down, selectors in gear boxes were welded, new bearings on drive plates manufactured and replaced in 24 hours.

The Meadows generators were good, but they were new; the Coventry Climax generators, on the other hand, were old and caused worry at critical stages, both mechanically and electrically. With plant so scattered about, the maintenance gang should have been larger. We succeeded in our tasks mainly because the fitters were capable of working flat out for three days and nights without sleep at the critical times: they certainly won the admiration of both the Navy and the scientific party.

Firing of weapons. The weather and especially the direction of winds at all levels are the vital factors influencing the time of firing of any nuclear weapons.

Due to the enormous publicity given to radioactive fall out these days, the Australian Government had to lay down stringent conditions for the firing of these weapons. There was considerable opposition in Australia to these experiments, not only from the dockers and seamen of the West Coast, but other sections of the public for one reason or another (lack of knowledge of the subject causing fear, or else the pleasure of causing political trouble and embarrassment). Accordingly, a Safety Committee of Eminent Scientists and Meteorologists was appointed to the squadron shortly before the tests, to see fair play. Skilful forecasting by our Naval meteorologist and the goodwill of the Safety Committee allowed us to fire the first weapon on the first day we were ready.

As soon as the weapon was ready a period of standby was declared and was followed by calling the next day (on weather forecast) D-1. This started the aircraft patrols to scour the area for stray shipping, fishing boats, etc. It had to be a daylight search, thus causing us to have a D-1 day instead of going straight from standby to D day. This actually was done for the second weapon when it was agreed the aircraft could search by night with radar.

The upper winds normally blew at great force (100 m.p.h. in a westerly direction directly over the mainland for about twenty-eight days per month). As it turned out from 7th April, when the main scientific party arrived, until the end of June there were only two days good enough for firing and we were lucky to make use of both.

The staff work organizing the firing of these weapons was excellent and everything went off smoothly producing two very nice explosions for the layman to admire at a safe distance. It was a pity they had to be fired by day as they would have been even more awe-inspiring by night.

After the explosions recce parties suitably clothed went ashore and collected the various instruments, took necessary samples and measured the residual radioactivity. The packing up at the end was achieved incredibly quickly. Within a week of the final explosion the islands were once more deserted, with few reminders of our visit. All that seemed to indicate that sappers had been there was a stripped down camera tower; of our major works there was not a sign—just so much radioactive dust in the stratosphere.

Narvik sailed home once more after another job well done, but for which she was not originally designed. For the return journey, as there was more room, the sapper element was increased to one officer and thirty-five who during the journey became quite adequate seamen. They had plenty of time to learn as the Suez crisis arose when they were approaching Aden and had to be diverted round the Cape.

So ended yet another operation in which Sappers have played a key part. For all those taking part it was a most interesting and valuable experience, so different from anything one hopes to get in the normal programme of training and exercise. Of the many lessons learnt perhaps the most interesting was the way such close and pleasant harmony was achieved between all ranks of all services and the scientific staff of A.W.R.E. It was very hard work in a hot climate with cramped living quarters, but the sappers once again rose to the occasion and impressed everyone with their energy, endurance and good cheer under exacting conditions.

The Waging of Modern War

By BRIGADIER M. C. A. HENNIKER, C.B.E., D.S.O., M.C.

IN the days of the Hohenzollerns war was a well defined affair, beginning with a formal declaration accompanied by mobilization of both sides. Thereafter a series of operations led to a victory by one side and a treaty of peace. War had a beginning, a middle and an end. The guns of the German Emperor's artillery had engraved upon their barrels "The Last Argument of a King"; and Clausewitz wrote that war was diplomacy carried on by other means. The era for that cut and dried conception has passed. It faded as the "twilight war" of 1939–40 turned into the Dunkirk blitzkrieg; and it vanished completely at Pearl Harbour, where a surprise attack upon the fleet of the United States was made under cover of conciliatory talks by the diplomats.

We have reverted to the conditions of a fiercer past. In days of old the statesman was a warrior and the warrior was a king. He never ceased to defend and enlarge his kingdom by every possible means: by guile, by industry, by blandishments, by artifice or by force. He was perpetually engaged in a struggle for existence. He knew no other condition. If once he failed against his neighbours he went under their yoke.

It is therefore misleading to think of four tidy compartments labelled Peace, Cold War, Limited War and Global War. They are all part of one thing, the Struggle for Existence. Peace, it has been said, is indivisible. War is indivisible too, and both are identical. Nations must struggle perpetually for existence either alone or in company with allies.

Nations conduct this struggle through the medium of their governments, whether totalitarian or democratic. The totalitarian dictators may be quicker to seize their chances and prosper accordingly; but the years of struggle weaken them; they grow older and they lose their grip. It is then that democratic governments may be able to redress the balance. It is, however, useful to study the dictators, to see how they conduct affairs to their own benefit.

First, a dictator controls all the means for prosecuting the struggle. He integrates the means through the medium of his own will. This is the first requirement: to integrate the means; so that every influence at the disposal of the State may be exerted to prosecute the struggle. The dictator, is in fact, the warrior-statesman-king.

In previous wars, we in Great Britain, have emulated the dictatorships at the centre by integrating our resources under a Prime Minister and a War Cabinet; but when the fighting has ceased we have relaxed the grip. We have done this lest continued governmental control might interfere with the liberty of the individual. The result is evident. Because of the cumbersome systems adopted in peace-time the government is liable to find itself a pace behind its rivals; and in trying to correct this, Ministers of the Crown are subjected to a strain which is a byeword in parliamentary circles; and under which the most robust of mortals is bound to wilt.

The governmental machine ought to be perpetually geared to the struggle. It is no longer acceptable to have one government machine for peace and another for adoption when fighting breaks out. Today there is no dividing line between peace and war. A war machine cannot be dispensed with, because there happens to be no shooting. The weapons of war may be different when there is no shooting, but unless they are speedily and effectively controlled they will only exert a part, not a whole, of their power.

In this connexion the means of conducting psychological warfare appear to be too nebulous. They must be more positively co-ordinated, and it would seem that that co-ordination should be done in the Ministry of Defence. The interplay of blandishment, guile and force can be more delicately adjusted under the aegis of one ministry than several.

There need be no fear in Great Britain of losing our liberty; for the government can be swiftly removed by the electorate if it fails to satisfy the people. Whatever the government of the day does, some members of the electorate will see no good in it; but if the government of the day fails in its main responsibility to manage the affairs of the Nation there will be far more widespread discontent.

Thus the organization at the centre needs some modification; and the type of organization required is plain for all to see, who have studied the workings of the British governmental machine throughout the two world wars. By the end of each Great Britain had a governmental machine that was second to none. While other countries have since profited by the lessons learnt, we have, ourselves, put many of them aside.

It is, however, overseas that the existing machinery is most inadequately attuned to present-day conditions. Since the dawn of history great kings who ruled domains beyond the seas have appointed viceroys, and we, in our day, have done this too. A viceroy, surrounded by his advisers, has all the advantages and few of the handicaps of a dictator. Every influence of government can be co-ordinated and integrated under the hand of one man, exactly as in a dictatorship. But there is this difference: a viceroy can be dismissed if he governs inefficiently, unsuccessfully or badly, whereas a dictator cannot.

Today, dominions beyond the seas are rapidly turning into nations; some great, some small but nonetheless nations. Yet Great Britain still has great responsibilities and interests beyond the seas. So much so that we have Commanders-in-Chief of every service scattered over the globe. But their influences are not co-ordinated locally; and they are not co-ordinated with policy and psychological warfare except through London. There is no one with an over-riding status nearer the scene than London. The term viceroy is no longer appropriate, but the responsibility for co-ordination remains. Today, co-ordination is attempted in London; but even with modern means of communication London is too far away. It would not be too far away if co-ordination on the other side had to be done in Moscow or Peking; for they too are far away. Unfortunately for us co-ordination on the other side is done locally; perhaps by a dictator in Cairo or perhaps by a Communist Secretary General in a Far Eastern jungle, or perhaps by some dissident sheik in a forgotten desert. The resources that these local puppets wield are insignificant compared with those of Great Britain, but they can be wielded more speedily and therefore more efficiently locally.

The *führerprinzip*, or the "leader principle", was adopted by the Nazis and is much despised because it failed before the might of democracy. What is overlooked is that the democracies themselves adopted it for the struggle and it worked extremely well. The idea of the Supreme Commander or the Minister of State is that of the *führerprinzip*, the idea of the viceroy. The deputed local *führers*, or leaders, of Nazidom were often bad men appointed by a dictator who was a criminal lunatic. The democratic leaders, on the other hand, were themselves only in power by the good will of their peoples; so *ipso facto* quite a different spirit of leadership would perculate down the channels from centre to periphery. There is no need to fear or despise the *führerprinzip*. The proper course is to adopt and apply it sensibly to the British way of life. Great Britain has already done so on many occasions. Malaya in 1952 comes to mind. In that year a High Commissioner was sent to Malaya to control all the forces available against the Communist Terrorists in the jungle. The civil power, the military forces, the police, the machinery of psychological warfare, and the trade and commerce of the country; everything was entrusted to one man with his advisers. The effect was electrical; and if he had not been successful the High Commissioner could have been removed.

Yet today we may search in the Middle East, for example, for a single hand controlling all our resources there and we cannot find one. Even in the military field there is no Supreme Commander. Who controls our propaganda, our psychological warfare or other resources there? No one nearer than London.

In the Far East the machinery is more nearly in existence. We have a Commissioner General for South-East Asia. Within his domains he could control all—though it is a matter of opinion whether he does so. It is for consideration whether his field is wide enough or his terms of reference sufficiently precise; but the right principle has been adopted.

Great Britain should follow this principle elsewhere. There should be High Commissioners or Ministers of State appointed for every theatre of importance. They should be charged with the co-ordination of all our resources within their orbit.

It is important at the same time to control "parallelism". Perhaps this term needs some explanation. Let us picture a High Commissioner in (say) South East Asia surrounded by his advisers—political and military—and confronted by a problem. Supposing he decides on a course of action involving (say) the movement of a military force from one place to another. Suppose that the military commander (as opposed to the Naval or R.A.F. commander) does not approve of this move. Suppose the soldier is overruled by the High Commissioner supported by his advisers. To what extent has the soldier the right of appeal to the military commander on the level above him: to the C.I.G.S. for example? Parallelism postulates the right of appeal up a parallel channel to the level above. It must clearly be controlled, or every decision which is unpopular can be almost infinitely delayed. Unchecked parallelism enables a subordinate to force almost any decision, however trivial, up to a higher level. This tends to undermine local authority, to cramp local initiative, and to slow down decision and action. Unchecked parallelism brings about staff expansion at every level and results in "empire building", obstruction and bureaucracy. Parallelism ought not to be forbidden, but it must be carefully controlled. It requires more study than space here affords.

We thus see that to wage the perpetual struggle Great Britain requires some, but not much, modification to her government machine in Whitehall. A new conception, however, is required to watch her interests overseas. The conception is embodied in the appointment of High Commissioners or Ministers of State for overseas theatres. How should these High Commissioners overseas be appointed? They need not necessarily be politicians though they often would be. They should, in short, be men of vision and ability. They should be men of the calibre we sent of old as Viceroys of India, recruited from many walks of life. It is for consideration whether they should have Cabinet rank and be Ministers of State, for whom there are precedents. They would have to have wide powers and their task in its broadest terms would be "To further the interests of Her Majesty's Government within the area specified and to co-ordinate the activities of all forces to that end."

While Britain retains sovereignty over overseas bases these High Commissioners, Ministers of State, Proconsuls—call them what you will—could be located there. Singapore, Bermuda, Cyprus and Mombassa spring to mind at once. It is also for consideration whether they might on occasions be located in H.M. ships at sea in a force that would be a task force in the widest sense of the term.

The need for some such organization as this was forcibly demonstrated during the Suez crisis in 1956. A supreme commander had to be hurriedly appointed and a staff improvised. He had little or no control over one of the most decisive weapons—broadcasting—which should in any case have been established long before the need for military action arose. And the Supreme Commander's communications between him and various forces under his control had to be improvised for the occasion too. A similar shortcoming in our arrangements was exposed in Oman in 1957. For a long time after the first signs of trouble nothing was done. Partly, this stemmed from the fact that no one on the spot had either the responsibility or the authority to do anything. Commanders-in-Chief were to be seen ignominiously flying to London for consultations. Had there been in existence the type of proconsul envisaged he would have been continuously in touch with the situation; he would have been directing the information services throughout and would, with his military staff, have initiated military action at the appropriate time and on his own authority. Properly managed it would not have got such publicity, though this is not to decry the skill shown when action actually began.

It is often misleading to argue from the particular to the general, though sometimes it is helpful to quote a specific example, even though on a small scale, to illustrate a broad principle. The example is the organization recommended for adoption to combat terrorism in a colonial theatre. In each administrative province there is an Emergency Committee presided over by the senior civil servant in the province; and this committee prosecutes the operations in every aspect—political, psychological and military in its widest sense. The committee is permanently in being and frequently meets. The local situation is kept under constant review and appropriate action can be initiated as soon as required. The system could hardly be bettered, though the adequacy of some of the committees is influenced by many factors. Of these the two most important are the calibre of the senior civil servant presiding over the committee, and the degree to which parallelism is controlled. In a colonial territory the choice of civil servants is not unlimited, and some are better than others. Nor has parallelism always been regulated by decree; it depends on personalities. But in the wider sphere envisaged for the prosecution of the struggle on behalf of Britain throughout the world there should be no such shortcomings. The nation can produce men of the calibre required and their authority can be regulated by decree.

The dangers of "war by committee" can be much exaggerated. If you permit unlimited parallelism you get unlimited war by committee with all its faults. But if parallelism is controlled and the High Commissioner or Minister of State is given real authority no such dangers are to be apprehended. After all a High Commissioner presiding over a committee of service chiefs and political heads does not, providing he has authority, differ materially from a service commander surrounded by his staff. The staff has a dual function, to advise the commander and to execute his plans whether he has taken the advice or not. The responsibility must rest with the commander, or in this case the High Commissioner.

The question arises: how far down the scale must the principle be taken? There is co-ordination at the centre in Whitehall, and we see the need for High Commissioners appointed for various spheres of influence throughout the world. They would control all the forces within their special spheres, but they too may in some places be too remote. The thought is that there might be lower levels of co-ordination; a Commissioner level, for instance; and perhaps even below that too.

Many factors would influence the decision which must be made on the merits of the case. One factor is distance. A High Commissioner dealing with the Middle East might find himself rather remote from the Persian Gulf. While the High Commissioner was advised by Commanders-in-Chief, a Commissioner more nearly on the spot, might be advised by subordinate admirals and generals. Ultimately a Deputy Commissioner might be envisaged or even a political officer working with or under a column commander. At the lowest levels the political officer might more appropriately work as adviser to the military man; though each case would have to be judged on its merits.

Language is another factor that has a bearing on the problem. The information service (or propaganda as ruder people call it) is the dominant "arm" for 90 per cent of the time. It must, for technical reasons, be based on static installations, and it must, for reasons of language, be subdivided to suit local circumstances.

The information service network might, therefore, be the appropriate frame on which to build the whole edifice. Every level of the information service would require the appropriate political control; and having set up political control it might be appropriate to allot armed forces too. The commander of each service would be on the advisory cabinet for the political chief. And the political chief would be a man of ability chosen from any walk of life.

It must, of course, be remembered that the system proposed does not involve more armed forces than exist today. It is a system for controlling and co-ordinating those we have. The allotment of funds and forces to each sphere and level would be the business of the centre, acting on the needs of the day. Some spheres of action might be in a state bordering on suspended animation, others would be intensely busy. It is the framework that is lacking.

How does all this fit into the three great treaty organizations, the reader may well ask; into U.N.O., N.A.T.O. and S.E.A.T.O.? Let us deal with U.N.O. first, as it is the most straightforward. The link between Great Britain and U.N.O. is through the central Government. The High Commissioners, proposed under this dispensation, are at the periphery, and are responsible to the central Government. There will, therefore, be no direct contact between them and U.N.O. So long as the central Government is supporting U.N.O. it will direct its High Commissioners to pursue a course calculated to do so too. Circumstances can, however, be envisaged when the line a High Commissioner at the periphery would like to take might bring the central Government into conflict with U.N.O. The question then becomes a matter of confidence between the High Commissioner and the Government that appoints him. The Government must either over-rule the High Commissioner or support him and take the consequences with U.N.O. No new principle is involved.

It is perhaps worth recording here that a wise High Commissioner—and by hypothesis he will be wise—will foresee a clash approaching before it becomes critical. He will have warned the central Government in Whitehall of what he believes to be impending and the steps he proposes to take to meet the situation. He may perhaps have asked for additional resources. Both central Government and High Commissioner will be thinking on the same lines. Occasions should seldom arise when some event bursts like a bolt from the blue with literally no warning at all. More usually a general course of action will have been agreed upon and the High Commissioner will be acting as the local instrument of the central Government—and a far more efficient instrument than anything existing today.

In the context of S.E.A.T.O. the Commissioner General for South-East Asia already occupies a position very similar to that envisaged in this paper. He is in direct touch with the central Government, and he represents all the local resources at the disposal of Great Britain within the S.E.A.T.O. area.

It is in N.A.T.O. that difficulty is to be apprehended; not so much in the Central European Sector as on the fringes, where N.A.T.O.'s interests tend to merge or conflict with outside interests. Thought might be given to the Mediterranean Area. It is here that conflict of loyalties is likely. In its simplest terms the problem may be this: Are British fighting men to take part in a N.A.T.O. exercise or squash a local sheikh in the Aden Protectorates? A problem such as this divides itself into three elements. First there is the principle, whether to attend to N.A.T.O. or the sheikh. This must be resolved by the central Government, though the local advice of the High Commissioner would be valuable. Secondly, having decided to squash the sheikh a mass of detail must be settled regarding ways and means. This is best done locally by the High Commissioner assisted by his Service and other advisers. (At present it must mostly be done in London.) Thirdly, the central Government must be kept informed of what is happening. A High Commissioner would have the machinery for doing this.

It seems that the conception put forward in this paper does not necessarily conflict with Great Britain's commitments to U.N.O., N.A.T.O. and S.E.A.T.O. And if the High Commissioners are looked upon as local instruments of the central Government, it may be that other commitments, which at first sight seem to conflict with the conception, may succumb to similar analysis.

The interaction between High Commissioners and the Diplomatic Service needs careful thought. It is clearly undesirable to have ambassadors controlling information services, though their contribution towards their efficient control could be considerable. Some link would be needed, but in the nature of a liaison link.

The conclusion may be summarized thus. There is no longer a cut and dried dividing line between peace and war. The Nation is perpetually struggling against one adversary or another. A world-wide organization is therefore required to enable Great Britain to wage this struggle.

Because of distance it is necessary to de-centralize this organization so that in every region there is an authority capable of wielding all the forces available. Normally armed force will not be required; but when it is, no change in organization should be necessary. In this way only will Great Britain continue to exercise at the periphery her full influence in a consistent manner making effective use of all the means available. Modern war must be waged all the time.

The Great Ditch of Canute

By COLONEL R. B. ORAM, O.B.E.

THE discovery recently in the heart of the City of London, of the Temple of Mithras, has shown the power of the spade, supplementing Hitler's blitz, to uncover one of the unknown incidents of the remote past. There is one geographical feature, familiar though it certainly was to many generations of Londoners, which the engulfing sea of industry and suburban building, has submerged beyond the power of the spade to rediscover.

Few areas suffered more from Hitler's attentions than Rotherhithe and Southwark. In spite of the reconstruction, since the war, of these two boroughs, no additional evidence of the Great Ditch of Canute has come to light.

In the troublesome times before the Conquest, Ethelred had shamefully "pawned" his kingdom to the Dane, Canute. On the death of the English king, his son, Edmund Ironside, was recognized as the rightful monarch, not only by the few magnates that remained faithful, but what was more important to the new king, the stout citizens of London.

Wessex, Northumbria and the Mercian shires were subject to Canute. Edmund had only the City of London in which to make a stand for his rights.

But London stood on the great River Thames, at all times a formidable obstacle. All the great roads from the South Coast and the Straits of Dover converged on the metropolis. In that age, when treason was general, the Londoners had a deserved reputation for good faith and loyalty.

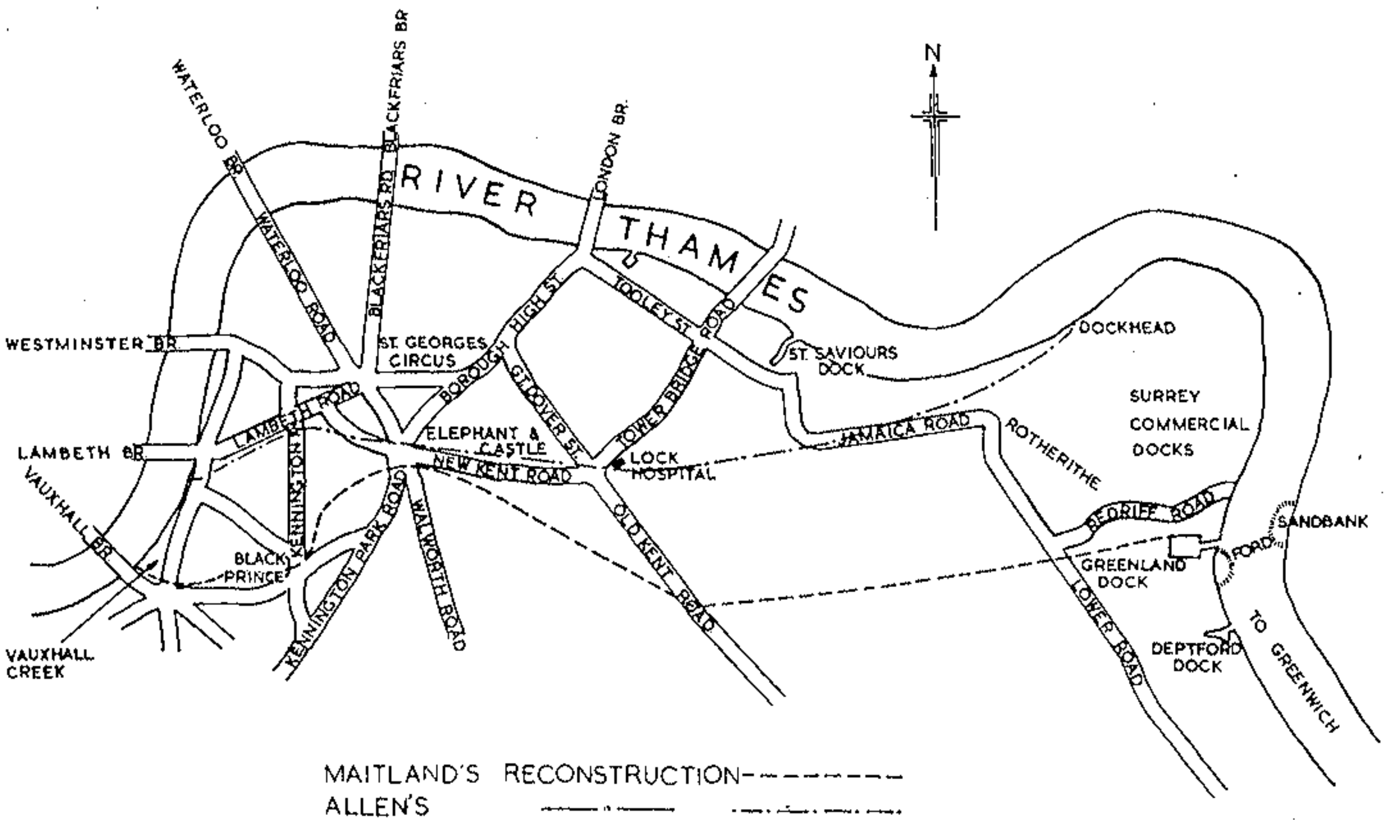
As soon as he heard the news of Edmund's defiance Canute left Southampton. In the spring of A.D. 1016 he embarked his army and sailed through the Downs to Greenwich, where he made a fortified camp and a base for his operations. From previous experience he knew the futility of besieging London whilst London Bridge remained intact. It was the citadel and also the sally point from which his vulnerable ships could be attacked and sunk with heavy stones and blazing timber. In order to outflank the bridge, he put in hand the digging of a canal which left the river at Rotherhithe, took a line across South London and entered the Thames again at Battersea. This was a distance which has been computed at about four miles. In spite of this fine piece of tactics, Canute was unable to reap the reward of his ingenuity and laborious work, for Edmund who had been collecting loyal forces in Wessex, returned to London, drove through Canute's lines and forced the Danes back to their ships. Canute, however, held the command of the seas and maintained the advantage. The partition of the realm followed soon after and Edmund died in November of that strenuous year.

The text books give a bare mention to the canal which Canute dug, but there is general agreement that it was a military work of some importance, of which traces have from time to time been found. Both Maitland in the seventeenth and Allan in the eighteenth centuries give it so much credit that the latter has produced his own suggested route across the southern suburbs of London and at the same time reproduces Maitland's version. Before listing the supporting evidence of this very considerable work the reference in the Anglo-Saxon Chronicle may be quoted. "Then came the ships to Greenwich in the Rogation days (May 7th); and within a little space they went to London and they there dug a great ditch on the south side and dragged their ships to the west side of the bridge and afterwards ditched the town without so that no one could pass either in or out."

Having settled in his fortified camp at Greenwich Canute had time to make a thorough reconnaissance of the position. Firstly, there was the walled city, and the speedy reduction of walled towns was beyond the tactical resources of the Danes who had no siege train. Secondly, there was the very considerable defence work which stood on the south side of the bridge. "Suthringa Geworche"—the Surrey folks' defence work, as it was then known—stood at this meeting place of the Roman roads. These led from Kent and Surrey and the Channel Ports to London. Communications with the Continent were maintained through the Channel ports and the junction or apex of these roads at the south end of the ford across the Thames which had preceded the building of the wooden bridge had always been a strongly defended point guarding the conventional approach to the City. Thirdly, there was the River Thames itself which could be regarded as neutral. If Canute could tame it the City with its outworks could be enfiladed. If the invader failed to control its immense power, the flood waters could wreck his fleet and leave his army immobilized in a hostile country. There was also the problem of provisioning his army during the campaign, but as the Danes were adept at living off the country this can be excluded as a difficulty peculiar to this campaign.

With what kind of bridge was Canute faced? We know that a bridge across the Thames existed at this point because it is mentioned in A.D. 993 when Anlaf Tryggvason sailed up the river. William of Malmesbury mentions

ALTERNATIVE ROUTES TAKEN BY THE GREAT DITCH OF CANUTE 1016



the bridge as existing in the following year and there is, of course, the legend that in 1014 Olaf pulled the bridge down with his horses and his fleet. The main support for this would seem to be the jingle about "London Bridge has fallen down".[1] If Olaf had pulled the bridge down in 1014, the primitive resources of the time and the unsettled condition of the country could have done little to restore the structure. The remaining ruins would not have been an obstacle sufficiently great to induce Canute to embark on so considerable a work as digging a canal 4 miles in length.

We know that this wooden bridge remained until it was burnt down and eventually supplanted by the stone bridge built by Peter Cole, who began operations in 1176. The stone bridge was finished in 1209 and it remained until the present bridge, built by Rennie, was opened in 1824. The idea might certainly have occurred to Canute that the wooden bridge could be pulled down, but without doubt he preferred the outflanking approach to the direct one of attempting to destroy the bridge. Without any knowledge of the way in which it had been built, it must have impressed him as one of the wonders of the world at that time. Like its successor it was generally held that the wooden bridge was built on piers but such was not apparently the case if an examination made prior to the destruction of the stone bridge eight centuries later can be taken as evidence.[2] Having decided that he must go round it, Canute considered what we should now call the logistics of his campaign.

At this point Canute had to decide on the kind of canal that would answer his purpose; where was it to leave the river and where to re-enter, how deep should it be and what obstacles would lie in its way? Before reconstructing Canute's train of thought or examining what Lieut.-Colonel Burne so rightly calls the "Inherent Military Probability" of the situation, there is one theory that by reason of the eminence of its author demands careful thought. Sir Walter Besant has gone to much trouble to prove that all the Danes needed to do was to dig a semi-circular trench some 300 feet in length with the raised causeway from the bridge, running south, as the radius. He demonstrates mathematically how much turning space is required for a Danish galley of a maximum length of 78 ft., a beam of 16½ ft. and a draught of 4 ft., and is quite satisfied that Canute would never have given himself the trouble involved in digging a canal 4 miles long. The writer feels that to solve a problem of the eleventh century by applying an overdose of the midnight oil of the nineteenth, is to do much less than justice to the capacity of Canute both as a soldier and as a navigator. As the former he was unlikely to attempt an operation on which success or failure of the campaign depended—his stake was the Kingdom of England—under the eyes of a vigilant enemy. As the latter he could not have been unaware of the foolishness of crowding his ships in so narrow a gut with an erratic and unpredictable tide. To transport shallow draughted vessels of that length and beam through a cutting albeit

[1] This is now held to refer to the frequent collapse of the stone bridge, completed in 1209, as the direct result of the foolish overloading of the structure by massive houses; in 1437 the Southwark Gate House and the two adjoining arches fell into the river. There had been an earlier major collapse in 1282 which was hastened by frost and snow.

[2] A surveyor (Mr. William Knight) from Rennie's Office in 1821 made a survey of one of the "starlings", or the base of one of the piers of the stone bridge, and to his surprise found nothing to support the theory that the starlings had been constructed on piles. How unlikely then that the bridge which was so resolute an obstacle to Canute and which was built mainly of wood should have been reared on piles.

mathematically capable of containing them, was not then, any more than it is now, a manoeuvre likely to commend itself to a sailor. The writer has had many years experience of ships being moved about in the confined waters of enclosed docks and on the River Thames. He has some knowledge of the vagaries of the weather and the tides, and is consequently inclined to be sceptical of the "nicely calculated less or more" which can in a few seconds turn complacency into disaster.[1]

Now it is worth while to examine the riparian conditions which spread themselves before Canute at Greenwich. From his camp on the south side of the river he looked sideways to Rotherhithe which must have seemed a convenient place to breach the river bank. Tradition holds that there was a ford in ancient times at a point where the Greenland Entrance to the Surrey Commercial Docks now stands. A plan of the area in 1813 shows a large sand bank almost opposite this point. It is also a fact that just below the present entrance there is still a gravel bank which reforms as constantly as efforts are made to dredge it away. Assuming that the ford was usable, it would have allowed Canute to tap what resources there were on the north side of the river. The general picture of the Thames was then of a wide, turgidly flowing stream free to flood much of the surrounding country during each series of spring tides. The sea walls must have been but an ineffective barrier. There was an ill defined and uncharted course leading from the Estuary to London and there were no pilots to offer their services as experts on the wandering channel. In his *History of the Port of London,* Sir Joseph Broodbank paints a word picture of the desolation of water that swept with each tide. through the Fenlands of Essex and Kent. He points out the understandable preference the Romans had for the land route to London.

The relevant stretch from Battersea to Rotherhithe has now for many years been embanked and controlled. The natural drop of the river bed between the two points is today only 2 ft. 3 in. over the 7 miles of water. In 1016 the drop was about the same. Canute therefore had no problem of differing levels to contend with; he did not have to consider building a lock. On the other hand there is of course a considerable variation of height in the water due to tides, which amounts to as much as 20 ft. between low and high water at spring tides. The tidal variation could not in fact have been so great in those days. The embanking of the river, which process naturally tends to deepen the river, was ineffectively done, if at all. With suitable weather conditions, at each series of spring tides, the area which is now South London must have been regularly flooded. Many years later the ground here was shown by the Ordnance Survey to be consistently below the level of high water.[2]

It might then be asked—why did not Canute aid the natural flooding by demolishing the retaining walls, thus providing himself with a permanent

[1]Besant also ignores the forbidding factor of the Suthringa Geworch from which could have been launched repeated and effective sallies on Canute and his workmen. Every soldier needs elbow room. A historian of the future with the aid of a slide rule might prove that the trenches in the 1914–18 war were obviously within a few feet of each other from the North Sea to Switzerland. It is well known that in the long intervals between active fighting opposing troops combine to ignore each other; lest they should inadvertently "start something", they keep well away.

[2]This was disastrously brought home to the inhabitants as recently as 1928, and again in 1953, when the flood waters of the river poured over the dock quays, "down town", into Rotherhithe and Bermondsey.

lake, on which his shallow draughted long boats could ride? To have done so would have been to invite disaster. Canute needed an alternative water way but he needed one that he could control. It is doubtful if he understood the behaviour of flood water as we do today, but as a maritime race the Danes probably had some empirical knowledge of flood conditions. He would certainly have taken no chances of stranding his fleet on the Surrey marshes. The theory that governs flood levels can be put briefly. When a breach occurs in a river wall and the tidal water is allowed to flow through, this process will continue until high tide is reached. The succeeding ebb draws some of the water away from the flooded area and this will continue until the river is level with the breach. Meanwhile imprisoned water tends to increase in area and to decrease in depth until it gains a further accretion from the next incoming tide. At the end of each tide cycle the depth of water in the flooded area will have increased, assuming that no rescue parties meanwhile arrive with clay and sandbags. Left to itself the ultimate depth of the lake will become about half the height of the river above the marshland. To illustrate this theory—in the Fenland it is recorded that in 1882 a wide and deep breach in the bank of the Ouse caused the inundation of 9 sq. miles of country. At no time did the depth of water in the inundation exceed 5 ft. although the tide on the Ouse rose 12 ft. above the Fen level. The level of the lake so formed hardly varied in the later stages by more than 6 in. although the tide alongside in the Ouse rose and fell 19 ft.

After he had dug his canal, and we may assume he did not open the ends connecting with the river until he was satisfied with the course and the ultimate depth, Canute would then have had all the water he needed by allowing the free passages of a few tides. Had there been in 1016 a tidal range at the lower entrance of 15 ft. only, in place of the present 20 ft., Canute could have relied on 7 or 8 ft. at least of water in his canal so that his ships could come and go as they pleased.[1] This seems to dispose of the question of his bringing them through on one tide. The canal was in use for some time because we know that his ships were evacuated by the same method when the pressure from Edmund was felt. We shall never, however, know where he secured the workmen for this huge work. The Danes have left very few relics of hard manual labour behind them and presumably such peasants as had not sought refuge in the City were impressed. Tidal prediction was unknown to Canute; it was a science developed only in the nineteenth century by Lord Kelvin. "High Water at London Bridge", the datum from which all predicted heights in the Estuary and as far up as Richmond are now operative could not have had the same meaning to Canute.[2]

Having served its purpose the canal ceased to have any interest to Canute or to his immediate successors. It comes once more into the history of London in the year 1176. With the need for a new bridge the practical means of building one engaged attention. What was to be done with the River Thames during the years that the construction of the bridge would take? Quite soon one can imagine that the suggestion was made to put the river back into the channel dug 160 years before by Canute. A certain amount of

[1]Except around low water, in the river. Canute would certainly have dug a few feet below the ground level.

[2]Taking into account his better known experience with the incoming tide at Southampton the Danish King does not seem to have been fortunate in his dealings with the English tides.

erosion had no doubt taken place in the period, but it would have been to no one's interest to fill it in. The digging out and the necessary widening was no problem in the settled times of Henry II. We have little knowledge of the progress of Peter Cole's work but there were eventually nineteen "starlings", or oval shaped islands, which carried the bridge piers. There was also next to the huge gate-house on the Southwark side a drawbridge for the passage of ships. In the twelfth century, methods of working in or under water were unknown. The use of extensive camp-sheeting or of diving bells came many centuries later.[1]

Conditions certainly must have been difficult and thirty-three years was not unduly long for the enterprise.[2] The sea borne traffic to London was so small in those times that diversion of that part of the river from Rotherhithe to the Upper Pool could have caused little inconvenience.

Once more the canal had served its purpose and the next reference is to the use of the lower portion at Rotherhithe. Some mercantile traffic began to come by sea to London as the centuries rolled on and conditions on the river improved. Chaucer was a clerk of the King's revenue in London port in the time of Edward III. More settled conditions would have produced a better river channel so that much of the hazard of earlier voyages would have disappeared. Nobody was more likely to take advantage of these better conditions than the Venetian traders whose well organized mercantile marine held the monopoly of the essential spice trade from the Levant. We know that they were particularly favoured and that one of the first acts of Henry IV in 1399 was to grant the Venetians a new charter. During his banishment the young Bolingbroke had visited the Holy Land. The journey could be made only under the auspices and the sponsorship of the Venetian merchant fleet, and from the port of Venice. He seemed to have kept a pleasant recollection of the work of this early "Thos. Cook & Son". The Venetians had already in 1378, been allowed by Richard II to make Southampton their place of call instead of Calais.

What is it that today a new shipping venture demands before anything else? Surely it is a safe and regular berth to which each incoming ship can immediately proceed without the hazards of waiting about in the river for a vacant berth. In searching for such a berth the end of Canute's Canal at Rotherhithe, disused since the preceding century, must have been an obvious favourite. A little scouring out of the channel for a couple of hundred yards and the building of a stone jetty as a cross wall, with a "hard" on which a vessel could lie at low tide, and there was a really modern river berth. The cargo so brought could be taken directly from the ship and loaded on pack horses at a point within two miles of London Bridge. The fall of Constantinople in 1453, however, put an end to the Venetian trade. Close to the

[1]An early diving bell was used on Brunel's tunnel under the Thames which was started in 1824.

[2]It can be assumed that the work proceeded something on these lines. Having diverted the main stream of the river it would then be necessary to take care of the land water flowing in from the Westborn, Holborn and Fleet rivers and other tributary brooks on the City side. This was probably done by making channels in the now dry river bed so as to contain each rivulet between clay embankments. Similarly, as work began on the base of each starling, the small area involved could be protected until the structure reached a level which would be above what we should now call Trinity High Water.

Tributaries normally flowing into the river from the Surrey side would pour their contents into the Great Ditch.

berth in Bermondsey, which it is conjectured was used by the Venetians, there is still "Galley Wall Lane" to mark the one time connexion with the gorgeous East.

In conclusion, a word on the rather scanty authorities whose evidence is at all circumstantial. The Anglo-Saxon Chronicle has already been quoted. Stow refers to Canute's Canal and also to the use of the ditch during the building of Peter Cole's London Bridge, but Maitland, writing a century later, mentions the evidence of a carpenter named Webster with whom he had actually spoken. In 1694 just above Greenwich, the Great Howland Wet Dock was being constructed and, according to Webster, considerable quantities of fascines, faggots and stakes were found when the entrance to the River Thames was excavated. It is on this site that the present entrance to the Greenland Dock, part of the Surrey Commercial Docks, now stands. Maitland feels that this is an irrefutable argument for the lower entrant to Canute's Canal. Alternatively, the remains may have been left from work done on widening and deepening the ditch at the time of Peter Cole. Again, it may be direct evidence of the use of this entrant by the Venetians.[1]

In Pepys' correspondence there is mention of a Dr. Wallis who writes to the diarist in 1699 and recalls a visit to Redriff (the old name for Rotherhithe) "In company with a Mr. Gataker, walked across the fields in the direction of Lambeth. He showed me in the passage diverse remains of the old channel which had heretofore been made from Redriff to Lambeth for diverting the Thames whilst London Bridge was burning all in a straight line but with intervals which had long since been filled up." As this journey was made fifty years before the time of his writing to Pepys even these had now, he opined, been filled in.

Not to be outdone, Allen, working on Maitland's lay-out of the Canal as passing near the present "Elephant & Castle", recalls that in 1824, near the New Kent Road, an extensive sewer was being laid. In the course of this work, there was discovered a number of stakes driven into the ground several feet below the surface and evidently intended at some remote time to form an embankment. In 1826 he had a piece of one of these stakes in his possession—it was very dark and black.

It is too much to hope that there will ever be revealed any further evidence of this most interesting project. If Allen's "bog oak" has any connexion with Canute, or Maitland's faggots with the Venetians it can at least be accepted as one more example of the history that can be learned from the spade.

[1]It may be mentioned that timber used on under water work does tend to last far longer than timber used in city buildings. The original entrance to the Grand Surrey Canal higher up the river in Rotherhithe was faced in 1802 with oak logs chamfered to give a smooth face to the lock side. One of these was recovered in 1954, during a sweep of the dock bottom. It was in excellent condition and easily identifiable against the particulars of the material set out in the original contract.

Civilian Labour—Its Recruitment, Organization and Control

A LECTURE GIVEN TO H.Q. EASTERN COMMAND

By LIEUT.-GENERAL SIR ERNEST WOOD, K.B.E., C.B., C.I.E., M.C.

EDITOR'S NOTE

THIS lecture was given to explain the necessary characteristics to be considered when recruiting native labour, and in connexion with the employment and working conditions for such labour. It is based mainly on experience in India and Burma during the last war, but will apply again in countries where labour is plentiful and plant is scarce.

R.E. Officers will have to plan their work and base their requirements for labour, transport and plant on what is likely to be available. The recruitment of the labour will normally be outside the scope of Sapper Officers, although there may be occasions when they have to undertake this, but to get the best work out of the labour provided they must know the characteristics of the labour and especially religious customs, food etc.

It must be stressed once again that the subject of the lecture is "Civilian Labour—Its recruitment, organization and control" and that priorities for planning the work might be different where labour was scarce but plant more plentiful.

When your Army Commander told me that the War Office considered me to be a leading expert on the subject matter of this talk I was, to say the least, considerably surprised, and I can well believe that many in this audience with Indian experience also doubt my claims to talk on the subject. Such claims as I have for talking on civilian labour derive from a short and intensive period of several weeks between the loss of Rangoon and the final evacuation from Burma in 1942 when it was my task, with the overriding powers of Government and the Commander-in-Chief, to do all that was possible to prepare for the reception and maintenance of our forces as they fell back before the Japanese onslaught. However, more of that later.

I should first like to give you my views on certain characteristics of native labour wherever you may find it. From past experience my remarks apply to such labour in India, Africa, or the West Indies. I have found that such labour has three characteristics:—

(*a*) A powerful curiosity to know more of the ruling race, which in turn is supported by the local importance they acquire from such contact. In Africa, as many of you well know, there is a female-fostered tradition that a man is not a man until he has worked in the gold mines of South Africa; that the "blanket boy" of the village must, through such experience become the wearer of shirt and trousers, and above all the proud owner of a velour hat. They are the favoured in the eyes of the village maiden.

(*b*) Secondly, these primitive peoples—and particularly between the ages of 20 and 30—usually have a burning desire to acquire something which only money can buy; and the money can only be found by working. For example, in Africa the more cattle you own, the more wives you can buy and the more labourers you possess. In India, the boy growing to manhood always wants to own his own land. Indeed, this was one of the motivating forces behind the recruitment to the Indian Army as we knew it, which required no

Recruiting Sergeants to bring in the men. The attraction was that when a Sepoy had completed his colour service he had, through deferred pay, accumulated the 400, 500, or 600 rupees which was sufficient to buy the plot of land in his village on which he had set his heart.

(c) Third and last. Many simple people have a strongly developed nomad instinct; the desire to wander abroad.

It is important, if you are planning to employ any native labour, to know to what extent these three simple characteristics govern the people you propose to recruit because your call to them to volunteer to serve must in some measure be directed towards playing on such characteristics. Just as the skilled angler knows the time and place to fish, and the tackle and bait he should use, so must anyone responsible for obtaining civilian labour have close knowledge of the characteristics of the particular people he hopes to induce to serve him.

Moving now to more solid ground, and as a background to the lessons which would appear to derive from my experience, I should like to touch very briefly on the period of some seven weeks when I had to recruit, organize and control some 70,000 native labour.

From the time of the Japanese invasion and up to the fall of Rangoon, the Public Works Departments of Burma and Assam had jointly accepted the responsibility for constructing a road from Mandalay, across the Chindwin into India. As December, January, and February of the 1941/42 winter slipped by, it had become increasingly clear that nothing adequate was being done, or was likely to be achieved. In early March, 1942, I was called upon to undertake this and other tasks, for which I was given eight weeks. My responsibilities included:—

(i) The construction of two-way M.T. roads aggregating some 700 miles in length which over nearly half their distances ran through mountains 5,000 to 6,000 ft. high.

(ii) To construct a full-scale Army Depot, to be carved out of dense jungle, and of which the petrol depot alone was to cover 25 square miles.

(iii) The construction of a dozen large aerodromes for the air support of Chiang Kai-Shek, which later became known as "flying over the hump"; the latter being the high spurs of the Himalayas.

When you realize that at the beginning of my task there was virtually nothing of labour, tools and plant at the site, and that many important road alignments in the mountains had yet to be determined, you will appreciate the heartbreaking nature of the task, particularly as all requirements had to be delivered over a single-line, metre gauge railway to the base at Dimapur. There was not even a road connecting Dimapur to India, only the railway.

I particularly wish to draw attention to the fact that any job of this nature falls broadly into three separate phases of time:—

(a) The movement of vast quantities of earth necessary for road construction, and particularly for building up of embankments on low land, or of making cuttings in mountainous country.

(b) When sufficient progress has been made with these earth-shifting tasks the next phase is to bring to the site vast tonnages of stone, first for soling a road or a runway, and next for putting on the top layer of metalling.

(c) Finally, there is a third stage of finishing off the roads, culverts, bridges, runways, buildings, etc. which is largely a matter of machinery and plant, and in particular tar and concrete mixers and sprayers, and road rollers.

I mention these three stages because to the man who is planning the operation over-all these three stages spell three different things. In countries like Assam and Burma where labour was plentiful, but plant was scarce you require vast labour forces for earth shifting, even where you have assistance from bulldozers and graders. Secondly, the accumulation of astronomical quantities of stone requires vast transport resources. Lastly, in the finishing stage, considerable quantities of plant and machinery are required.

In other words it goes in sequence—the labour force; then the transport; and finally the plant and machinery.

Now this is an over-simplification because one stage overlaps another. You will always need some transport, some plant, and some labour in all three stages; but the order of labour, transport, then plant is true in so far as it marks the peaks of demand and priority.

For my 700 miles of road, my Base Depot construction and the dozen aerodromes, I had to acquire an adequate labour force as soon as possible. After two weeks or so we had accumulated in and around railhead the following:—

Coolies from India	35,000
Local labour	12,000
Naga Tribesmen	7,000
Nepalese	1,000
Manupuri Porters	15,000
	70,000

This was apart from the drivers of locally raised transport units which consisted of:—

200	elephants
750	pack mules
1,000	pack ponies
800	pack oxen
2,400	river boats

and all the civilian lorries we could get from the Tea Gardens and the Manupuri State.

Our problem was complicated by the fact that the monsoon was upon us, and during the first seven weeks the average time when it was not raining was six to eight hours of any one week. However, we were ready at the end of seven weeks, when we were called upon, to deliver 850 tons of supplies to Kalewa on the Chindwin, being 335 miles from where we had started, and to meet the foodless Army as it arrived, near the borders of India.

So much for what is perhaps an all too brief background of the events concerning the use of 70,000 civil labourers, on which I have unfortunately no time to expand but must turn to the problems and lessons of civil labour:—

In the first place, if any of you should ever find yourselves faced with the type of job that was handed to me, I would strongly advise that you ask that the over-all problem be stated in terms of what is required to be delivered and where over a progressive period of time. I consider you are entitled to know exactly what your masters have in mind in the matter of what is to be delivered, from where to where, month by month, over the period that your construction operations will last. It is only by these means that you can settle intelligently and for yourself the thousand-and-one conflicting claims of priority that arise almost every hour, and so keep everything moving ahead in a balanced way to achieve all the objects and purposes you have to meet. If your masters cannot tell you that, you may not be able to do anything about it, but at least it will have a negative value in knowing that they themselves are not very certain of what they are asking you to do, and you can proceed to settle priorities accordingly.

My second point, deriving from the first, is that you yourself must now work out your own phased programme. I have mentioned to you the sequence of labour, transport, and plant, as three successive stages for road and aerodrome construction. Competent technical advisers must assist you to determine the sequence in which, and the days on which, you must phase in all that is required by way of food, accommodation, labour, stores, tools, plant, transport, etc. etc. In this connexion it is interesting to remember, for example, that if you are proposing to move a steamroller some 150 miles in mountainous country, you may have to allow a month for it to reach its destination. It is no use thinking of it a day or two before you require it. A phased feeding-in of everything needed for the job is terribly important, and an important part of that will be the feeding-in of your civilian labour which, as always, will be required in quantity at an early stage.

Having completed your phasing-in plan you will now turn to the problem of getting your labour. The first thing you will have to decide is whether you want women as well as men, and whether you will let children accompany the women. In many backward races it is the women who are the workers. When you reach this point I beg of you to eschew all thoughts of organized male labour corps drawn up in neat khaki-clad lines on a parade ground. With civilian labour you are now dealing with gangs and bosses. But you must consider whether you can get the men without the women, and whether the women will go without the children. In my Assam experience we had both men and women and only the babies from which mothers could not be separated. We found little difference in work output between the sexes.

The next point you must decide are the terms of service; and the first point to decide here is just for how long, for how many weeks, will you ask them to come. You must be very careful about this. You may well find you can get all the people you want for six or eight weeks' work, but you will get very few if the general idea is they will work for months and only go home when the job is finished. You have to make a promise, and needless to say you have to keep your promise, even if it means letting your original force go and recruiting replacements.

Another important matter to settle is the number of days to be worked in the week, and the number of days' holiday they will expect by tribal or other custom. In my experience civil labour will work six days in a week, but will require one day's rest. This has nothing to do with religious or any other scruples, but merely that they must have opportunities sometime to wash their clothes, trim their hair, and attend to all related things. Then there follows the terms of service. Your conditions would almost certainly include free food, free accommodation, and free medical attention. The only discipline you need is that any person who proves a slacker or is a nuisance will be sent away before the end of his or her time. It is no use contemplating any stricter discipline than this. To be sent away carries a stigma few will be willing to face. In fact they would "lose face".

Lastly, there is the matter of pay. I have not mentioned so far, but I will stress now that you should have been operating throughout in the closest consultation with the appropriate civil authority. However sketchy your co-operation may have been on other matters, it is absolutely imperative you take competent civil advice on the matter of pay. So frequently the pay level to be offered will represent a fine balance between cupidity on the one hand and personal fear, or the fear of living conditions and other kinds of fear. A point of importance is that pay should be calculated as payment for each day's work, i.e. no payment for days of rest or holidays. This gives you a lever, because if you wish them to work on a holiday all you have to do is to offer pay and a half and you will probably get all the labour you need.

I have three other points of some importance.

The first is never if you can avoid it permit groups of civil labour to move forward without having first been equipped with such personal equipment and tools as they require. Next, and most important is the matter of supervision. If you wish to extract anything approaching the work potential from civil labour you must find somehow or other an adequate number of what might variously be called foremen, or Sub-Divisional Officers, or what you will. You must have these Gangers, each in charge of about sixteen to twenty-four labourers. Indeed, there must be some loose hierarchy of command above, leading to the man at the top who is directing operations. I assure you it is utterly futile to mass together thousands of labourers unless it can be organized at ground level in such way that labour can be told exactly and precisely what they have to do hour by hour and day by day.

Lastly, there is the welfare aspect. The needs may be very simple and it should not be too difficult to meet the demands for the simple comforts these backward people will want. It may be coconut oil or native tobacco, or even a little arak, but always sugar, salt and tea. The fact that you are looking after them and have thought about these things will be repaid a hundredfold.

How should you recruit? In Assam my job was done for me. Indeed it must always be done for you by the people who alone command the confidence of the people to be recruited. In Assam the main bulk were recruited through the Indian Tea Gardens Labourers' Association that had been in operation nearly a hundred years. It was a Headsman who provided the Naga tribesmen, and in the Manupuri State it was the Maharajah who arranged the numbers I required. The parallel that exists in Africa is the 350,000 Africans of the Gold Mines who are recruited through two organizations—the Witwatersrand Native Labour Association, and the Native Labour Recruiting Corporation. These cover the whole of Africa, almost up to Egypt and French Equatorial Africa. There are literally scores of these recruiting offices which sign up men on contract, arrange for their feeding, accommodation, and onward transit to the Cape. The point is to use some known instrument and avoid if you possibly can trying to recruit people through any form of Army organization.

Finally, and in conclusion, please bear in mind that however backward civilian labour may be, it is human with human desires, human likes and human dislikes. You should know these and you should weave your plan to take account of the strengths and weaknesses you discover. Indeed, a knowledge of their characteristics is imperative to any effective control and organization. Once you have passed this stage and you have got your labour organized, then nourish, cherish, but do not mollycoddle them. The line then is justice with firmness. And if you do all this civilian labour will not fail you.

Erection of a Wireless Mast Radiator

By Major P. M. Leslie-Jones, R.E.

Introduction

The Forces Broadcasting Service transmitter for the Canal Zone is situated between Fanara and Geneifa, and was proving inadequate to give good reception at distant stations such as Tel-el-Kebir and Port Said. It was therefore decided to instal a quarter wave mast radiator together with a radial earth. A field engineer regiment was allocated the task of erecting the mast, while the installation of the radial earth and other electrical equipment would be the responsibility of a L. of C. signal regiment. Engineer assistance would be given in levelling the ground at the base of the mast for the radial earth.

This article deals solely with the actual erection of the mast, which proved extremely interesting and useful Sapper training.

Description of the Mast Radiator

The mast is 180 ft. high, exclusive of its base, and comprises fifteen sections each 12 ft. long and about 220 lb. in weight. The construction is triangular welded lattice framework whose sections are connected through flange plates by nine $\frac{3}{4}$ in. bolts (see Fig. 1(a)). Good electrical connexion is ensured by the chromium plating of the flange faces and of the bolts, and by the provision of copper gaskets.

The base of the mast is in the form of a pivoted bearing mounted on a steel plate carried on seven porcelain insulators. (See Fig. 2.) The nine guys are heavily insulated and are attached in sets of three to concrete anchorages.

Provision had to be made for aircraft danger lights, and the R.A.F. requirement resolved into a light at mast-head and one at half mast.

Erection Plan

The method used was adopted from an old project for the construction of a similar mast in Palestine several years ago. The plan was to build a tubular scaffolding tower 40 ft. high over a concrete base and to insert the mast, section by section, up the inside of the tower through specially made guides which would hold it in position. The mast would be lifted by three winches whose tackle passed over the top of the tower while further sections were bolted on below. Standing guys would be paid out from separate winches during erection and then transferred to their anchorages.

Construction

The Construction Tower

The base and the three concrete anchorages were first prepared, and then the tower put up. Its construction is shown in Fig. 1 (b). and comprised 2-in. scaffolding, built to a triangular plan, each corner being set on to a separate grillage of railway sleepers. Unfortunately 20 ft. lengths of scaffolding were not available, and the use of 10 ft. lengths with spigot couplers made it difficult to ensure the tower being absolutely vertical. To reinforce the upright members, on which rested the ultimate strength of the tower, additional vertical lengths were secured and so arranged that joints overlapped. The legs of the tower were anchored to O.P. holdfasts to counteract any possible turning moment due to whip in the mast, while the top was steadied by standing guys to the permanent anchorages.

The guides for the mast were then inserted. There were three guides made of welded scaffolding 25 ft. long, with welded supports which connected to the horizontal members of the tower. They were adjusted so that their vertical edges met the sides of the mast sections in the centre of the tower. They thus formed a channel up the middle of the tower through which the mast would slide. (Photo 1.)

Winches and Guys

While the tower was being built nine 3-ton winches were set out on sleepers.

(*a*) Three for lifting tackle about 30 ft. from the tower.

(*b*) Three for the middle mast guys directly behind the permanent anchorages, which were 100 ft. from the base of the mast.

(*c*) Three for the topmast guys in line with the anchorages and 240 ft. from the base.

The guy winches had to be set outside the anchorages, so that the standing guys would not have to be made fast to the winches. All winches were anchored against possible overturning by O.P. holdfasts.

Guys were $1\frac{1}{2}$ in. S.W.R. and were prefabricated, joints at insulators being made good with double throated clamps. They were coated with bitumastic paint and connected to the mast by shackles as the appropriate section emerged from the top of the tower. Guys were paid out from the winches as the mast increased in height, winch parties being controlled by voice and later due to an increasingly strong wind, by whistle and hand signals.

On the completion of erection the guys were disconnected and made fast to the anchorages by turnbuckles prepared from standard telegraph pole equipment. The lowest set of guys were connected directly to the anchorages prior to dismantling the tower.

Mast Sections

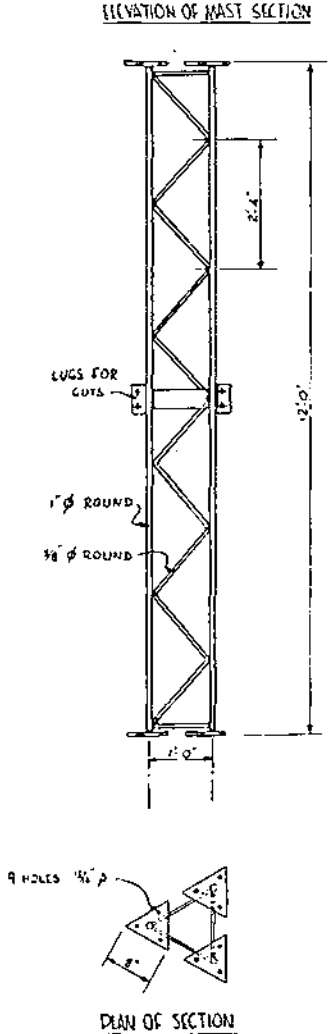
Sections were painted and then fitted together as a trial, after which they were serially numbered, and plates were welded to the top and middle sections to carry the danger light brackets.

The connecting bolts were found on receipt to have insufficient thread on the shank, and because of the large numbers involved the additional threading was done in Engineer base workshops. In the same way there was delay over the copper gaskets as the first set received were the wrong shape, and a new set, forty-eight in all, had to be cut by base workshops.

The mast sections were inserted at the bottom of the tower and bolted to the one above and the whole hoisted by the lifting tackle. Two sections could be put in and lifted before the tackle was changed, the mast being merely rested on the concrete base during the change. As each joint was made it was weather proofed with bitumastic paint. Little difficulty was

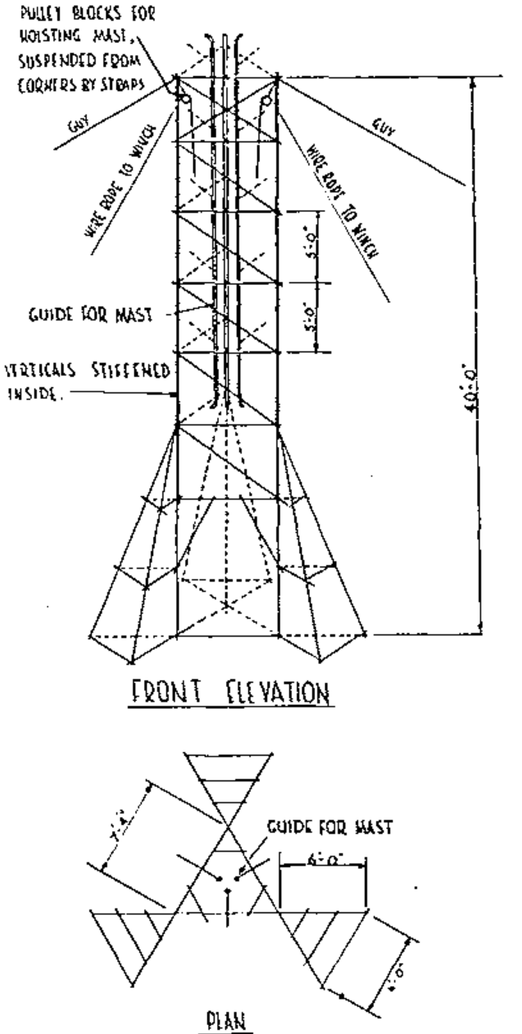
E.B.S. MAST - GENEIFA

FIG. 1(a)



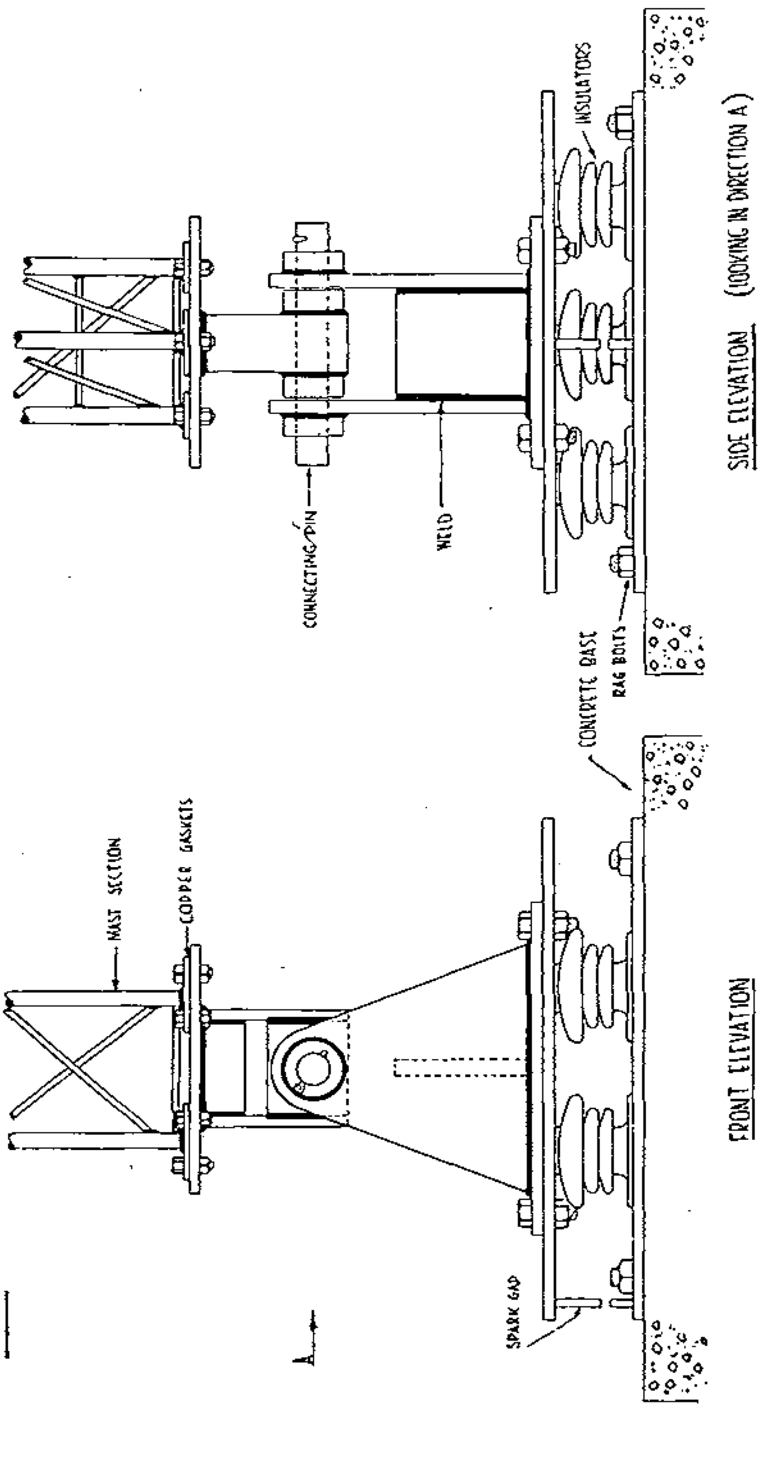
DETAIL OF MAST

FIG. 1(b)



DETAIL OF ERECTION TOWER

FIG 2



DETAIL OF BASE - F.B.S MAST - GENEIFA

Photo 1.—Erection in progress. Topmast gallows and guys can be seen. Winch parties seen are those on the lifting tackle.

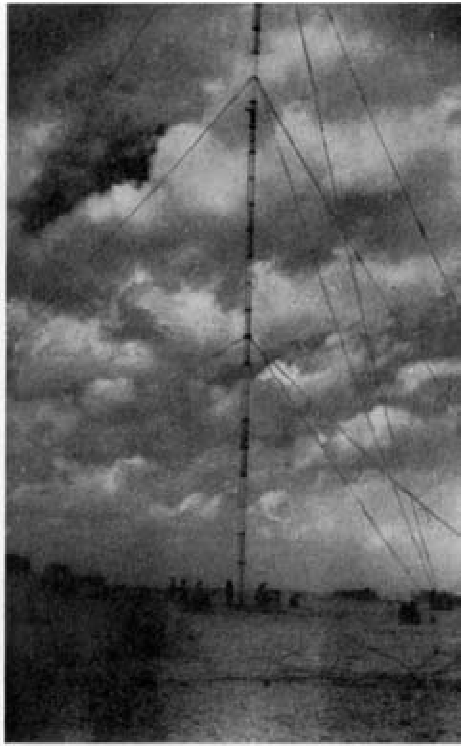


Photo 2.—Mast completed. Site clearance starting.

Erection of A Wireless Mast Radiator 1 , 2

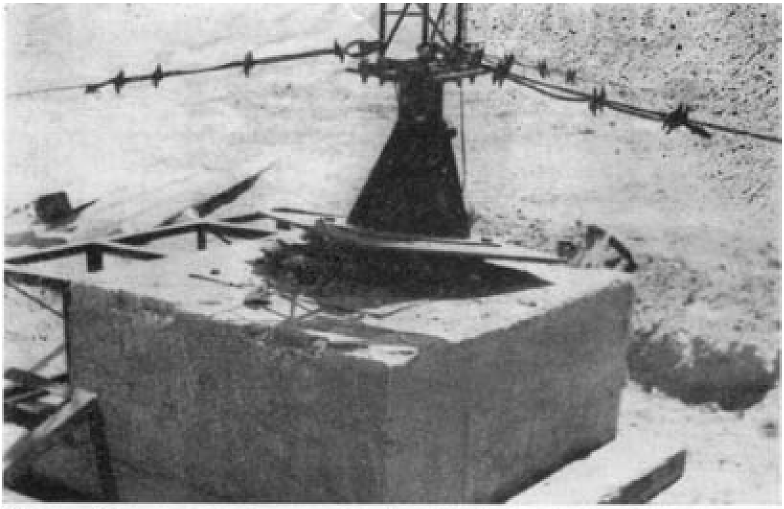


Photo 3.—Damage to the base assembly. Porcelain insulators broken. Note foot ropes already made fast.

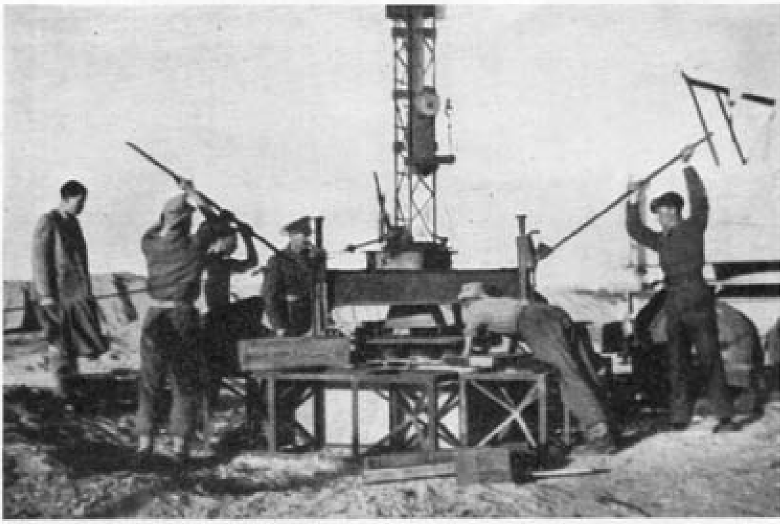


Photo 4.—Lowering assembly on to new insulators. R.S.J. framework can be seen. Note bracket and winches for danger light halyards.

Erection of A Wireless Mast Radiator 3,4

experienced in raising the mast though occasionally the flanges of the mast sections jammed against the guides. This was overcome by manipulation of the lifting tackles.

Base Assembly

Details of this assembly can be seen in Fig. 2. The steel plates carrying the insulators had to be drilled and tapped by Engineer base workshops, though the actual assembly was done by the Field Park Squadron. The insulators themselves were set on lead washers to take up any small irregularities.

When the mast was up, and before transferring the guys to their permanent anchorages, the upper part of the base was bolted to the lower mast section. The lower part and insulators were then moved into position and hung from the mast by inserting the coupling pin. The whole mast was then lowered onto the concrete and the rag bolts grouted into place.

R.A.F. Danger Light Fittings

The design was severely limited by stores available from the R.A.F., but separate gallows were built to carry the two lights, which were hoisted by winches mounted on the bottom section of the mast. All these and the cradles for the lights were designed and manufactured by the Field Park Squadron. The gallows were to be bolted to plates on the mast sections, but because of their size and position would not pass up inside the tower as they would foul the guides. They had, therefore, to be hoisted up outside the tower and bolted on as the particular section emerged from the tower. This process caused some delay in erection as fitting the rather heavy gallows 40 ft. above ground with few handholds proved a slow and difficult job. Halyards were rove immediately and paid out from the ground from drums as the mast went up.

A temporary light had to be hoisted to the mast head pending the fitting of the lower bracket and winches. In lowering this some time later the topmast halyard jammed and broke at the top pulley. A junior N.C.O. then climbed the 180 ft. mast and rove a new and heavier halyard, a most creditable performance.

General

The actual erection of the mast, once temporary constructions were prepared, took one day with a liberal working party of sixty-seven all ranks. The average time for one section was approximately thirty minutes. Work was not made easier by a 25 m.p.h. southerly hot wind which arose during the morning and made control extremely difficult, though it did not seem to effect the stability of the mast. The mast appeared to lean alarmingly at times, but manipulation of individual winches soon corrected such tendencies.

The next day the base assembly was added as already described. Then with the lowest set already in position, the guys were transferred to their permanent anchorages by slackening off simultaneously, first the middle mast guys and reconnecting them and then those to the top mast.

On the third day the construction tower was dismantled, and the verticality of the tower checked in two planes at right angles by using a theodolite. Adjustments were made on the turn buckles. (Photo 2.)

Finale

While clearing and levelling the ground for the radial earth, the blade of a size II dozer struck the base assembly of the mast. All the insulators were broken and the whole shifted sideways, though fortunately it did not slip off the concrete base. The mast itself was undamaged. (Photo 3.)

Footropes of S.W.R. were at once secured to the bottom of the mast and to the permanent anchorages, and a plan made to re-seat the mast by attaching a framework to the underside of the mast proper, using Bailey jacks to lift the mast, and remove the entire insulation assembly. Thus repaired the mast could then be skidded on rails to its correct position and jacked down. The framework comprised two sets of R.S.J.s welded into equilateral triangles, to give clearance of the base for jacking. The jacks were set on Christchurch cribs round the concrete base. (Photo 4.)

The above repair work was carried out by the Field Park Squadron, whose dozer had done the original damage! The plan worked out excellently in practice, and the insulators were replaced, and the mast reset with comparative ease.

Notes on the Origins of the Canadian Sappers

By Major N. Sadlier-Brown, C.D., R.C.E.

The following extracts from an article printed in The Canadian Army Journal *for April, 1955, are reproduced by permission of the Editor of that paper.*

Introduction

Most Canadian sappers and a few other people have a rough idea of the story of the development of the Corps since the date of its official birth on 1st July, 1903, but few know what happened during the many years of its gestation before that date. This article is intended to provide a brief chronicle of these "Dark Ages" as far as we have uncovered them.

You have probably heard the story of the schoolteacher who asked a new arrival in her class what his father was, and when he answered "Indian" she said "Oh, how interesting! What tribe?" and the boy replied "It wasn't a tribe, it was just one wandering Indian." Scandalously but perhaps, in retrospect, fortunately, the opposite was the case with the Corps of Royal Canadian Engineers. It did not, like Pallas Athene, spring fully formed and accoutred from the brain of a Jovian parent; it had, instead, many fathers, and arrived only after a slow and painful series of false starts, forty-five years after it was first conceived, when its mother, the Canadian Militia, finally brought it into existence.

This biological metaphor becomes difficult to maintain if one accepts the Corps of Canadian Engineers (Non-Permanent) as a Siamese twin of the R.C.E. coming into existence on 1st August, 1904, thirteen months after the birthday of the permanent Corps. This odd relationship must have given the R.C.E. a queer feeling of being followed—a feeling that was more than justified with the advent of the First World War when the Canadian Engineers (NP) went to war and left its Permanent Force senior half in Canada, fretfully taking care of "works and bricks". However, these two bodies were happily united in 1936 to become the present Corps of Royal Canadian Engineers.

* * * * *

The Infant Years

The members of the volunteer engineer units of the earlier days saw little in the way of military action, unless they joined other more fortunate arms, even on the few occasions when Canadian Forces did get into action during the late 1800's. The Fenian Raids saw one Montreal company standing by, defending the border, but no sapper fired a shot; the North-West Rebellions had no volunteer engineer companies by that name on the side of the Government. However, it is worth noting that in the second North-West Rebellion an Intelligence Corps, composed of a company of Land Surveyors Scouts (50 surveyors recruited by one, Captain Dennis, who was, I strongly suspect, the Dennis whose activities are largely credited with provoking the second Rebellion), were recruited in Ontario, and their function was to carry out engineer reconnaissance. Whether they did any reconnaissance work or not, I do not know. General Middleton's dispatches refer to them as serving as infantry in the battle of Cut Knife Hill, where one officer was killed and two men wounded. I have not so far found any reference to any other action in which this company took part, or any further reference to them except the order of disbandment. In the South African War no Canadian sapper units went overseas.

Although from this distance the Government's indifference in those days to the need for military engineers in the Militia appears scandalous and, at best, short-sighted, we should not be too harsh in our condemnation of the official attitude. Down through the years, from the very beginning of French colonial settlement on this continent, skill in defensive warfare was the colonists' most vital art. As British colonists were added to the French and our frontiers extended, these pioneers organized militia companies of cavalry, artillery and infantry, but they did not see the need for engineer companies because the members of all these volunteer companies, indeed nearly the whole male population, were brought up to use hammer and saw, axe and auger, pick and shovel—all the tools that were needed to build the stockades, earthworks and bridges for the minor campaigns of their day.

Even as cities grew and the Canadian population became more urban, there were still, for many years, enough pioneers and mechanics in each militia company to do the engineering tasks, usually under the direction of an officer who had had engineer training. The bulk of the population appeared to be satisfied that every Canadian ought to be a natural engineer, just as he ought to be a born rifle shot, and if the voters thought that way, we should not judge the Governments of the day too sternly for agreeing with them.

That this attitude did prevail is illustrated by the following excerpt from the report of the Inspector of Engineers for the year 1885: "I have heard it argued that because Canadians are undoubtedly skilful with the axe, therefore there is not much need for an Engineer Corps in Canada. . . . To trust to any troops learning the technical work of the Military Engineer on the outbreak of war on the foundation of skill with the axe is to organize disaster, or to trust to effecting through needless bloodshed, what could be effected by organization and training."

Towards the end of the century the unanswerable arguments presented by the great technical advancements of the day in industry, which were having an almost parallel effect on the technique of warfare, supported by the strong national consciousness that was growing in Canada, made themselves felt, and the Government, after much deliberation, began to add technical corps to the Canadian Militia.

Several other factors were involved in this process, and their cumulative effect could not be ignored, particularly with regard to the development of the Sapper arm. These factors were: the effect of the work of the Royal Engineers garrisoned in Canada, who by example and instruction exerted a positive effect on the minds of both the people and the Government; the organization of the Royal Military College, which from 1880 onwards sent forth a steady flow of élite youth trained for leadership and in the military and civilian sciences; and the determination of the British Government to withdraw its garrison as soon as Canada should be capable of becoming militarily self-supporting, at least to the extent of being able to look after her domestic needs.

The influence of these factors was of vast significance to the country at large; on the technical Corps of the Militia their effect was vital.

The Royal Engineers

The R.E. and the Royal Sappers and Miners had seen duty here and there in Canada for generations. All permanent fortifications and militia buildings, the submarine-mine coastal defences, the construction of the Rideau Canal and other strategic waterways, the building of the Cariboo Trail in British Columbia—all these had been their responsibilities. Along with these purely technical tasks, they had also carried out garrison and staff duties, "showed the flag" on occasion, and instructed the Canadian Militia, year in and year out.

The names of Colonel John By and Lieut.-Colonel Richard Moody are too well known to need repeating; less well-known Royal Engineers who nevertheless gave too much to Canada to be forgotten, were such men as Captain Haig, R.E.[1], A.Q.M.G. to the G.O.C. Government Forces in the second North-West Rebellion; Lieut.-Colonel Edward Osborne Hewitt, the first Commandant of The Royal Military College; Captain Edward Raban, Professor of Fortifications, R.M.C., and Inspector of Engineers from 1882 to 1886; and

[1]In his despatch quoted in G.O. 13, 8 July 1885, General Sir Frederick Middleton wrote: "Capt. Haigh, my AQMG, was very useful to me and cool under fire; he is a most energetic and willing officer and has been of much service to me all along, especially in rendering the zereba safe from enemy fire, and all other work requiring an engineer's knowledge." This is in contrast to the Inspector of Engineers' report already referred to, which says inter alia, "It is true that the recent operations in the Northwest were carried out without any engineers . . ."

Colonel H. J. Foster, Quartermaster-General of Militia from 1898 to 1901. There were many others "whose work remaineth, greater than their knowing." Our debt to the Royal Engineers cannot be expressed in words.

The Royal Military College

The greatest single factor in its effect on the military future of Canada was created by the establishment of the Royal Military College. This institution was founded in 1875 for the purpose of teaching "all branches of military tactics, fortifications, engineering and general scientific knowledge in subjects connected with and necessary to a thorough knowledge of the military profession." Its graduates, whether they chose to follow the profession of arms or a civilian career, well understood the position of their growing country and its place in the Empire; the consequence of their engineer training was to make them, out of all proportion to their numbers, within the next few years the most valuable body of men to Canada and the Empire that the country had yet seen.

The immediate military result of the graduation of the earlier classes from R.M.C. was the provision of properly trained young Canadians to lead the Volunteer Militia; the second result was the provision of trained permanent staff and regimental officers for the Active Militia; the third result was the provision of a flow of high-class officers to the Imperial Service so that by 1897, of R.M.C. graduates serving in H.M. Imperial Forces, one was in the cavalry, twenty-one in the artillery, thirty-four in the infantry and thirty-two in the R.E.

In the last-mentioned group, I think that Canada started to pay its debt to the Royal Engineers. There is now a R.E. tradition in some Canadian families, and the names of Sir Percy Girouard, Sir A. C. Joly de Lotbiniere, Sir George Kirkpatrick, Sir Godfrey Rhodes and Sir Frederick Carson, to mention only a few Canadian R.E., illustrate my point.

The effect of the graduation of a preponderance of sapper officers must now have become a potent factor in influencing the Government decision to establish technical Corps. For example, in 1896–97 the Reserve of Officers contained Cavalry (3), Artillery (14), Infantry (48) and Engineers (128). Of the Engineers, only one—Lieut.-Colonel Donald M. Vince—was not an ex-cadet or graduate of R.M.C.

The whole Canadian Militia benefited from the R.M.C., but I think that the Engineers were the first to enjoy it. In 1897, Lieut. Paul Weatherbe, who had graduated from R.M.C. in 1891, was appointed Chief Engineer in the Civil Branch of the Department of Militia and Defence, and therefore became the first man to have that title in a Canadian Governmental department, even though he was a civil servant at the time. He kept an active interest in the volunteer engineer companies, serving for a time as Captain in the Brighton Engineers, from where he was transferred to command the Ottawa Engineer Company as Major in July, 1902. He had already been granted the honorary rank of Major in 1900 for his services in connection with the preparation and organization of the South African contingent, and he was also at that time a member of the Board of Visitors to R.M.C. On 1st July, 1903, when the Royal Canadian Engineers was established, with provision for seven officers and 125 men, Weatherbe was promoted to Lieutenant-Colonel to command the Corps, and to be Director General of Engineer Services.

A corps of Guides having also been established in 1903, several R.M.C. graduates were appointed to fill its vacancies. The existence of this early Intelligence Corps (to give it its modern label) was curtailed not long after, and most of these officers transferred to R.C.E. Many of the R.M.C. ex-cadets who joined the Corps in those early days later rose to eminent rank in the Canadian Army. Major-General W. Bethune Lindsay, C.E. of the Canadian Corps in the First World War, Majors-General A. C. Caldwell, T. V. Anderson, W. B. Anderson and E. J. C. Schmidlin exemplify the stature of the type of men who formed that group.

The Story to Date

The Corps expanded as its responsibilities grew, and in 1907, the need for trained sapper soldiers having been recognized, a School of Military Engineering was established in Halifax. During the Second World War the School was moved to Chilliwack, B.C., where the many natural advantages of climate and location make it the most envied military engineering school in the Commonwealth.

In the First World War, as I mentioned earlier, the Canadian Engineers served under their militia title, and instead of wearing the R.C.E. badge of the Royal Cypher and Garter surmounted by a crown and surrounded by a wreath of maple leaves, they wore the militia badge of the Beaver, Crown and maple leaves. One Canadian sapper, Captain (later Lieut.-Colonel) Coulson Norman Mitchell, won the V.C. in the First World War. This feat, together with the many other notable achievements of the Corps in bridging, tunnelling and railway construction and operation, established the Canadian Sappers in the popular mind as a fighting arm of remarkable versatility.

Various changes in organization took place between the two world wars, notably the amalgamation of R.C.E. and C.E. into one Corps of Royal Canadian Engineers, with permanent and non-permanent establishments, under G.O. 75 of 1st June, 1936, effective 29th April, 1936. The value of this amalgamation was shown by the close co-operation between the permanent and reserve forces during the Second World War and since.

In the Second World War, the first Chief Engineer overseas was Brigadier (later Major-General) C. S. L. Hertzberg, who joined the 2nd Field Company in 1904 and who died in India in 1944. He was succeeded successively by Brigadiers J. L. Melville, A. T. MacLean and Geoffrey Walsh, the last-named being the Chief Engineer of the Canadian Army from July 1944 until the end of hostilities.

Since the Second World War, the Corps has been privileged to have an Honorary Colonel Commandant, and is fortunate in that the incumbent is Brigadier James L. Melville, C.B., M.C., E.D., Chairman of the Canadian Pensions Commission. As an illustration of the continuing happy relationship between the R.E. and the R.C.E., Brigadier Melville was elected an Honorary Member by the Council of the Institution of Royal Engineers in January, 1954.

In February, 1938, H.M. King George VI honoured the Corps by becoming its Colonel-in-Chief; on the 50th Anniversary of the Corps, H.M. Queen Elizabeth II carried the honour a step further in taking her father's place as head of the Corps.

Adaptation of the Heavy Girder Bridge for Rail Traffic

By MAJOR D. F. DENSHAM-BOOTH, R.E.

(*The opinions expressed in this article are those of the author and do not necessarily correspond with official views.*)

IN time of war, standard military equipment may often be in short supply and some items even unavailable for certain periods. It is then that the engineer has to improvise, and this may sometimes best be achieved by putting such equipment as is available to alternative uses.

To prepare for circumstances such as these it has been thought desirable to consider the adaptation of heavy girder bridge equipment for use in railway bridging. During the years 1948 and 1949, the design staffs at M.E.X.E. in conjunction with the Transportation Directorate gave some thought to this problem. Their final recommendations were that whilst separate equipments were necessary for road and railway bridges due to the wide difference in design specifications, further consideration should be given to the adaptation of the heavy girder bridge for emergency railway use.

Due to ever increasing pressure of work, including the design of an entirely new large span railway bridge, and the higher priorities given to other projects, it has not hitherto been possible to proceed with the second part of the recommendation. In recent months however, this problem has been revived at the Transportation Centre, Longmoor. Designs have been produced, and an improvised heavy girder railway bridge built and tested.

The object of this article is to describe the background to the problem and the development of designs for improvised railway bridges using heavy girder equipment. A description of the construction of an 80 ft. trial bridge and subsequent deflection tests is also included.

MILITARY RAILWAY BRIDGING EQUIPMENT

To appreciate properly the requirements of railway bridging it is an advantage to be conversant with the present range of equipment bridges, as well as to understand some of the more important factors concerning design.

Existing equipment:—

(i) Joist span—four No. 24 in. × 7½ in. R.S.J.s—27 ft. long.

(ii) Joist span—six No. 24 in. × 7½ in. R.S.J.s—35 ft. long.

(iii) 40 ft. sectional railway bridge—deck or through.

(iv) Unit construction railway bridge—spans 55 to 100 ft. (110 ft. at 10 m.p.h.)—deck or through.

All the above equipment bridges are designed to take the full twenty B.S.U.L. (British Standard Unit Loading) at 40 m.p.h. This is the equivalent of two heavy locomotives and tenders coupled together, and produces a total axle load of 280 tons. Allowance is also made for the considerable impact factor due to rail joints, track and wheel irregularities, hammer blows and the lurching of the locomotive. For example at a speed of 40 m.p.h. over an 80 ft. span, impact will increase the loading on the bridge by approximately one-third. If however, speeds are restricted to less than 10 m.p.h., the impact factor may generally be ignored.

Military railway bridges are normally designed so that deflection (sag/span ratio) does not exceed 1/600. This permits full tractive effort from all driving wheels of a rigidly framed locomotive and keeps the end slope of the bridge within reasonable limits. The latter is particularly desirable at junctions in multi-span bridges. For emergency requirements this rigid specification for deflection will necessarily have to be relaxed. It must be remembered, however, that excessive deflection will not only make traction difficult, but will also give rise to undue oscillation in the structure and a tendency to derailment on the vertical curves at the ends of the bridge.

To achieve the normal specified requirements, military equipment railway bridges are constructed from relatively heavy and stiff steel sections. All connexions are tightly bolted and the joints between main chords are rigidly spliced, often being stiffened with diaphragms, packings and cover plates. Because of their weight, rigidity and length of time to construct, the larger span bridges tend to be considered as semi-permanent rather than temporary erections. Unlike equipment road bridges, once built, they are seldom dismantled and replaced during a campaign.

Improvised Railway Bridges

The range of military equipment railway bridging appears to be adequate, but as mentioned previously, there will be periods of emergency when the correct equipment for the task may not be available. This may be due either to an interruption in supply or excessive rate of consumption. It is also possible that there may be a requirement for short term bridges, where improvisation would be more expedient than the commitment of heavy equipment bridging. In well wooded country, trestle bent bridges with short stringer spans may prove a satisfactory solution. Timber is, however, not always readily obtainable in the required sections or quantity, and moreover, such improvised bridges will generally take longer to construct than simple unit construction equipment.

During the 1939–45 war there were repeated shortages of railway bridging equipment and use was sometimes made of the Bailey Bridge to carry rail traffic. At times of course, Bailey was in no less short supply. However, there were often surpluses of Bailey panels available, without the necessary additional components to complete road bridging sets.

Realizing the advantage of being able to make use of existing stocks of Bailey bridging, the Transportation Training Centre produced a handbook on the adaptation of Bailey for rail traffic, early in 1944. The range of spans, designed for 20 B.S.U.L. at restricted speed, varied from 40 ft. double truss single storey, to 90 ft. quadruple truss double storey. Although both deck and through construction were possible in single storey bridges, the deck type was the most favoured for its economy in weight and component parts. Deck spans were, however, limited to 60 ft. quadruple single.

It will be readily appreciated that the main disadvantages of using this type of pin jointed equipment are the excessive deflection, due partly to pin hole tolerances, and the liability to considerable horizontal oscillation, which the relatively light lateral bracing freely permits. The former difficulty may be overcome by adzing or packing the sleepers to bring the track to the required grade. Oscillation must be prevented as far as possible by stringent speed restrictions, but even so, careful daily maintenance is necessary to keep the structure securely braced.

As a matter of interest it is worth noting that in recent years the manufacturers of Bailey bridging have also considered the use of this equipment for temporary civil railway traffic. They have developed an "expanding" panel pin which considerably reduces pin hole sag and have also designed a bracing system which permits the construction of a fourteen truss deck type bridge of 100 ft. span, suitable for 20 B.S.U.L.

With all the facts so far described in hand, the design of railway bridge spans improvised from heavy girder bridge equipment was commenced at Longmoor in February, 1957.

Design of Improvised Heavy Girder Railway Bridges

A possible range of spans in various forms of construction were first checked for bending and shear, allowing for 20 B.S.U.L. with speeds restricted to 10 m.p.h., i.e. little or no impact. Possible factors due to wind and misalignment of track were also neglected. Considering only the strength of single storey deck construction it was found that spans from 75 to 150 ft. might be supported by the following arrangement of trusses:—

75 ft.—double single—four trusses
88 ft.—double single chord reinforced—four trusses
100 ft.—triple single—six trusses
113 ft.—quadruple single—eight trusses
125 ft.—triple single chord reinforced—six trusses
150 ft.—quadruple single chord reinforced—eight trusses

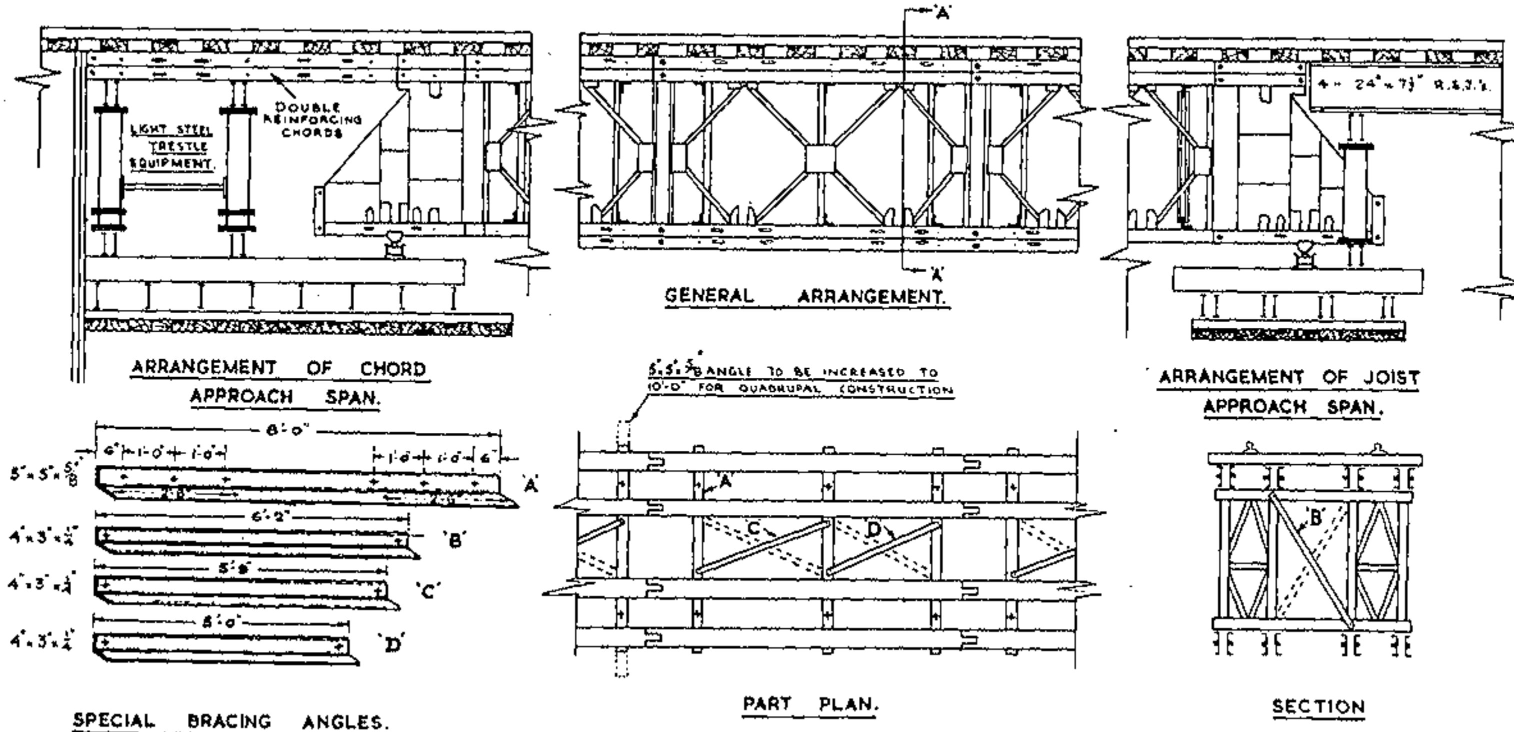
It was of course realized, that in the longer spans, excessive sag, due to pin hole tolerances, dead, and live loads, would impose certain limitations. Due to irregularities likely to be present in both the track and equipment, the impact factor also could not be entirely ignored. Unfortunately little is known at present about the "fatigue life" of H.G.B. welded panels. This important factor must, however, be kept in mind since rail traffic imposes almost maximum stress every time a train passes over the bridge.

The next stage was to discover how the required number of trusses could be suitably braced together to form an efficient and economical structure. It was considered essential that any bracing assembly should be designed on steel sections likely to be readily available from normal supply sources, and that any fabricating, cutting, or drilling involved, should be within the capacity of field units. Any design which required the cutting, welding, drilling or distortion of the standard heavy girder bridge components was considered undesirable, as this would prejudice the later use of the equipment in its function as road bridging. To facilitate the study of the bracing problem a set of model heavy girder bridge was procured. Various systems of bracing incorporating angles, channels, joists, flats and rounds were constructed from cardboard and built into the model bridge. The simplest answer to a problem, which is also often the best solution, does not necessarily present itself in the first instance. In this design, simplicity had to be the keynote, and the final arrangement was arrived at by the process of eliminating the more complicated systems.

A bracing system constructed of angles was finally adopted and is illustrated in the accompanying sketch and photographs. It comprises stiff lateral angles secured at every chord bolt position to locate correctly the panels, with lighter angles secured to laterals to provide vertical and horizontal diagonal bracing. Only four different "special" members need be produced in

HEAVY GIRDER BRIDGE ADAPTED FOR RAIL TRAFFIC.

DOUBLE TRUSS CONSTRUCTION.



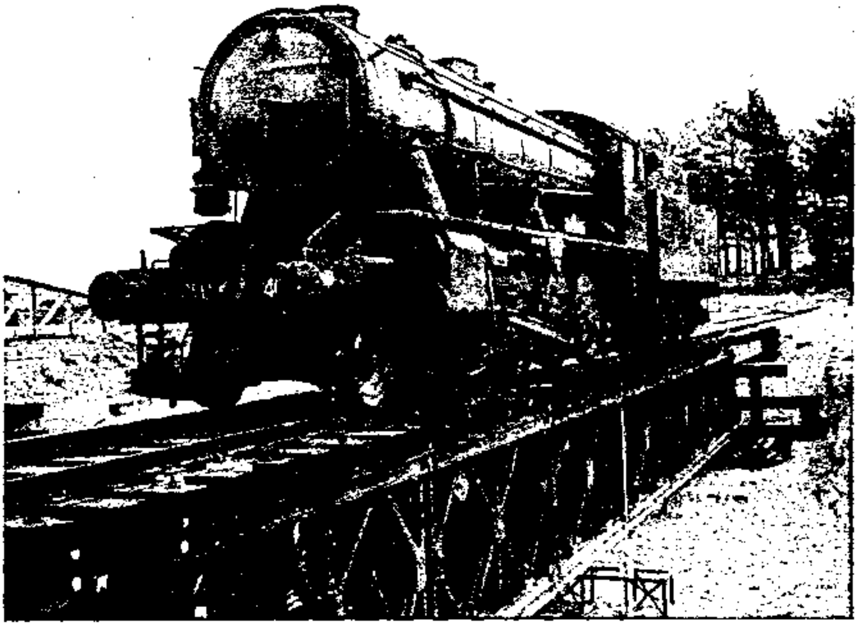


Photo 1.—2-8-0 locomotive and tender (120 tons) crossing 81 ft. span H.G.B. four girder improvised railway bridge.

the field. All are plain cropped and no trimming or fitting is involved. Bolt holes may be drilled by power or hand tools using a simple pattern or jig. The angles shown are 5 in. × 5 in. × $\frac{5}{8}$ in. and 4 in. × 3 in. × $\frac{1}{4}$ in. respectively. They were available at the time of design in existing stocks of scrap equipment. Alternative sections of similar properties would be equally suitable. Apart from panels, chords and end posts the only other heavy girder parts required are the standard bracing frames. These are secured at every possible location throughout the bridge to give additional rigidity to the trusses.

To complete the model study, metal angles to the correct scale were cut, drilled and assembled in the bridge. The full range of possible construction from double single unreinforced to quadruple single chord reinforced was completed in sequence. For each type of construction the improvised angle bracing system remained the same and no modification was required except that for quadruple trusses the lateral bracing angles are 10 ft. long instead of 8 ft. Before proceeding with full scale trials the model was demonstrated to members of M.E.X.E. bridging staff. It was agreed that an improvised railway bridge should be constructed to this design and subsequently subjected to deflection tests under live loads.

Practical Trials

The span selected for practical trials was 81 ft. between bearings in double single construction. This came within the range of most common spans and fitted into an existing gap.

To avoid an undue amount of equipment on the site the bridge was built *in situ* on cribs, being jacked on to its bearing blocks when construction was

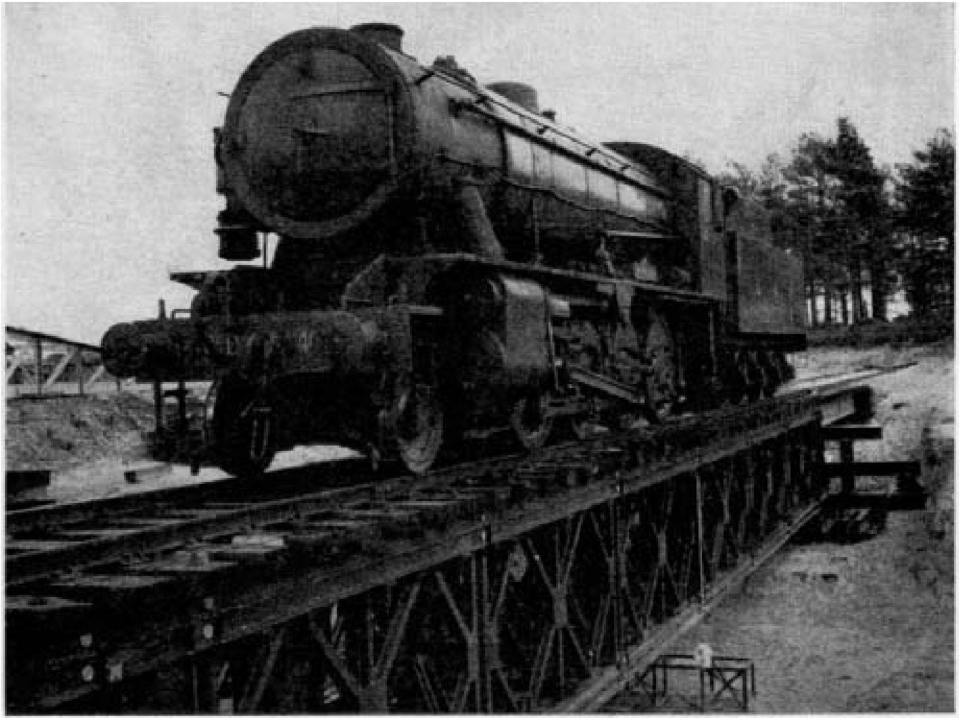


Photo 1.—2-8-0 locomotive and tender (120 tons) crossing 81 ft. span H.G.B. four girder improvised railway bridge.

Heavy Grider Bridge For Rail Traffic 1

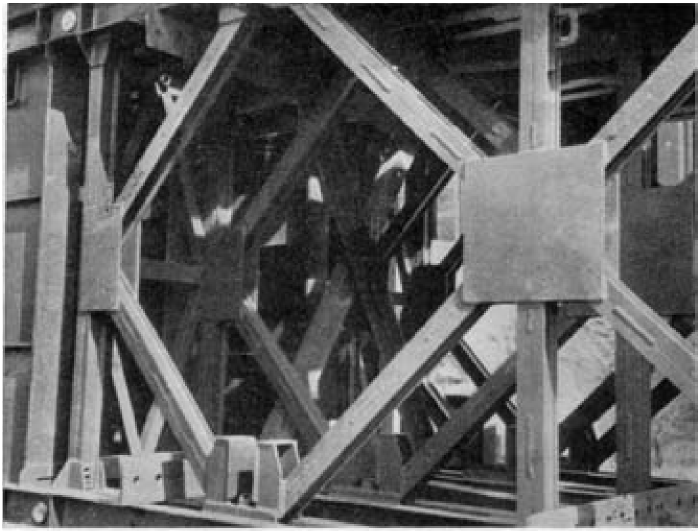


Photo 2.—View of double diagonal vertical bracing angles at end of bridge. The 5 in. × 5 in. lateral bracing angles are also shown.

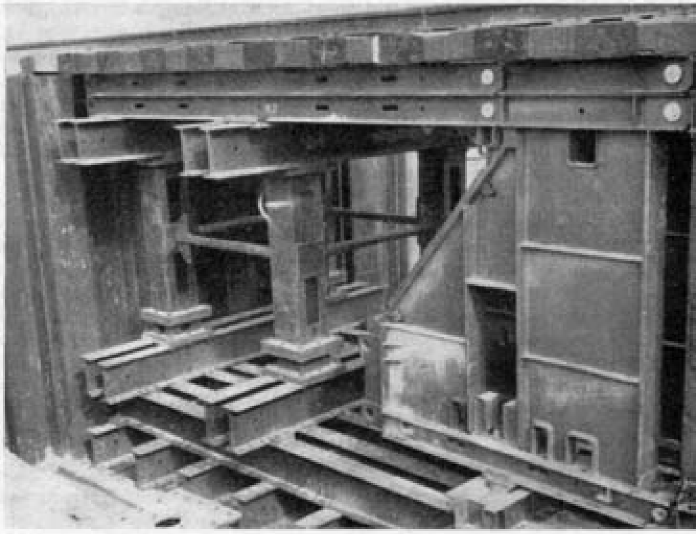


Photo 3.—Improvised approach span of double reinforcing chords supported on standard light steel trestling. The use of quarter chords on top of end posts is also shown.

Heavy Grider Bridge For Rail Traffic 2 , 3

Photo 4.—Underside view of four-girder H.G.B. improvised railway bridge showin lateral, vertical and horizontal diagonal bracing.

Heavy Grider Bridge For Rail Traffic 4

completed. There is no reason, however, why in field use the bridge should not be launched with a nose or kentedge and jacked down in the normal way. No difficulty was experienced in locating or fastening the improvised bracing members. The lateral angles were secured by reversing the chord bolt nuts over a washer. This is necessary, otherwise there is insufficient thread to secure. All diagonals were fastened with single 1 in. bolts in $1\frac{1}{16}$ in. holes.

As shown in the illustrations normal end posts and bearings were employed. To examine the possibility of using alternative approach spans, one was constructed from stock R.S.J.s and the other from pairs of reinforcing chords bolted together and pinned to the end posts. The latter arrangement is restricted to 8 ft. clear span, and standard quarter chords are required to cap the end posts. Normal grillages were employed and both approach spans were supported where necessary on standard light steel trestle equipment. Standard W.D.75 lb. flat bottom track in 36 ft. lengths was laid across the bridge and approach spans, carried on 12 in. × 6 in. timbers hook bolted to the upper chords. Expansion joints were omitted to reduce impact.

Using a standard crawler crane to aid construction the engineer effort in terms of eight hour man days was as follows:—

(*a*) Abutments, grillages and approach spans—eighty-six man days.

(*b*) Heavy girder bridge assembled and braced complete—fifty-four man days.

(*c*) Laying track over full length of bridge and approach spans (total of 121 ft.) and hook bolting down—thirty-four man days.

The labour had not been specially trained in this equipment and no doubt these construction times could be improved upon.

When finally complete, the central deflection of the 81 ft. span was carefully observed by surveyor's level, and found to be only 1 in. Electrically operated test instruments were then set up under the bridge by M.E.X.E. staff, at centre span and end posts, supported on independent structures. Their object was to determine the amount of live load deflection at centre span and under the end posts, and the extent of oscillation caused by varying loads and speeds. After the apparatus had been checked, a light locomotive, followed later by a heavy locomotive, passed over the bridge at dead slow pace. The speed of the heavy locomotive was increased by increments at every trial run, up to an average of approximately 15 m.p.h. Finally both locomotives coupled together accelerated across the bridge at about 17 m.p.h. in order to impose the severest conditions of vertical and horizontal displacement.

At the completion of the trials no outward sign of stress, failure or distortion of any standard or improvised parts could be found from critical visual inspection. The results of the deflection measurements showed that the greatest sag due to combined dead and live loads amounted to only 2 in., giving a sag/span ratio of 1/486. At the restricted speeds of 5 m.p.h. both impact effects and twisting of the bridge at mid-span were negligible for either locomotive.

Further Developments

The construction and testing of longer spans has not been possible due to lack of personnel. However, the trials so far carried out, although not conclusive, have confirmed the usefulness of heavy girder for emergency railway bridging and demonstrated the possibility of improvising a bracing system.

From the test results and subsequent calculations it is considered that chord reinforcement should always be used for spans of 75 ft. or over in order to keep both dead and live load deflections to a minimum. With the addition of a third reinforced truss under each rail, spans of 100 ft., 112 ft. 6 in. and 125 ft. would be quite practicable. The probable deflection over these longer spans is likely to be between 1/250 to 1/200, which could be accepted for emergency bridging with "dead slow" speed restriction. For deck type spans greater than 125 ft. quadruple truss construction would be necessary. Although spans of up to 150 ft. are quite strong enough in this construction, the deflections are excessive. At this stage therefore it is better that double storey through spans be considered.

An examination has been made of the possibility of constructing double-double and triple-double improvised rail bridges using the standard short cross girder, with either timber or steel joist stringers to carry the track. Although this form of construction greatly improves the deflection ratio, it is likely to be difficult to brace satisfactorily and considerable lateral oscillation is to be expected. It is also understood that the normal double storey road bridge construction has not yet been finally approved and the bracing arrangement of the upper storey may still have to be modified. Should an improvised railway bridge in double storey construction be seriously considered at any time it might be well worth modifying the short cross girder to give additional stiffness. It could be made 2 ft. shorter, also provided with knee braces to further stiffen the trusses, and still meet the structure gauge requirements. Such modifications would be outside the scope of field units and it is questionable whether the manufacture and stocking of these special parts for improvisation would be warranted. In view of the foregoing it is not proposed at present to design improvised double storey railway bridges, but it is worth while noting that spans of up to 200 ft. should be possible for rail traffic at reduced speeds.

Conclusions

There will undoubtedly be many occasions when improvised bridges may be necessary, particularly where a temporary rail service only is required and the use of standard railway bridging equipment would be uneconomical. They might also be useful for rapid construction alongside damaged bridges which are to be replaced later with more permanent equipment. The adaptation of heavy girder bridge equipment has many advantages over other methods of improvisation; some of these advantages are as follows:—

(*a*) The equipment is likely to be present in the theatre.

(*b*) All field units will be trained in its use.

(*c*) Its adaptation is rapid and simple and the "specials" are easily fabricated.

(*d*) Speed of erection is almost as fast as standard road bridging, and certainly much quicker than railway bridging equipment.

(*e*) No special tools are required and no on-site cutting or welding is involved.

(*f*) It can be readily dismantled and the standard components re-used in road bridges.

(*g*) Being manufactured of high tensile steel it is very economical in weight. An 87 ft. 6 in. deck span weighs only 44 tons compared with the 70 ton weight of an equivalent unit construction railway bridge.

Although there is much to recommend the use of heavy girder equipment under particular conditions, it has been stressed throughout that its adaptation for rail traffic can only be considered as an IMPROVISATION to meet emergency requirements.

Even under these circumstances it is imperative to restrict speeds to 5 m.p.h.; to ensure accurate track laying and alignment; and to avoid curved approaches. There would also be an element of danger if the bridge were under traffic in high winds, but this is a calculated risk which might have to be accepted depending on the degree of "emergency".

There is no question of making a case for substituting heavy girder for any standard railway bridging equipment. The normal operating requirements of the transportation service impose a specification for railway bridges which can only be achieved efficiently by special designs capable of carrying heavy and sustained traffic at high speeds.

At some time in the future it may be possible to establish the fatigue life of the welded H.G.B. girder panels and also to design a more positive bracing system made up from production parts. If this can be accomplished no doubt some of the restrictions could be relaxed and heavy girder bridging might be more freely used for rail traffic. Meanwhile the method of adaptation described in this article can only be recommended for emergency periods of short duration. Of course, in time of war the stakes are high and known risks are freely taken—it is then that Sapper improvisations really have a chance to flourish.

ACKNOWLEDGEMENTS

I would like to acknowledge the efforts of my staff and others who have contributed to these investigations:—

115 Construction Regiment R.E. (T.A.) who erected the trial bridge during their 1957 summer camp.

The Bridging Staff of M.E.X.E. for their interest, advice and encouragement.

My three Q.M.S.I.'s, W.O.II Woolford, W.O.II Silcott, and W.O.II Myles, who supervised the steelwork erection, prepared surveys and drawings, and supervised track laying for the trial bridge.

Refuse Incineration Plant with District Heating at Berne, Switzerland

By Major C. W. Moon, R.E.

It is thought that the following description of a modern refuse destructor in which the heat produced by burning the refuse is utilized to provide heat to several buildings might be of interest to many Engineer officers. The article is written with acknowledgement to the Staedtische Baudirektor Berne, L. de Roll S.A. Zuerich and Sulzer Bros. (London) who kindly gave permission to refer to their literature and to copy their sketches.

General Description of Kehrichtverbrennungsanlage—Berne

The plant consists of two specially designed boilers by de Roll that burn refuse which is unsorted and untreated in any form. The boilers generate steam at 10 A.T.U. (approx. 145 lb. per sq. in.) the greater quantity of which is converted to H.P.H.W. at 10 A.T.U. in two cascades. This H.P.H.W. is distributed by a normal district heating system to the following groups of buildings:—

Insel hospital
Lory hospital
Tener childrens' hospital
Institute of Dentistry
Steigerhubel School

The steam is fed to two small industrial premises for process work and the condensate is not returned. The H.P.H.W. is stored in three heat storage cylinders each of 100 cu. m. capacity (22,000 gallons approx.) to allow for fluctuations in load.

Sequence of Operations

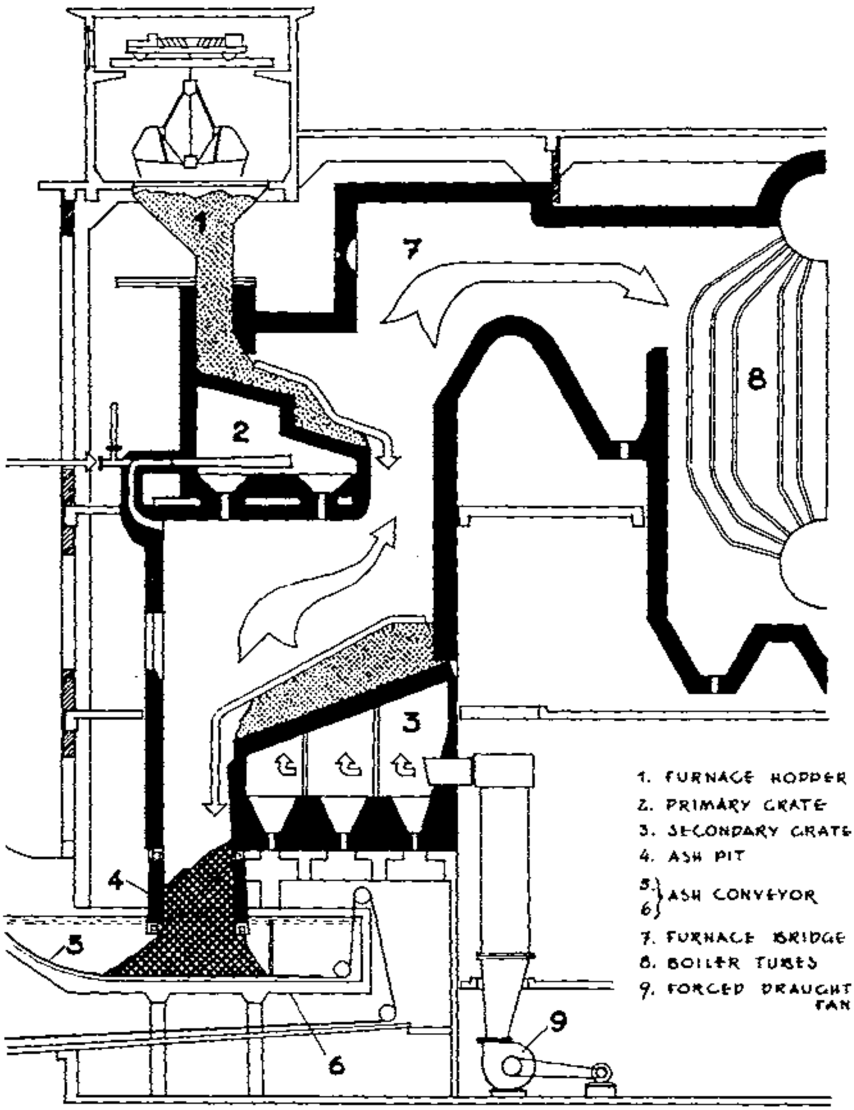
(*a*) The refuse is brought to the installation in specially designed trucks which remain sealed until the refuse is deposited into the hopper. All loads are weighed on receipt. The capacity of the hopper is 21,500 cu. ft.

(*b*) The trucks are backed up to the hanging doors of the hopper which are opened simultaneously with the tipping of the body and closed immediately the load is discharged so that the refuse is not exposed to the outside air for more than a few seconds. Further to prevent smell, etc., a permanent air suction is created in the hopper to draw small particles and vapour away from the opening.

The refuse is continually fed into the boiler furnace so that there is virtually no actual storage in the hopper.

(*c*) The refuse is then lifted by a mechanical grab, capacity one ton, to the top of the building and fed into the boiler hoppers. It then feeds down on to the first grate which is in two sections and oscillates to keep the refuse

FIG. 1



CROSS SECTION THRO THE FURNACE

DE ROLL REFUSE INCINERATOR.

moving. Partial combustion takes place aided by preheated forced draught which dries the refuse. The burning refuse then passes to the second grate below, where almost complete combustion takes place.

The arrangement of the furnace is shown in Fig. 1.

(*d*) The hot gases from both grates combine and burn at 900–1,100°C. and pass through the boiler proper. These gases contain a large proportion of solids and there are three collecting hoppers in the flues with water disposal to a sump.

(*e*) The flue gases are finally cleaned of solid matter by electrostatic precipitators, two to each boiler. The gases at the base of the chimney are at 250°C. and the chimney 80 m. tall and specially insulated to create sufficient draught to get rid of the smoke.

(*f*) The unburnable refuse, e.g. tins, etc., together with any unburnt material falls from the lower grate to a collecting pit at the front of the furnace where the combustible material is burnt by forced draught and the ash and tins carried by mechanical conveyor to the ash hoppers.

(*g*) The ash and sludge is finally removed by mechanical grab from an overhead gantry on to lorries and used to fill a gravel pit.

Auxiliary Boilers

There are two auxiliary boilers each of 5 million Kcal/hr capacity, one oil fired with furnace oil, and one electrode boiler requiring 6,000 kW. The former is used to increase the capacity of the system in the winter when the refuse burning is insufficient. The latter is a standby for the same purpose.

The district heating system, by Sulzer, is a normal pumped system with heat exchange stations at suitable points.

Electrical Generating Plant

A steam generator of 170 kW capacity is installed and run from spare heat available in summer. The current is fed back to the grid through a 50,000 volt transformer station.

Some Facts and Figures

(*a*) The installation cost approx £1,260,000, not including the wagons (amortization based on fifty years life).

(*b*) The population of Berne is approx. 160,000 people.

(*c*) Each boiler is capable of burning 100 tons of refuse per day, max. refuse received is about 150 tons in winter and 100 tons in summer.

(*d*) Yearly steam output 30,000 tons = 18 milliard K/cals. (72,000 million B.Th.U.).

(*e*) Saving in coal per year: 5,000 tons.

(*f*) Operating costs approximately £44,000 not including interest on capital or depreciation. Income from heat and electricity is slightly less than this but the heat is sold at a very reduced rate to the hospitals.

(*g*) The maximum output per day from refuse received is 240 million B.Th.U. per boiler = 480 million B.Th.U. total. The maximum load may be double this and is met by bringing on the oil burner. The heating load is shown on the graph at Fig. 2 (one kilogram calorie is approximately equal to four B.Th.U.). The shaded area represents the maximum and minimum heat output from the incinerator.

FIG. 2

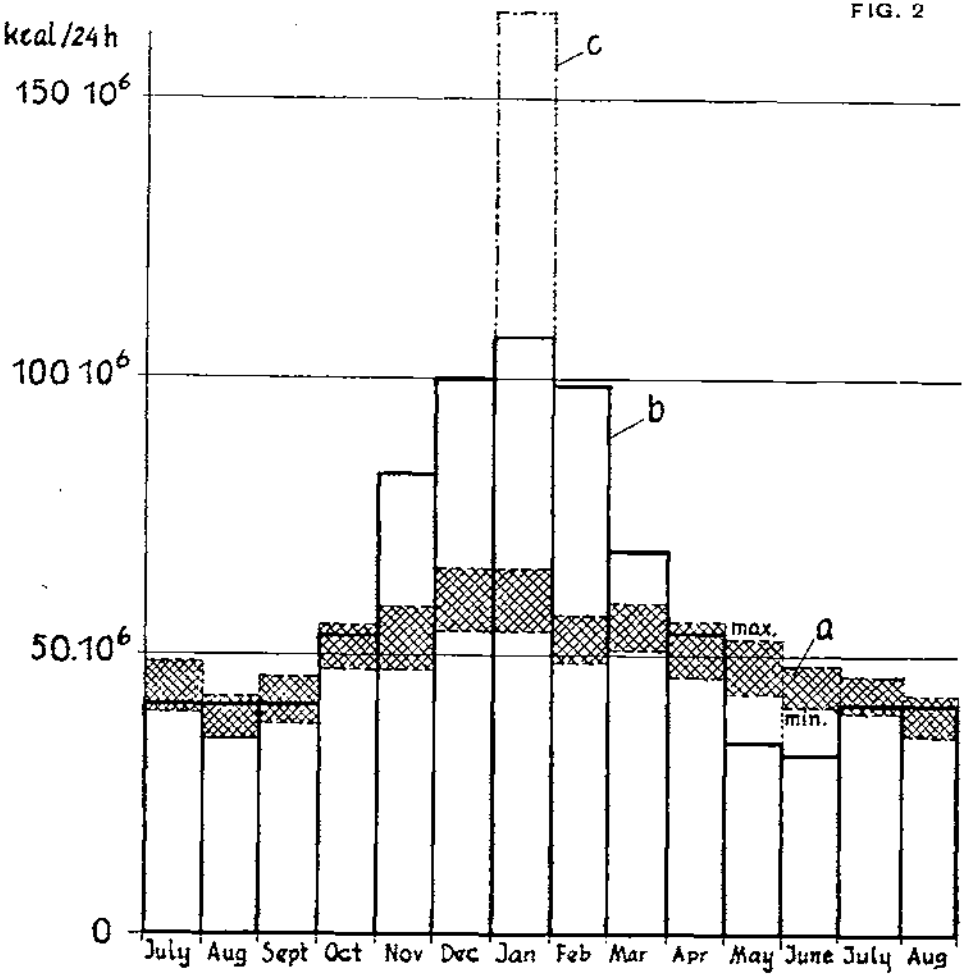
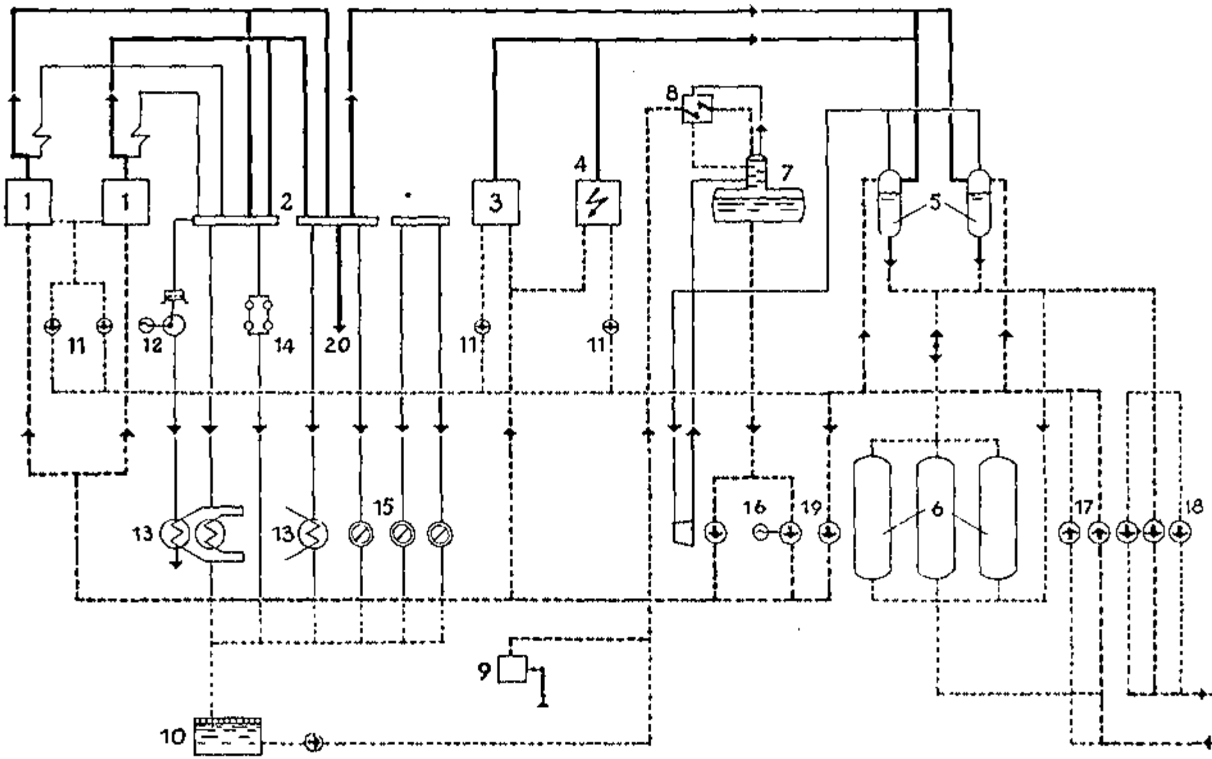


DIAGRAM OF THE MEAN DAILY HEAT OUTPUT AND CONSUMPTION EXTENSION 955.

A) EFFECTIVE INCINERATOR HEAT,
B) MEAN HEAT CONSUMPTION,
C) HEAT CONSUMPTION PEAK.

FIG. 3



LAY-OUT-DIAGRAM OF THE DISTRICT HEATING STATION AND THE GARBAGE INCINERATING PLANT OF THE TOWN OF BERN

(1) WASTE-HEAT BOILER
(2) STEAM DISTRIBUTOR
(3) VELOX STEAM BOILER
(4) ELECTRIC STEAM BOILER
(5) CASCADE TRANSFORMER
(6) HOT-WATER ACCUMULATOR
(7) FEEDWATER TANK WITH DE-AERATOR
(8) VAPOUR COMPRESSOR
(9) MAKE-UP WATER PLANT
(10) CONDENSATE COLLECTING VESSEL
(11) SALT EXTRACTING PUMPS
(12) STEAM ENGINE
(13) CONDENSERS
(14) ELECTRIC FILTERS
(15) STEAM CONSUMER
(16) BOILER FEED PUMPS
(17) CASCADE CIRCULATION PUMP
(18) HEATING SUPPLY PUMP
(19) RETURN PUMP
(20) STEAM PIPING TO FACTORIES

DIAGRAMMATIC LAYOUT OF PLANT.

(*h*) The ash removed is equal to 50 per cent by weight (13 per cent by volume) of the refuse received in winter, in summer the figures are 30 and 8 per cent.

(*i*) The water requirement is approx. 260 gallons/minute, most of which is pumped from a local well. Boiler feed is from the town main suitably treated.

(*k*) The electrostatic filters require 50,000 volts.

(*l*) Operating staff is twenty-four men working two shifts on the boilers and three shifts on the district heating system.

A diagrammatic layout of the plant is shown at Fig. 3.

Conclusions

It is believed that there is a very definite future for similar plants in Great Britain. Their provision would go a long way to reduce the number of refuse dumps to be seen, particularly in industrial areas. They can be built in residential areas without being an eyesore or creating a nuisance, although the very tall chimney necessary might not please everyone. There was certainly no evidence of smell or smoke nuisance at the plant visited by the author at Berne, Switzerland.

With a Pinch of Salt

By Major R. W. T. Britten, M.C., R.E.

Note.—All names and details are fictitious.

Not having seen Dixon for some years I was extremely interested to hear what he was doing now. Time had taken very little toll of the tall and athletic-looking warrior I had last seen leading his armoured brigade down the Mandalay road some ten years ago.

As C.R.E. of the same division I had been impressed by his boundless enthusiasm for thinking up novel ways of waging war, and I can remember wondering at the time how such a bubbling imagination would ever settle down to the monotony and austerity of peacetime soldiering.

I myself had been out of it since a fateful day in the spring of 1945 when my Madrassi orderly had tried to "ease" the springs of his Sten gun whilst sitting behind me in my jeep. The offer of a reasonable managerial post in a British firm in Ceylon all but compensated me for the loss of my left arm, and until my arrival in London on business in July of this year I had remained abroad ever since.

At the end of half a pink gin and the usual platitudinous generalities Dixon told me that he was in the very happy position of being DMT designate and was at present undergoing what he called a "defrustration course" prior to taking up the appointment.

"They call it 'Exercise Montessori'—very refreshing, and of course just up my street, old boy." Knowing the rather conservative views of the War Office I found it hard to believe that they could ever have devised anything far-fetched enough to have merited Dixon's approval. However, the speed with which he sank his second pinkers convinced me that the enthusiasm was certainly there.

Apparently the War Office had come to the reluctant conclusion that something had to be done about the mass of bright ideas on both doctrine and hardware which had had to be ignored for the want of an organization, funds or time to try them out. Gallant majors blossoming into galaxies of pretty frustrations in the pages of their regimental journals—voices, strength one, crying in the wilderness—nothing heard, nothing done.

The exercise, so he told me, was planned to last a year and consisted in the early stages of sifting out some of the more practicable bright ideas in the tactics and equipment line. With the help of the Staff College and Arms Schools, the doctrinal bombshells were beaten into shape during the winter months in a series of T.E.W.T.s and study periods, whilst the Sappers, R.E.M.E. and the Ministry of Supply did what they could with the equipment and gadgetry generally.

Early in the new year a T.A. division had been earmarked for guinea-pig duties in the coming autumn manoeuvres, and by the end of March had been told of any changes in organization or battle drill that would be required of them. In April the commanding officers and adjutants of all units in the division attended a weekend sand-table exercise held at Camberley. Before the battle commenced the originators of the bright ideas were allowed to explain their concepts with whatever justification they could muster and were available for technical advice for the remainder of the weekend.

By July the last of the special equipment had been placed in the hands of the potential users, who were then left with two months in which to learn how to handle it before the manoeuvres started.

At this point my mind was not unnaturally bursting with questions and I took advantage of a soldierly pause for liquid refreshment on Dixon's part to seize the initiative.

Where, I asked him, did the bright ideas come from. How was the gunner's revolutionary approach to modern war reconciled with that of the sapper. What sort of hardware was considered, how was it designed and made so quickly, and who paid for it—and many other similar questions.

"Really quite simple, old boy." Dixon was one of those fortunate people to whom the majority of life's problems came under the "really quite simple" category. A mutual R.A.F. friend of ours once described it as an ability to take off with propellers almost completely feathered and then to cruise indefinitely and effortlessly on charm alone. Whatever it was it seems to have worked on Exercise Montessori.

"Officers," he said, quoting the words of one far greater than either of us, "come in two grades. Those that lay eggs and those that don't. Unfortunately the officer-type egg-layer, unlike the chicken, has to do more than just sit in order to incubate. Having laid his egg he has to push it around the office, up the stairs and into the colonel's office, where, if it is an egg laid to order in normal working hours, it is probably criticized but accepted for want of time to lay another.

"But if it is the egg which he hopes will turn out to be the golden one, the egg which he has laid with infinite care and patience after hours of midnight oil and entirely contrary to specifications—he is faced with a problem. Whatever it contains it is to him *the* war winner, regardless of how unacceptable it might, and invariably does, appear to his superiors.

"It is rejected and he broods. He tries his regimental journal, his article is accepted and morale rockets. But what happens next? Nothing, absolutely nothing, until the next edition arrives three months later. And then the only comment to the most golden of all eggs is a rather narky letter to the editor from one of General Gordon's contemporaries. It explodes with a noise that sounds like 'what's-all-this-about-helicopters-company-commanders-in-my-time - achieved - just - as - much - with - six - mules - and - a - screwgun - pschaw!' and one can almost visualize the vitriolic flourish with which it was signed. Not good enough, old boy. We cannot afford to have our messes filled with frustrated field officers and at last the War Office has woken up to the fact.

"So here we are, giving them the opportunity to let off steam, trying out their pet theories and having the whale of a time in doing so. Let the little boys break the windows and scribble on the walls, who knows but one of them might not produce a Picasso.

"But I digress, you asked me how we sifted it all. Quite easy really. Formed a little ad hoc committee last July with myself as Chairman, the members being picked from the relevant Arms and Services Directorates of the War Office on an as required basis.

"For a whole week we waded through all the service journals of the past year, making a note of everything that was out of the ordinary. Gave special priority to all those articles that were prefaced with the familiar 'The views expressed are those of the author and do not necessarily represent . . . etc. etc.' "

He then went on to describe how the selected authors had been summoned to attend a two-weeks symposium at Woolwich, the War Office Mess offering its customary vivacious service.

Finance had narrowed the field to those stationed in Europe, but even so it was, as he put it, a "colourful conglomeration of crack-pots".

For the first week the authors presented their theories and proposals, all by order related to the organization and operation of the division in an atomic war, and each presentation being limited to thirty minutes. During the following thirty minutes the audience were invited to point out any basic fallacies, bearing in mind that the object of the exercise was to encourage the unconventional and not to stifle it.

By the end of the first week the corn had been separated from the chaff and a faint outline of the answer began to emerge. During the weekend Dixon and his team sketched out this outline a little more firmly and presented it to the assembly on the Monday as guide lines within which the various arms and service protagonists were to remould their proposals. It was during this week that the gunner and the sapper, with slight concessions on each side, became reconciled to each other's theories, in so far as reconciliation is possible in barrier planning.

The fortnight over, the party broke up to return to their stations, hoarse but happy that at last their theories had been aired.

ACROSS THE RIVER

"a book of remembrance with far more than names"

by

Richard Jocelyn

price 16s. net

published by Constable

Across the River is a novel about sappers at war.

It is the story of a few week's work by a squadron of Royal Engineers in Italy. The lifting of mines, and rafting and bridging operations in conditions of great danger and physical stress, are described in fascinating detail that every sapper who saw service in Italy or in any other theatre will recognise as authentic.

But it is not merely an essay on the role of engineers in battle. It deals with people, too, and the characters in *Across the River* are brought to life, rounded and complete. In this respect Richard Jocelyn's writing is wonderfully evocative. One character, Nick Boonin, you will have known in person or by repute: others will remind your of your companions in arms. These are the men you knew—and know—or honour in death. *Across the River* is a better memorial to them than any statue, a book of remembrance with far more than names.

Here you will find the scents and sounds of an army in the field: the misery of hopeless delays in wet discomfort: the pregnant silence of a still river during a recce patrol: the hearty rivalry with men from infantry and tanks: the ubiquity of any good unit commander: the *feel* of danger. The stamp of authenticity is assured above all, perhaps, by the way in which you will be reminded of the reviving power of sleep and food after days of danger and physical exhaustion.

For those who were sappers themselves, this book will stir many memories—the flat cold metal surface of the Tellermine, the square-edged wooden box of terribly sensitive Schumine, the three deadly little prongs of the S-mine, and the trip-wire with a pull or release igniter which would go off either way. Also, the sickening body-blows of underwater shell-bursts when you were waist deep trying to build a tank raft, and the sometimes hopeless battle against rain when the floods swept away in a moment what you had struggled all night to create.

In face of these dangers, the technical achievement was immense: but alone it was not enough. In the last resort it was vitality—the human qualities of comradeship, gaiety and courage—which counted most. For this reason, perhaps, it is just these qualities that remain in the memory long after the misery and hardships have been forgotten. For this reason, too, *Across the River* will not easily be forgotten.

Lieutenant-General Sir Richard Hull, K.C.B., D.S.O.
Deputy Chief of the Imperial General Staff

"The author I knew well when he commanded a sapper field squadron under me in 1st Armoured Division in Italy in 1944. He was an outstanding young officer at that time, so I was not surprised to find *Across the River* rang very true to life and to all the sapper problems of the fighting in Italy, especially at the time of the Gothic Line battle. As far as I know it is the first of the last war books dealing with the sapper side of the business."

Major-General C. P. Jones, C.B., C.B.E., M.C.
Vice-Adjutant-General

"*Across the River* is the first novel to be written about the Sappers in the last war, and it rings true. It grips the interest and imagination.

"It tells the story of battles, fictional maybe, but very real for all that, which the Sappers fought in Italy in 1944. It follows the fortunes of soldiers and young officers and describes their problems, their disasters and triumphs, their hopes and fears, their easy relationships and their reliance on each other in times of stress.

"It is written by one who obviously saw for himself and understood the fears which he and those around him had to face and defeat."

Major-General N. A. Coxwell-Rogers, C.B., C.B.E., D.S.O,
E. in C., Allied Armies in Italy in 1943

"*Across the River* gives a vivid and realistic picture of what sappers were doing in the fighting area during the war in Italy. It is a thrilling story of the exploits of some of the men in a typical Field Squadron of the Royal Engineers."

ORDER FORM

Please supply me with .... cop.......... of ACROSS THE RIVER, by Richard Jocelyn, published by Constable & Co. Ltd., 10 Orange Street, London, W.C.2, at 16/- net (postage and packing 11d.).

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So much for the sifting of doctrine. As far as hardware was concerned they tried to follow the principle that there is really very little that has not been thought of before. They therefore concentrated on bright ideas related to items already in use and as there was very little money available, the maximum use had to be made of army workshops, both in schools and in units. Coincidentally this proved to be a boon to Territorial R.E. and R.E.M.E. workshops who found that live and interesting work orders acted as a draw during weekday evenings.

Projects were as far as possible given to the appropriate Corps to sponsor, as for example the two given to the R.A.C. In describing these an added light of enthusiasm came into Dixon's eyes, and I must admit that I was beginning to get interested myself.

These two projects were really quite simple adaptations of the rocket-propelled holdfast. The first was designed primarily as a pre-counterattack weapon and consisted of dual rocket-propelled cables. At the rocket end the cables were joined together by two horizontal cables, 50 ft. in length and 50 ft. apart, from which hung sharp weighted hooks on 6 ft. steel traces. The hooks were well barbed. The rockets were fired at a slightly divergent angle to give maximum spread to the cables at destination, the principle being that the cables should straddle the newly captured position and should entangle men and equipment before they had time to get underground. The home end of the cables were anchored to a tank which moved away from the position immediately the cables had landed, dragging away its victims with it. Tests with dummies had proved highly satisfactory and in some cases the weighted hooks had even dropped into foxholes and winkled out their straw-filled occupants.

The second was yet another attempt to solve the problem of increasing the range of the heavy flame thrower. The basic instrument was again the rocket motor towing a line, except that in this case the line was a rather stronger edition of the garden hose and was filled with petrol prior to flight. The rocket end contained a simple revolving spray which switched itself on as the rocket hit the ground. The home end of the line was connected to a petrol trailer towed by the launching vehicle and power was supplied either by pump or air bottles.

The first model to be made had been over-designed to the point of having a petrol-igniting device in the rocket. Tests on the ground against a simulated company position proved the weapon to be much more effective if the major portion of the fuel was allowed to spill before ignition. It could then be lit at any time with H.E. or tracer. The joy of this particular little toy was the fact that any action on the part of the enemy to destroy or cut the line lying across his position merely increased its effectiveness.

We then went on to discuss the infantry suggestions, which I had gathered. had been for the most part minor modifications to weapons or equipment, all very sensible and nearly all very dull.

However, an officer of the Small Arms School at Hythe had unconsciously produced the makings of an excellent one when he rather sarcastically suggested that an additional pouch should be added to the web belt to carry the infantryman's cigarettes to prevent the ammunition pouch becoming filled with soggy tobacco in wet weather. Such a suggestion was of course impossible in this form, but there appeared to be absolutely no reason why the butt of the new rifle should not be lightened by cutting out a recess the size of a packet of twenty, the hole being closed by a small sliding metal plate. The outside of this plate was to be milled to facilite opening and closing with one hand—and matches could also be struck on it. The recess would also accommodate an alternative of sweets and chewing gum for those who did not smoke.

There was, however, one outstanding idea from the School of Infantry, who, thanks to Korea, had been giving increasing thought to the mass attacks so beloved of the Chinese and their friends. This one was merely a refinement of the old chain shot principle, but in spite of that had proved particularly effective on the ranges. Both the Energa grenade and the Bazooka had been used in these trials, the "chain" in each case being 50 ft. of $\frac{1}{8}$ in. diameter high grade steel cable to which had been wired small sharpened steel triangles of about half-inch side. The cable came pre-flaked on conical cardboard dispensers and could be attached in a matter of seconds to small securing rings welded to the side of the grenade or bazooka shell.

The weapons were sited in pairs and the order to fire was given by the previously designated leader of the pair. Plaster of Paris dummies had literally been cut in half by the cable and the School could hardly wait to try it out on live targets. For night work the weapon could be used singly, one end of the cable being fixed to the top of an angle iron picket 50 ft. in front of the weapon pit. In an emergency the operator merely fired his grenade or bazooka at a tangent to the cable and centrifugal force did the rest.

Last, but by no means least, there was the sapper contribution to the party.

Being somewhat biased I think I had better quote rather than misrepresent what at the time seemed rather an unfair exposition.

"I think it was Louis XIV," Dixon said, "who once described his ministers as being as hard to control as a handful of oiled marbles. We found almost the same problem in trying to get our sapper advisers to narrow their field of worries, or should I say endeavours, to a tangible level.

"We were first of all led to believe that the root of a particular problem was the size of a pallet, and then when we were just about ready to make a crisp off-the-cuff decision we were told that perhaps after all the pallet wasn't quite so important as the turn-around time of the ship that brought it. From there it was only a very small jump to the training of crane drivers in port operating squadrons, and thence to the rights and wrongs of wearing a sapper jack-knife whilst dressed in a diving suit.

"At one stage, looking down the conference table, I really thought that we were rehearsing for the Mad Tea Party. The officer on my right was totally engrossed in entwining the initials S.M.E., no doubt his own, in monogram form around a very good perspective sketch of an 'A' frame. Opposite him another member of your Corps fiddled continuously with a working model of a fork-lift truck on which were stacked half a dozen copies of the *R.E. Journal*, all of which I imagine contained his articles. At the far end of the table a very persuasive major was arguing hard with both his neighbours, drawing little crosses on the table with piece of white chalk to emphasize his point. My attempts to interrupt his conversation by asking him his name merely evinced the reply that he was the Station Master at Hamm—or words to that effect.

"I need hardly add that hovering in the background was an Alice-like figure of a W.R.A.C. typist saying 'Shall I bring the tea now, Sir?'

"But chaos notwithstanding, the tea party did produce a rather pleasant scheme in the realm of field defences which we considered urgent enough to follow up.

"You will probably remember from your own experience in the late conflict that whereas ammunition, petrol and food generally manged to find their way to the front, engineer stores were always a bad starter in the bid for R.A.S.C. transport. I was told that it was primarily a question of awkward loads and ungainly packages which put people off, so now your lads have entered very heartily into the field of palletization—horrible word—to make the job of stores handling a little easier. Nothing particularly revolutionary about that of course; the removal and storage boys have been doing it for years.

"What is interesting is the fact that whilst your left hand has been thinking up brighter and better ways of boxing up engineer stores to send up to the front to solve the field defence problem, your right hand, through the medium of troop tests in Germany, has proved that it takes at least fifty potentially non-existent three-tonner loads of conventional revetting material to complete the 'bunkerization'—I excel myself—of one infantry company. An atomic war offers countless opportunities for digging bigger and deeper holes, practising mobility and firing off tons of ammunition, but under no stretch of the imagination would it produce extra transport out of thin air to meet these added commitments.

"With the momentum of over 200 years of tradition behind them, the designers of 'A' frames and scarfed joints in 12-in. timbers took a little time to shudder to a standstill. In the resounding silence that followed this realization, only the gentle ticking of sapper brains could be heard. Pallet and 'A' Frame looked at each other across the table and without a word went into a huddle in one corner, pausing only briefly on their way to collect old envelopes from the remainder of the gathering on which to jot their notes.

"Alice seized the opportunity to quickly dish out mugs of tea all round and it wasn't long after this that Pallet and 'A' Frame returned to the fray with their solution.

" 'There are two major factors" said Pallet, looking uncommonly like counsel for the prosecution, 'which I shall endeavour to prove are so closely related that they might just as well be considered as one.

" 'There is first the need for a pallet, or perhaps I should say a family of pallets, in which can be carried every type of military store, be it food, petrol, ammunition or hardware.

" 'Secondly there is the requirement for a revetting medium which can be used to retain vertical walls as well as support overhead cover. The material must be light, easy to handle, be in sufficient quantity to be issued to all troops in the combat zone and at the same time impose no load on the supply channel.

" 'I should like to submit that these two requirements . . .' I won't bore you," said Dixon with a chuckle, "by imitating Pallet's rather weighty delivery any further—but in brief he suggested that every load carrying vehicle, including the jeep trailer, should have as standard equipment a three-sided pallet which fitted snugly into the load-carrying compartment.

Q

The pallet was to be made of pressed metal or plastic, and as well as having the usual lifting rings and fork lift grooves, was to be designed to cause the minimum reduction in the load-carrying capacity of the vehicle.

"The key to the whole show was the lightening holes punched in the sides of the pallet which acted as embrasures and firing slits when the pallet was inverted over a hole in the ground. I should also add that the sides were easily removable, and, with the base, could take the place of corrugated iron for normal vertical face revetment.

"Pallet here got quite carried away by his enthusiasm and took us in great detail through the life cycle of the hybrid from the moment it left the ship to its final resting place as overhead cover for a Bren gun team of the Black Watch. I won't waste your time by doing the same thing but I am sure you will see that the implications are pretty far reaching.

"A couple of weeks after our meeting, Pallet and 'A' Frame produced detailed drawings and a magnificent set of 'palletized' dinky toys. Thus armed, the three of us later that week descended on D.W.D. at the War Office in an attempt to extract his approval in principle. I shall never know whether it was the logic of our argument or the fact that by sheer coincidence the dinky toys had the D.W.D.'s late divisional sign painted on them that finally won the day, but the old boy was simply delighted.

"As a result of all this we now had permission, and what was far more important, the money, to order enough pallets to equip a complete brigade group on the scale of three pallets on the ground to every pallet on a vehicle. The manufacturers, seeing that if all went well this project would prove to be the thin end of a very large wedge, gave us a high production priority—and the brigade now has the pallets."

Dixon paused to knock the ash out of his pipe, and as he straightened up again I noticed a look of puzzled dismay pass over his face. He was staring at the clock on the wall and appeared not to hear me when I asked him if anything was wrong. I waited a few moments and repeated my question. He turned round quickly, as though suddenly remembering my presence, and with an embarrassed smile whispered in my left ear what sounded like an apologetic farewell.

It must have been, for the next moment he had left the room and although I hurried after him to the front porch he had already been swallowed up by the gathering darkness of St. James's Square.

My left ear, for rather obvious reasons, is not as good as it might be, but I could have sworn that he said something about having promised them at Netley that he would get back before dark because of the full moon.

It is all very puzzling.

Some New East African Timbers

By CAPTAIN A. H. HARRISON, R.E. (A.E.R.)

WITH the expansion of the East African Forests Department certain new timbers have been brought forward for utilization in this country on a commercial basis and it is thought that Engineer Officers would like to be acquainted with some of these. The writer therefore submits the following with comments which may be of interest. Technical data has been omitted, save for the botanical names which are included for identification purposes. There are many timbers which come from East Africa, but only the newer and more rare species have been included.

MWANGA (*Afrormosia Angolensis*). Very similar to the well-known West African afrormosia which is used widely in this country as a substitute for teak. Has pleasant khaki colour with an occasional green tint; can be used for joinery and cabinet work.

BRAYERA (*Hagenia Authelmintica*). Heartwood is rich reddish brown, planes to a very fine finish. Could be used for furniture and good strip flooring.

MULULU (*Chrysophyllum Albidum*). Pale brown in colour, of medium texture. Straight grained, as from a very tall tree, which it is; little or no interlocking. A good general purposes wood.

LOLIONDO (*Steganthus Welwitchii*). An excellent wood for flooring, but supplies not too good. Has a mottled colour from pale brown to deep brown, sometimes with a pleasant roe figure effect. Very hard and durable.

MFURANGI (*Albizzia Spp*). One of the many specie of *Albizzia*. Moderately hard and tough. Can be used for furniture and floorings.

MLOMBELOMBE (*Mitragyna Rubrostipulata*). Could be called *East African Abura*. Light golden brown in colour, but with little character. Adaptable to turning and will not split easily. Suitable for plywood and pattern making.

MKOMOHOYA (*Pygeum Africanum*). Reddish brown and with rather a wild grain. Suitable for heavy construction work. Door frames and windows.

MKONGONI (*Trichilia Emetica*). One of the mahoganies with a pinkish brown heartwood. Suitable for manufacture of furniture.

MKOBAKOBA (*Baikiaea Emini*). Softish and light in weight. Yellowish brown in colour. Suggested for interior joinery, kitchen cabinets, etc.

MUBURA (*Parinari Holstii*). Heartwood dull reddish brown. Has close interlocked grain. May contain large deposits of silica and care should be taken with tools, etc. Suggested as bridging timbers, sleepers, floorings, and similar.

MUCHENCHE (*Netonia Buchanania*). Pinkish brown in colour with sometimes a pronounced greenish tinge. Suggested for general work in joinery.

MUHIMBI (*Cynometra Alexandii*). This timber has been known on the English market and has been called Uganda Ironwood. Heavy hard wood, with good bending and compression factors. Heavy construction work is suggested here.

MUHUMULA (*Maesopsis eminii*). A light wood, but strong with interlocked grain. Interior work only suggested.

MSAMBU (*Allanblacksia Stuhlmanii*). A very striking dark brown to blood red heartwood. Moderately hard and heavy. Cabinet work of a more decorative nature.

MSABULA (*Parinari Spp*). Reddish brown. Very hard and moderately heavy. Ideal flooring wood.

MROMA (*Cordyla Africana*). Yellowish brown wood. Hard with an interlocked grain.

MUGONYONE (*Apodytes Dimidiata*). The white pear. Straw to brown in colour. Suggested for turnery. Little character in the timber, but it is fairly hard and strong.

MUMULI (*Holoptelea Grandis*). White to pale yellow. Fairly close and even texture. Large quantities are now available, and it is suggested as a general purpose timber.

MUSIZI (*Maesopsis Eminii*). Heartwood is a bright yellow green to pale golden colour. A general purpose hardwood which could be utilized in general building construction.

MUSHABARARA (*Drypetes Sp*). Pale yellowish white. Straight grain and has a "silky" feel when planed. Strength similar to that of Iroka, though it is somewhat heavier. Suitable for internal joinery purposes.

NKOBAKORA (*Baikiaea Minus*). Whitish brown, often marked with streaks of dark brown, moderately hard and heavy and has straight grain. Suitable for floorings, heavy construction, but as it is very prone to attack by pin worm, I cannot recommend it for sleepers.

NKUNYA (*Manilkara Cuneifolia*). Very dense and is exceptionally hard. It has a rich reddish-brown colour and is fine and even in texture. Suggested for marine work, heavy duty flooring and for mining construction.

MUSUGA (*Olea Welwitschii*). Yellow brown to pale red-brown with dark brown streaks. Hard and fairly heavy. Planed surfaces are usually somewhat lustrous. Suggested for heavy construction, bridge beams and decking, etc.

NKOBA (*Lovoa Brownii*). This wood might be likened to the well-known African walnut (*L. Klanecina*) and could be used as a substitute. High-class decorative work, furniture, etc.

MKARAMBAKI (*Warburgia Stuhlmannii*). Yellowish to olive green. Very hard and heavy and is recommended as a substitute for greenheart.

The Author will be pleased to supply further details of these timbers, and if required, send samples for cost of postage only on application to him at 46 Huxley Road, Welling, Kent.

Memoirs

MAJOR-GENERAL R. L. B. THOMPSON, C.B., C.M.G., D.S.O.

Richard Lovell Brereton Thompson was born on 23rd November, 1874, the son of Colonel Richard Thompson, C.B., R.E., and was educated at Mannamead School, Plymouth, and the R.M.A. Woolwich, where he passed out top, at the minimum age of 16, with over 25 per cent more marks than the second candidate.

Commissioned in the Corps on 10th February, 1893, he was posted to Malta on completion of his course at Chatham in 1895, and served with the 24th Fortress Company.

Here he met Louise Vassallo, the daughter of P. P. Vassallo, Esq., whom he married in 1898 and had a very happy married life for fifty-eight years, till she died in 1956. Unfortunately for the last nine years of her life she was an invalid in a nursing home where her husband visited her almost every afternoon without exception. They had one son who joined the Corps in 1919 and retired as a Lieut.-Colonel in 1948 and a daughter who is married.

On returning to the U.K. from Malta in 1901, he was posted to the S.M.E. Chatham as an Assistant Instructor in Fieldworks, where he remained till 1906, having been promoted Captain in 1904.

On leaving Chatham he went to India, first as Garrison Engineer at Bombay and then at Quetta. Returning again to the U.K. in 1910 he was posted as a Staff Captain in the D.F.W.'s office, where he was still serving on the outbreak of war in 1914, having been promoted Major in 1913.

At first he acted as Liaison Officer between the Director of Works in France and the D.F.W. in the War Office arranging for the priority of the supply of stores. Early in 1915, however, he went to France on the Staff of the Director of Works where much of his work was concerned with the supply of timber, enormous quantities of which were required for revetting trenches and making dugouts. In 1917 a separate Directorate of Forestry was formed and Thompson was made the Deputy Director, which appointment he held till the end of the war.

For his services during the war he was mentioned in despatches three times, promoted brevet Lieut.-Colonel in 1915, was awarded the D.S.O. in 1917 and appointed a C.M.G. in 1918.

After the war he served successively as D.A.D.F.W. in the War Office from 1919–20, C.R.E. Lowland Division in Scotland 1920–21, and C.R.E. Singapore 1921–24. He was promoted subst. Lieut.-Colonel in 1920 and Colonel in 1924 with an ante-date for seniority, June 1919.

After a short period on half pay he was appointed A.D.F.W. at the War Office in 1925 and Chief Engineer Western Command in 1929, in which year he was also appointed a C.B. In 1930 he was promoted Major-General and became Director of Works at the War Office the following year, which appointment he held till he retired in June, 1935.

It was during Thompson's period of office that the title Director of Fortifications and Works was temporarily changed to Director of Works. The original title which had been in existence since 1904 was resumed again by his successor Major-General S. D. Collins. As for a hundred years before 1904 the title had been Inspector-General of Fortifications, it was unfortunate that the Army Council decided to drop the title of Fortifications even for so short a period.

Thompson was made a Colonel Commandant R.E. in 1939, and died on 11th May, 1957, at the age of 82.

His main recreations were shooting, fishing and tennis. He always tried to find a bit of rough shooting wherever he was stationed, and even during the 1914–18 War in France, whenever possible, he would snatch a brief period from work to go out with a rod or gun.

He was a strong character, in which a high sense of duty was blended with his love of sport and keen sense of humour. He is much missed by his son and daughter and grandchildren, and all those amongst whom he spent his latter days.

H.W.T. says:—

"R.L.B. was always cheerful and had a keen sense of humour, seeing the humorous side of things however difficult the problem. He had a wide experience of Works Services and his decisions as Director of Works on matters affecting buildings, etc. were carefully thought out and sound. He had an exceptionally clear brain, much above the average." C.C.P.

BRIGADIER S. A. H. BATTEN, C.B.E.

Stephen Alexander Holgate Batten was born in London on 3rd July, 1898, the second son of John Holgate Batten and his wife Jane Leckie Forbes. He was educated at Uppingham and the Royal Military Academy. Commissioned in the Royal Engineers on 26th August, 1916, he served in France with the 1st Field Squadron during the latter half of 1917 until the end of the war, and was mentioned in despatches.

In October, 1920, he went up to Clare College, Cambridge, on a "Supplementary" course for one year.

From 1921 until 1931 he served in various sapper units in the United Kingdom, doing an equitation course at Weedon in 1923 and from September, 1926, to December, 1930, was Adjutant of the Royal Monmouthshire R.E. (S.R.). He was promoted Captain on the 16th November, 1926.

In March, 1931, he went to India as Garrison Engineer, Meerut, until March, 1933, when he joined the Bengal Sappers and Miners commanding first, 8th Army Troops Company at Roorkee and secondly, 5th Field Company in Nowshera. He returned to the United Kingdom in December, 1935.

From June, 1936, to December, 1938, he was D.C.R.E. East London, being promoted Major on the 23rd December, 1936. In March, 1939, he went to Palestine as S.O.R.E. 2, at the H.Q.s at Jerusalem, and was there when war broke out.

He spent the early part of the war on special duty in Turkey and was awarded the O.B.E. in January, 1942. He was then C.R.E. of an armoured division in the North African desert. He was appointed acting Lieut.-Colonel in March, 1941, and promoted substantive Lieut.-Colonel in January, 1943. In the summer of that year he came back to the United Kingdom and was

Major-General RLB Thompson CB CMG DSO

Brigadier SAH Batten CBE

appointed Temporary Brigadier and Deputy Chief Engineer, 21 Army Group. He went to France with the Invasion Forces and remained as Deputy Chief Engineer for the rest of the war, being awarded the C.B.E. on 1st February, 1945, Commander, Legion of Merit, U.S.A., on 15th August, 1946, and Knight Commander of the Order of Orange Nassau with swords on 23rd May, 1947. He was mentioned in despatches in July, 1940, and November, 1945.

In July, 1946, he became Deputy Chief Engineer, British Army of the Rhine, returning to England at the end of that year, when he was given command of the 27 A.G.R.E. (T.A.). He retired on 11th December, 1948.

On retirement he became Chief Engineer of the English Section of the Forestry Commission, in which appointment he remained until he retired on account of ill health in October, 1956. He died on the 10th January, 1957.

Steve Batten was a fine horseman and show jumper and the following is an extract from Vol. VII of the *History of the Corps of Royal Engineers:*—

"In 1925 he was the first R.E. Officer to compete at the Royal Tournament and International Horse Show, and qualified for the Daily Mail Cup with his two horses, 'Milly' and 'Ghurka'. In the International Horse Show he was placed 2nd and 3rd in the King's Cup, 2nd and 3rd (three times) in the Connaught Cup and 2nd in the Canadian Cup. He also won open jumping pools. He was selected as a Reserve for the British team in the Prince of Wales Cup. At the Royal Tournament he was placed 2nd and 6th in the King's Cup and 3rd and 4th in the Prince of Wales Cup.

"In the Aldershot Command Horse Show and Bronze Medal Tournament, he was a member of the R.E. Mounted Depot Team which won the Open Jumping three times. Batten was also a member of the British jumping team that competed at Rome and Nice in 1927."

He also drove the R.E. Coach at Ascot and was a keen follower to hounds. Besides his riding he was an all round games player. He represented the Corps at golf in the Triangular Tournament against the Royal Artillery and Household Brigade in 1921, 1922, 1923, and 1924. He was a good tennis player and was in the Clare VI when up at Cambridge. In 1922 he and his partner H. T. S. King playing as R.E. Chatham reached the final of the Army Doubles and only lost to Captains R. G. Stone and L. C. Owen, also representing the Corps, 11–9, 6–8, 4–6, 6–0, 7–9.

He was twice married. There were two daughters by the first marriage and a son and daughter by the second.

J.D.I. writes of him as follows:—

"Steve's personal characteristics made him an ideal staff officer. He was well liked by all with whom he had to work and did much to promote the excellent relations which the Corps enjoyed both with the staff and with the services at 21st Army Group Headquarters.

He was exceptionally modest about his achievements as a horseman and as a tennis player. He was perhaps a curious mixture of shyness and quiet confidence which with a highly sensitive nature gave him his great charm and made him such a lovable personality." J.F.B.

Book Reviews

SECRETS OF SUEZ

By Merry and Serge Bromberger

(Published by Pan Books Ltd. Sidgwick and Jackson Ltd. Price 2s. 6d.)

It would be wrong for a reviewer, who had been to some extent "in the know", himself, and who took part in the Suez Operation in 1956 to comment on the veracity or otherwise of this book, *Secrets of Suez*; but no soldier could possibly read it without feeling that the authors have written a compelling book. The argument of the book—and, I stress that I do not comment upon the accuracy of its basis—is this: Intervention was agreed upon by the heads of the British and French Governments, as being the best solution in the last resort to the situation created by Nasser's seizure of the Canal in July 1956. The French felt that both justice and expediency demanded intervention, but Sir Anthony Eden, so the authors tell us, was not so sure about it. He could not bring himself to turn into a Bismarck and order the thing without scruple. He wanted something to happen that would give him a cast iron reason for resorting to force. That something *did* happen—the Israeli attack. The French knew all about this beforehand and tried to get the British to see eye to eye with the Israelis and themselves; but the scrupulous Sir Anthony preferred not to share their knowledge, and did not allow his subordinates to share it either. The authors think the British were very foolish in their attitude here; and they say that it lengthened the odds against success. According to them, Sir Anthony Eden forbade even a single ship to sail before he had his cast iron excuse for intervening. The sailors could not therefore set ships in motion from Malta or the Home Ports till Eden had issued his ultimatum to both Israel and Egypt. As it takes six days for a ship from Malta to reach Port Said, and twelve from England, it followed that no seaborne landing could happen for six to twelve days after the ultimatum. If anything were to be done in the meantime it would have to be through the medium of the air. The British, the authors say, were so obsessed with the memories of Arnhem that they would not countenance parachutists being dropped more than twenty-four hours in advance of the seaborne assault. Consequently reliance had to be placed on what they call "aeropsychological" warfare. This, they say, should have been a skilful *blitz*, attacking every target whose destruction was calculated to lower the morale of the Egyptian people. But again, they say, Eden could not bring himself to allow anything so ungentlemanly; and a polite kind of bombing was decided upon instead. So polite was it that it had little or no chance of unseating Nasser.

While this emasculated bombing went on, day after day, the Russians and Americans, from different motives, became irrevocably aligned in the councils of the United Nations against the Anglo-French allies. At last, when the landings actually began (airborne on 5th November, and seaborne on 6th November) the forces on shore were really fighting time rather than the Egyptians.

It was then, say the authors, that bad communications intervened fatally. The need for haste was realized acutely in London and Paris, but not by the Force Commanders on the spot. Simultaneously, no one in London or Paris knew that the Force Commanders were unaware of this need for haste. Consequently the Force Commanders thought they could wield their sledge hammer in the massive way they had planned; and the politicians supposed that they had abandoned a cumbersome plan in favour of something much more in accord with the needs of the situation as they saw it. The imminence of a cease fire order was not, because of bad communications, realized by the Force Commanders; and the fatal consequences of that cease fire were not, also because of bad communications, realized in London and Paris, where it was supposed that operations were going more quickly than they were. The result was therefore inevitable.

Through all this maze of politics, planning and operations the authors lead the reader in the breathless prose of press reporters. But, although they feel that the British erred both in London and in the field, they never say an unkind word about them. Indeed, they go out of their way to see good in British actions and intentions, and they say many complimentary things about the quality of British fighting men.

They claim that their account is a fair one. Whether it is fair in the sense that the facts are correct is a matter on which it would be wrong to offer an opinion here. But whether the facts stated are right or wrong it must be granted at once that a generous interpretation has been put on them. It must also be said that no attempt is made to be wise after the event, though lesser writers might have fallen prey to this temptation. Soldiers should study and learn from this book—whether the facts are right or wrong—for it illustrates the interactions of politics and fighting and the incalculable effects of that imponderable factor, the fog of war.

The book is excellently translated by James Cameron, though the political opinions of the translator—whether one agrees with them or not—do not seem very relevant, and might perhaps have been omitted from the Translator's Preface at the beginning.

M.C.A.H.

Editor's Note. In view of the very controversial comments which have been published in the Press about this book, readers are advised to study the "Publisher's Note", the "Translator's Preface", and the "Author's Foreword".

ACROSS THE RIVER

By Richard Jocelyn

(Published by Constable, London. Price 16s.)

One is apt, in this atomic age, to exaggerate the importance of machines in a future war, welcoming military automation as though to solve all one's problems; as though man-management is now replaced by machine handling. *Across the River* is a timely reminder that the man is the sinew of war most likely to influence its success or otherwise. The sappers, reliable and not so reliable; the corporals, the sergeants and the sergeant-majors who never change; the officers, good and not so good; these are the meat of this book.

My reluctance to begin what I imagined was just "another war book" was tempered when I read inside the paper cover that the book concerned the exploits of a field squadron advancing up Italy in 1943. The other flap of the cover told me the author, writing under a *nom-de-plume* was a serving Sapper with considerable experience in command of squadrons. Was this going to be a training memorandum in a different cover? This could be boring and as I began the book I was prepared to be bored.

The introductions to the main characters were unlaboured and spontaneous. I liked the idea of the S.S.M. with the "respectfully amused tolerance towards young officers, now extended to majors as well", disapproving slightly of the flambuoyant background of his new O.C., Major Dan McGilligan. The S.S.M. decided that, to preserve the respectability of the squadron, he must "take the Major quietly but firmly in hand". Now a posting order is no help to a new O.C. in this sort of situation, but Dan McGilligan turned the episode, in that French chateau outside Tunis, to his advantage. I felt I could see the S.S.M.'s face "suffused with a cunning smile" as he tried to fool the O.C., and could feel his "speechless rage" as his little plot failed. Command of the squadron was not in doubt from that moment and throughout the story runs the thread of Dan McGilligan's almost indefinably sound process of command. All trace of my boredom had gone.

The story is told in a simple, sincere way. The detail and the circumstance is authentic. After a short inter-troop exercise in mine-detection, the squadron is required to support a brigade in an advance on two routes which has as its objective the seizure of crossings over "The River". Mine reconnaissance is seen through the eyes of Nick Boonin, a remarkable troop commander, who existed in fact, and who was killed in Italy doing things the book describes so well. Mine warfare is a battle of wits between layer/booby-trapper and the lifter. Sapper Collins saw it that way and he regarded every mine as his personal enemy; he treated each with a fierce hatred. We see how his morale was steadily sapped by the thought that one day one of his malevolent enemies would beat him. One nearly did.

You will perceive the perversity of nature in holding back the flood waters until the culvert was almost complete, only to sweep it away in a moment, as those who toiled and sweated to finish it in time stood dejectedly watching on the bank. You will be amused at Peter Lyon's encounter with the Town Major who suffered from the "occupational hazard" of growing very fat. And finally, that is except for a revealing anti-climax, you will be brought face to face with "The River."

You will not learn from this book how to build a raft or lift or lay a minefield. But if you served in the last global war you will find the story nostalgic. If you are younger, you will learn as much about man-management and the human aspect of field engineering with all its frustrations and joys as can be learnt from a book. If you have no connexion with the Service you will just enjoy reading a good novel.

D.R.C.

BY COMMAND OF THE EMPEROR—A LIFE OF MARSHAL BERTHIER

By S. J. Watson

(Published by The Bodley Head, London. Price 25s.)

"As Chief of Staff, Berthier has no equal" said Napoleon. Yet in spite of this high praise, the libraries of the British and American staff colleges have no biography of Berthier in the English language. Each of them can now rectify this strange deficiency by acquiring a copy of this very human book. In making it so, the author shows his understanding of the modern world's immense relish for close-up studies of famous peoples. The cinema, radio and television, as well as books, are busy tearing away the veils of private life and broadcasting their discoveries to the public. Perhaps rather to their secret chagrin, "peeping Toms" find that great men and women stand up well to nearer scrutiny. When Napoleon in his bath splashed water derisively at his tiresome brothers, he was still no doubt a remarkable spectacle. For the great have stature in little things and do them with an air. In point of fact, the best books on war have always devoted much attention to the idiosyncracies of their chief characters. Otherwise military history would have the triteness of mere despatches and only experts would bother to read it.

The hero of *By Command of the Emperor* emerges as a man of immense physical strength and of indefatigable industry. He was close on sixty years of age and still in good fettle, when he recrossed the Niemen after the rigours of the retreat from Moscow. During the Jena Campaign, which is admirably set out, he went for thirteen consecutive days and nights without sleep. The copy of an excellent engraving, undated but later than 1809, portrays a short sturdy man with strong legs and thighs and an appearance of unruffled calm. The same imperturbability of countenance is apparent in Gros' romantic picture of Berthier with an enormous sword at the bridge of Lodi. A man of lesser strength, industry and calm would have collapsed under the labours, which for so many years Napoleon thrust upon him. Major Watson does what he can to suggest that Berthier was a good commander, as well as being a superlative chief of staff. The evidence of this is not convincing. The generals, who were subordinated to him, usually savage and sometimes quarrelsome men, soon seemed to get restive. We see him looking round, almost anxiously, for the arrival of his master. Indeed Napoleon's domination was so absolute, that he even arranged Berthier's marriage for him, just as he tried to do for the members of his own family. And this was in spite of Berthier being deeply in love with another woman!

Sidelights on the extraordinary character of Napoleon perforce enrich the book. Napoleon's comment on the field of Borodino, as he rode over it after the battle, is also mentioned in Colonel Jackson's *Seven Roads to Moscow*. The two accounts have interesting differences. It is perhaps a little hard on Lucien Bonoparte to describe him (see page 85) as "shallow and facile". After all, Lucien behaved with great decision during the events of Brumaire and even Napoleon found him a tough proposition.

On the whole, however, there is little at which to cavil in this measured and well-balanced biography with its few but extremely well chosen illustrations. Readers will enjoy the wideness of a purview which ranges from the American War of Independence to the opening moves of the Waterloo Campaign. A script writer of any worth could turn *By Command of the Emperor* into a magnificent film, for it has everything—war in many fascinating lands, a complicated love story and a dramatic, although tragic ending.

The authors acknowledgements to his C.R.E. and his S.S.M. are pleasing in themselves. They also suggest a commendible belief amongst all concerned, that the absence of officers from a unit is often a good thing. B.T.W.

LANDSLIDES IN CLAYS

By ALEXANDRE COLLIN—1846. *Translated by* L. W. R. SCHRIEVER

(Published by University of Toronto Press. London: Oxford University Press. Price 52s.)

The prospective reader would be well advised to ask himself two questions before he starts on this book. Do I expect to arrive at a greater understanding of the factors affecting slides in clay? or do I want to read a narrative of the major failures in clay cuttings and embankments of the French canal system that occurred during the middle of the nineteenth century?

If the reader's interest is attracted by the answer to the first question, then there is little in the work for him, and he would be better engaged upon a study of a standard modern work in soil engineering. With this knowledge a certain amount of value may be derived from Collin's book by applying modern theories to check the effects of failure which he has so meticulously recorded.

If the answer to the second question covers the reader's interest, then further study will be rewarded. Here will be found lengthy descriptions of failure, even lengthier diagnosis of the cause; and all based on the flimsiest knowledge, often at variance with the evidence. Notable exceptions are the ideas put forward by Collin, who undoubtedly was remarkable in his time for his refusal to warp facts to fit theories. The work is a translation of Collin's memoirs but despite the efforts of the translator to use modern word usage, the verbosity and pedantry of the period are still very much in evidence in the ponderous sentences and metaphysical arguments so often quoted.

Professor Skempton states, in a very interesting introduction, that Collin might well be regarded as one of the pioneers of soil mechanics; but this is perhaps taking veneration of the antique too far. Collin's contribution can be fairly described as a refusal to accept as "truths" the authoritative utterances of the famous engineers of his time—notably that cohesive soils did not conform to Coulomb's conception of a wedge of failure along a plane surface, and neither were the curved surfaces of failure the result of the pre-existence of these surfaces.

He observed at an early stage in his career that the geometrical shape of the profile of the slip surface was the cycloid; and he was also aware that the shear strengths of cohesive soils varied with moisture content.

It is, therefore, surprising that his attempt to analyse the stability of a slope using his observations were by his own admission inconclusive, and were relegated to a note in the back of his book. Here is the pity, for under certain circumstances, the method is valid and gives results that accord well to those failures noted in practice. In being so easily dissuaded from his convictions the foundation of soil mechanics was delayed for nearly three-quarters of a century.

A criticism that may be made against the publishers is the reproduction of Collin's sketches, of which there are twenty-one, in that the scale of the plates is such that it is difficult to read the descriptive letters on the sketches, which makes it even more difficult to follow the descriptive matter of the text. J.P.F-S.

TECHNICAL ASPECTS OF SOUND

Volume II

Edited by E. G. Richardson, B.A., Ph.D., D.Sc.

(Published by Elsevier Publishing Co. Price 70s.)

The second volume of this treatise deals with the ultrasonic range and underwater acoustics, and as this subject matter might suggest it is of a rather specialized nature. The volume is a collection of contributions by authors eminent in their specialized fields, and so while it is always authoritative it is not uniformly easy to read.

A common form for each section has been adopted, which is a more or less rigid mathematical analysis of the fundamental equations governing the phenomenon under consideration, followed by a discussion of the variables in these equations, concluding with practical applications of the principles and techniques discussed in the earlier part of the section.

This arrangement results in a book which is of considerable value to the designer and technologist concerned with ultrasonic equipment, while the latter part of each section is of interest to the general reader. The explanation of the now familiar echo sounding device and ASDIC equipment are well covered together with limitations of these equipments, perhaps not so well known.

Of topical interest, now that an earth satellite has been launched, is the discussion on the probable existence of progressively warmer layers in outer space, the result of experiments carried out on the total reflection of sound, and observations of sound waves of large intensity heard at distances of hundreds of miles from their source.

It is recommended that the book be read in a selective manner by the general reader and that attention should be mainly devoted to the subject matter dealing with applications of ultrasonic methods. Others with specialized training in sound engineering will benefit from a more complete study of the volume. The very comprehensive list of references, of which there are 374 alone for the first part, make the volume a most useful reference book on this aspect of sound. J.P.F.-S.

Technical Notes

CIVIL ENGINEERING

Notes from *Civil Engineering*, May, 1957

A New Development of Prestressing Concrete in France

This article by M. S. Winiarski contains information on some new techniques which are particularly applicable to pretensioning prestressed concrete. After some preliminary discussion on the relative merits of pretensioning and post-tensioning, in which the author concludes that the disadvantages due to stress concentrations in anchor blocks, and the friction in ducts of post-tensioned systems favour construction by pretensioning. An interesting feature in post-tensioning systems not usually recognized is the liability for a group of wires in a cable passing round a bend to trap some of the wires in the group before these are stressed, thereby leading to those wires having part of their length unstressed, while the remaining length is overstressed. It is unfortunate that the descriptive matter in the article is not as clear as it might be; but the diagrams included give a reasonable idea of the use of some of these new ideas. One of which allows 0.276 in. dia. wire to be used with internal anchors in pretensioning, instead of piano wires and the normal tensioning block. Another is the use of hinged bend anchors to obtain a change in direction of stressing wires in pretensioned beams. The idea of using a reinforced concrete channel section beam to form both the function of formwork for a precast beam and also the strut system between the end jacks is one that might receive more attention.

Field Measurements on a Composite Slab Girder Bridge

A problem that those who have classified deck type bridges may have encountered is that of deciding to how many of the main beams does the deck system distribute the load. The article describes a full scale test on a composite deck bridge. This consisted of a reinforced concrete slab cast with the top flanges of nine plate web steel girders embedded in it thus producing a composite Tee beam construction.

The amount of distribution that might be expected was worked out in accordance with an expression derived by the University of Illinois; and the actual stresses were observed by measuring strains on main girders, both by the use of electrical resistance strain gauges and mechanical gauges.

Much of the article deals with the technique of applying electrical resistance strain gauges to steel, and carrying out the tests, but at the same time it contains two interesting conclusions.

1. The design based on interpolated curves of distribution obtained from a five-girder system was conservative, actual stresses were 50 per cent of those expected.
2. Electric resistance strain gauges proved an effective means of measuring stress.

Notes from *Civil Engineering*, June, 1957

Rapid Determination of Influence Lines for Three Pinned Arch Ribbed Domes

The authors set out to provide straight forward formulae, which will enable designers to draw influence lines for this class of structure. They are to be congratulated in their achievement of this aim. In two pages they present their formulae which takes into account:—

(*a*) Vertical and Horizontal loads applied at any position on the ribs.
(*b*) Existence of any number of ribs provided they are arranged in cyclic symmetry.
(*c*) Bending moment, shear force, and axial force in the ribs.

The article concludes with an example on how the influence lines for an eight ribbed dome can be calculated and plotted. The article should prove useful to any designer, as it contains information not usually available in design hand books.

Model Analysis of Belfast Power Station Building Frame

Readers of the June issue of the *Journal* will be familiar with the author's method of analysing stresses in difficult frame structures by the use of large models, upon which easily scaled deflections can be impressed. The present article, the first of a new series, describes how the method was applied in practice to the frame of the Belfast power station, a rather complex frame, to determine influence line diagrams for both wind and vertical loads. The results are compared with results obtained using the classical slope deflection method; and also those obtained, using a digital computer method, which took into account both flexural and direct strains. The results will come as a surprise to engineers, who may have considered the effect of axial distortion as negligible. Considerable differences apparently occur between results calculated by the three methods under the vertical load: the slope deflections method being most widely out as can be seen in the following example. In one case the values given by model analysis, slope deflections and digital computer were: + 79, + 157, — 6 respectively. The rest of the series will be devoted to showing how the model analysis method may be corrected for axial distortion. The article is to be concluded.

Notes from *Civil Engineering*, July, 1957

The Failure of Concrete Compression Test Specimens

The presence of failure planes at angles inclined to the direction of loading in test specimens has generally been ascribed to diagonal shear failure in the concrete. The author has concluded that this is not so, and that in most cases the failure is due to lateral tensile strain induced in the specimen. The argument is that concrete is a material which has an ultimate strain of order .0001 to .0002 in tension and .002 to .004 for compressive strain. Poisson's ratio for concrete is about a quarter. The result is that in a specimen under compressive load the ultimate strain in a direction transverse to the applied load is reached before the ultimate compressive strain along the axis of the load can be achieved. The effect is therefore one of splitting along the axis. This, in fact, has been observed in specimens where precautions have been taken to prevent restraint at the platens of the test machine. The diagonal planes previously observed are stated to be the result of frictional restraint due to the platens, which for the test cubes generally used extend over the full depth of the cube. Taller test specimens after failure show the diagonal planes extending for a distance down from the platen commensurate with the cross section of the piece, and then the longitudinal split postulated by this theory occurring along the central portion.

The New Longton By-Pass

The article describing the work on this concrete road, which is due to be completed in October, 1958, is of interest in that it describes in some detail the specification laid down to achieve the high standard required. The work, with the exception of some work on a roundabout, was carried out entirely by machines. The carriageways are 24 ft. between kerbs, and consist of a 10-in. air entrained concrete laid on a 1-in. bed of sand spread and compacted on a surface dressed base of burnt shale with a minimum thickness of 6 in. Two course construction was decided upon, and this facilitated the positioning of the layer of fabric reinforcement placed at the top of the first course. The mix varied in each course, an aggregate/cement ratio of 7.75/1 was used for the bottom 7½ in. thick layer and 5.75/1 for the top layer. Strengths of 5,500 and 7,500 lb./sq. in. were usually achieved against the 4,000 lb./sq. in. specified. The compacting factor in both courses was 0.82 (about ½ in. slump) with a water cement ratio of 0.54 for the bottom course and 0.46 for the top course. Each course was laid by a separate train of plant consisting of one spreader and one finisher, operating on rails supported by the road forms. The spreading machines were fed with side tipping lorries, and by this arrangement 500 ft. run of carriageway was laid in a day. The surface of the concrete was finally finished by brushing; and curing with an aluminized curing compound, sprayed on to the surface. Special care was taken with expansion joints to reduce surface irregularities. This was achieved by sawing through the surface of the green concrete to previously positioned planks of chipboard.

The Safe Use of Electricity on Building Sites

The author, a senior electrical inspector of factories, states in his opening remark that there is a tendency in the building industry to take the dangers of electricity too lightly, and no doubt this will find an echo in the minds of readers familiar with site conditions. Apparently all the troubles may be traced to non compliance with Regulation I of the Electricity Regulations, which incidentally form part of the Legal Code for this country. This states: firstly, that only apparatus suitable for the work it may be called upon to do should be installed; secondly, it should be properly installed; thirdly, that it should be efficiently maintained after installing. The regulations are deliberately couched in general terms and leave their final interpretation in the hands of the court. Specific codes specifying ways and means, being covered by codes and specifications issued by the British Standards Institution.

It is shown by statistics, garnered since 1900, that accident rates have followed the same general rise as the consumption rates for electricity, until 1948 when despite the increased consumption the accident rate showed a decreasing trend. This is ascribed to recommendations made by the Factory Department to reduce the voltage of hand tools. Among the items listed as dangerous are:—

(*a*) The general use of vulcanite indiarubber cable instead of extra heavy tough rubber sheathed cable for both portable apparatus and for fixed temporary wiring.

(*b*) Cab tyre type "Fairyland" strip lighting with detachable lamp holders.

The cause of electric shock is dealt with in some detail. It is interesting to read that the resistance of the human body to alternating current varies with the frequency as well as with the voltage and that at 60 V. it is 4,000 ohms compared with 1,000 ohms at 120 V., while 25 to 50 cycles per second is stated to be the worst frequency range. This is one of the reasons behind the move to reduce the voltages on portable hand tools. The only reason why more shocks are not lethal is that apparently fortuitous contact resistances may be present up to 200,000 ohms. There is some confusion in the article over the lethal current. An example worked out indicates this to be 50 m.a.; while an undescribed graph shows it at 10 m.a. Presumably this is for current passing through the heart. The article continues on dangers related to fusing, and concludes that the cost of a circuit breaker instead of a fuse is justified for currents above 100 amperes.

Earthing is dealt with and includes the circuit diagram for a loop tester, and describes with an example how the earth fault loop resistance can be calculated. The article is to be concluded.

A Prestressed Concrete Road Bridge

The 126 ft. bridge across the River Glatt near Zurich is an interesting example of the aesthetic forms this new medium permits. The deck is a solid slab about six inches thick, carried on two inverted trestles, which divide the length of the bridge into three spans 25, 76 and 25 ft. Strict analysis of the structure would have involved the determination of nine redundancies. The work has, however, been simplified by assuming the structure to act as a hinged arch with two cantilevers, a consideration prompted by the relative stiffnesses of the trestle legs and the bridge slab. The assumption has been fully justified by careful measurements for strain and deflection since carried out by the Federal Laboratory for Testing Materials. These showed a very close agreement between calculated values and measured values. The presentation of the stress diagrams and deflected forms of the bridge by isometric sketches is an unusual and helpful method of showing the complicated relationship between the various values. There is also an intriguing reference, unfamiliar to British readers, which is the fact that the stresses were calculated in accordance with the influence surface method of Olsen and Reinitzhuber in their publication *Die zweiseitig gelagerte Platte*. The article concludes with an analysis of prices which in pounds sterling is £9,649 for the bridge; or £23.4 per sq. yd. top surface.

An Unusual Method of Concrete Bridge Reconstruction

Of interest to military engineers, aware of the replacement bridging problem in the communication zone, is the method used by the British Railway Engineers when they carried out the work of putting a new bridge at Cooks Green on the London–Clacton Line.

The bridge consists of a number of prestressed slabs with a span of 33 ft. 5 in. Each slab is constructed from three pretensioned "I" beams: 18 in. wide by 10 in. deep; placed side by side, with a space of 1 ft. 1 in. between. In these spaces are placed rubber cores, which when the high quality *in situ* concrete has been poured are withdrawn; leaving a composite slab, 4 ft. 8 in. wide and 16 in. deep, with ducts in which a second stage prestressing operation can be carried out, using the post-tensioning method of Magnel-Blaton. The whole slab is then lifted into position by cranes. The resulting slab, while only 16 in. deep, is capable of carrying Ministry of Transport loads with adequate reserve of strength.

Temporary Roads of Reinforced Concrete Slabs

The article describes a method used in Poland of providing temporary construction roads, by means of large precast slabs of doubly reinforced concrete, 9 ft. 9 in. by 7 ft. 7½ in. by 6 in. thick. Their experience of clay soils under wet site conditions showed that the expedient of laying rubble tipped roads was unsatisfactory. The use of slabs, although three times more expensive gave seven or more uses; as it is their practice to lift these slabs after the construction phase is finished, and relay them where required. A record rate of laying achieved under summer conditions was fifty-six slabs per shift; while lifting averaged about twenty slabs/shift under adverse conditions. It was normal to lay the slabs on an ash, or sand bed with concrete pads underneath junctions to assist in laying the slabs with level joints.

Notes from *Civil Engineering*, August, 1957

The Principle of Cartridge Operated Tool Fixings

The author explains the variety of uses to which these fixings may be put, amongst which are included: fixings to steel, brick, and concrete. The principle is that, a toughened steel nail like stud is fired by a cartridge into the material, where by nature of its forced entry, it causes the material to flow out of its way rather than chip and crumble.

Test results are quoted, where 2⅝ in. studs fired into 1 : 2 : 4 concrete with ¾ in. aggregate, required forces of 6,000 lb. to extract. Another case cited is the fixing of metal plates to the web of a mild steel joist without drilling the plate or the joist. The studs are supplied with nail heads; or heads drilled and tapped to take screw fixings.

The military use that comes to mind for this equipment, is the rapid means of fixing demolition charges to any type of structure; or fixing strain gauges of the type referred to in the article contained in the September, 1957, issue of the *R.E. Journal*.

THE MILITARY ENGINEER

Journal of the Society of American Military Engineers

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"Progress in Atomic Power" by K. D. Nichols, Major-General U.S. Army (Retd.)

The author, now a consulting engineer, was from 1953 to 1955 general manager of the Atomic Energy Commission, U.S.A., and writes with authority an interesting review of the development of atomic power from 2nd December, 1942, the date of the first controlled chain reaction, until the present day. He pays tribute to the value of the contributions of the military programme to over-all progress, including responsibility for the first controlled chain reaction, training of personnel and organizations, ensuring adequate supply of uranium ore, production of U235, reactor and power technology, and health and safety regulations.

He then deals with the years of early Government control, from the appointment of the first Atomic Energy Commission in 1946 until the passing of this Government monopoly with the introduction of the 1954 Atomic Energy Act. In this period the Atomic Energy Commission continued the established principle of the Manhattan Engineer District of using industrial and scientific contractors rather than creating large Government organisations. During this period of monopoly the author notes construction was not started on a single large-scale power reactor. This did not start until September, 1954, with the Westinghouse Pressurized Water Reactor, the first of a number in a five-year programme to encourage private enterprise to participate in the construction and operation of large-scale power reactors of types demonstrated to be feasible by the Government research and experimental studies.

In listing the advantages of atomic power the author does not include cheapness in areas like the Ohio Valley, where the abundance and proximity of fossil fuels makes four-mill power available. The two main advantages are first a greater potential source of power for the world than would be possible from hydraulic or fossil fuels and secondly a reduction of the factor of cost due to either transportation of fossil fuels or to transmission losses from hydraulic sources. The United States, with adequate supplies of conventional fuel never faced the same urgency to develop atomic power as did the U.K. or U.S.S.R. He considers that in 1948–52 the United States might with advantage have adopted the U.K. policy of concentrating on power plant reactors that were basically plutonium producers, with power as a by-product. Duel purpose plants at that time would have done much to advance the technology of atomic power plants.

He is now certain that the atomic power programme of the United States should be accelerated, but that it should be directed towards cheaper atomic power rather than an international race to produce most atomic power. The achievement of cheaper atomic power will eventually also win the race for kilowatts. To do this the free enterprise system has a better record for obtaining economic competitive results when over-all costs are considered.

The author concludes with recommendations of what he considers the best procedure for achieving an accelerated atomic power programme, based on a partnership between free enterprise and the Government.

ENGINEERING JOURNAL OF CANADA

Notes from *The Engineering Journal of Canada*, June, 1957

Ultimate Strength Design of Reinforced Concrete Beams

In recent engineering publications there has been a marked tendency to acclaim the plastic theory of design as superior to the established method, utilizing working stresses and factors of safety, particularly when applied to reinforced concrete structures. At present the practical application of the plastic, or ultimate strength, theory is severely limited, and it is refreshing to find an author who points out that actual stresses are not modified by a convenient method of calculation, and that a better understanding of stress variation, and of the causes of disintegration leading to failure, is the real requirement for better and more economical design. After an interesting discussion of stress variation in relation to assumed distribution, he concludes that, until an accurate, consistent, and simply applied basis is found for design by the plastic theory, engineers will probably do well to use the present method, but he concedes that improvements in its application are desirable, particularly in relation to building codes.

Electrical Energy from the Wind

The constantly rising cost of fuels and of their transportation encourages investigation of alternative sources of power, especially for remote or undeveloped areas, and it is a chastening thought that modern progress has led to the re-invention of machines which were basically familiar to the ancient Persians. During the last six years considerable progress has been made in this country in wind-power research and development work. This paper shows that the contribution which wind power could make to the production of energy is, though limited, far more than an interesting possibility, and the results achieved by experimental plant in various parts of the world will certainly surprise the average reader.

Wind power characteristics and the main features of recent windmill design are described very clearly, and the economics of wind power, on three different scales of utilization, are dealt with convincingly.

Notes from *The Engineering Journal of Canada*, July, 1957

The Foundation Failure of the Transcona Grain Elevator

The application of soil mechanics theory is a modern weapon in the engineer's armoury. The Transcona failure occurred in 1913, when the newly erected million bushel bin house began to settle while being loaded, and then tilted, coming to rest after twenty-four hours at an angle of nearly twenty-seven degrees from the vertical, with the west side some twenty-four feet below its original position.

It is only when actual failure occurs that it is possible to correlate ultimate bearing capacity with the analytical determination of bearing pressures. Although the Transcona failure has often been cited as an example of difficult soil conditions, it was not until 1952 that detailed soil investigation was carried out at the site. Results were prejudiced by excavation during the righting of the building, and by continued pumping over nearly forty years since then. Though the sceptic may regard the calculated correlation with reserve, this full and interesting account of the investigation provides further justification of modern soil mechanics theory.

Notes from *The Engineering Journal of Canada*, August, 1957

Nuclear Power

The August issue of *The Engineering Journal* is virtually a review of progress and prospects in the development of nuclear power.

Two papers describe the design of nuclear reactors now under construction, the Canada–India reactor near Bombay, and the N.R.U. reactor at Chalk River, which has about five times the neutron flux of the existing N.R.X. reactor there. The C.I.R. project is described largely from the point of view of the engineers who are converting the ideas of nuclear specialists into practical structures: the description of the N.R.U. reactor deals more specifically with nuclear design technique.

The construction and operation of a remote control handling cell built at Chalk River in 1954, and contingent shielding experiments, are dealt with in a third paper, which will be of value primarily to specialists.

The remaining two papers, both contributed by officials of the U.S. Atomic Energy Commission, are entitled respectively "The latest prospects for economic nuclear power", and "The international outlook for atomic power". Both these papers contain much that is of general interest, and both give clear pictures of present problems and of the trend of development.