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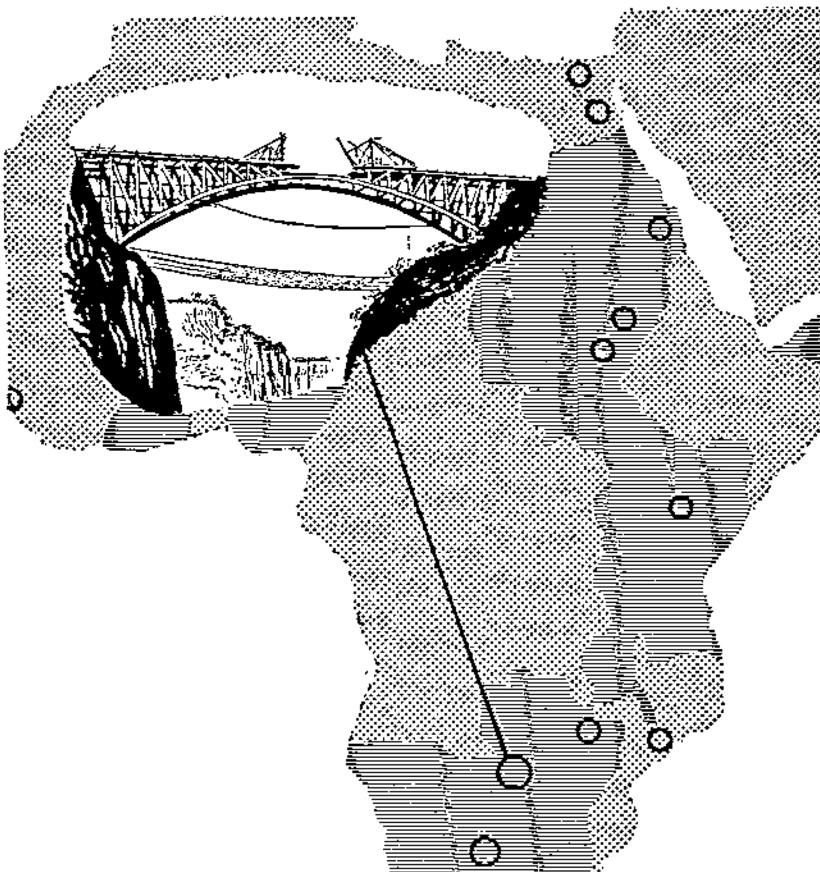

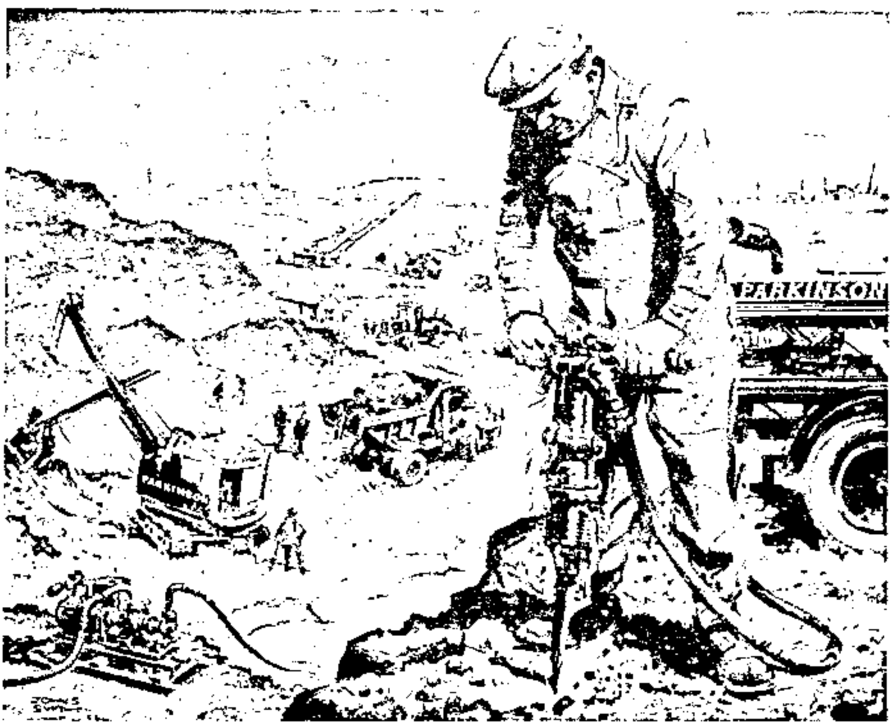

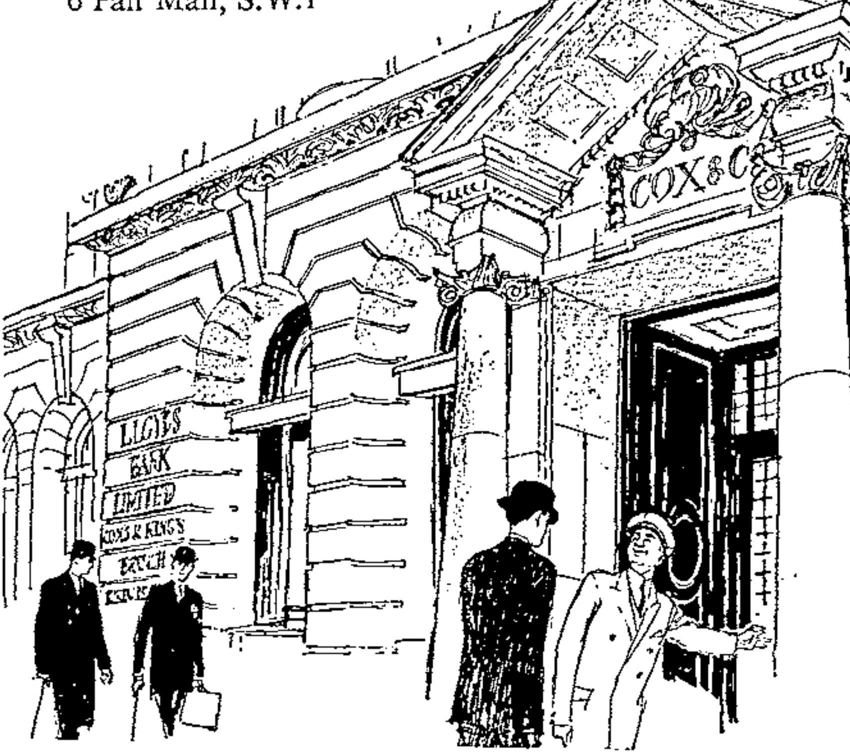
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THE ROYAL ENGINEERS JOURNAL

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MARCH, 1960

Corps Notes

The whole Corps will have been delighted over the Knighthood bestowed upon Major-General Sir Henry Sugden in the New Year's Honours. This is the first time that an Engineer-in-Chief in office has been knighted; it is not only a great personal honour but a reflected honour to our Corps, which he has so ably directed from the War Office for the past three years.

Congratulations are also extended to Lieut-General Sir Charles Jones on his knighthood. It will be remembered that before his present appointment he was a Vice-President of the Institution of Royal Engineers, his place being taken by Major-General Sugden. It must be almost unique for any Institution to be so doubly honoured.

* * * * *

Lieut-General Sir John Cowley has been appointed to the recreated post of Master General of the Ordnance, now an additional Member of the Army Council. The post is one of the oldest in the Army and goes back to the Ordnance Trains from which the Gunners, our Corps and the Ordnance Corps are descended. The post was dissolved in 1855 but revived in 1904. In 1938 the post lapsed again when it was merged with the appointment of Director General of Munitions Production.

The last Master General was another distinguished Sapper Officer, Lieut-General Sir Hugh Ellis.

Our congratulations go also to Lieut-General Sir Ian Jacob (late RE) on becoming a Knight Grand Cross of the Most Excellent Order of the British Empire and to Sir William Glanville, Kt, CB, CBE, DSc(Eng), FRS, Past President of the Institution of Civil Engineers and a Member of the Royal Engineers Advisory Board.

* * * * *

The statue of Lord Kitchener, which previously stood in Khartoum and was repatriated to this country as a gift from the Sudanese Government, is being re-erected at the south-west entrance to Kitchener Barracks, Chatham. The Secretary of State for War has kindly consented to unveil the statue on the morning of Monday 25 April. Further details are to be found in the *Supplement*.

* * * * *

36 Corps Engineer Regiment RE has returned to Invicta Lines, Maidstone, from Christmas Island where it spent an extremely busy and constructive year. In accordance with the run-down plan the Regiment now loses one of its Squadrons, 57 Field Squadron, which is to amalgamate with a Squadron of 1 Training Regiment RE. Another amalgamation has taken place in Germany; 46 Field Park Squadron RE has joined with 80 Workshop and Park Squadron RE to form 46 Workshop and Park Squadron RE.

The Engineer-in-Chief held his biennial "small" Conference at the School of Military Engineering, Chatham last December. The Conference was attended by all Chief Engineers, certain other officers holding senior appointments in the Corps and senior officers from the War Office. After visits to FVDRE and MEXE, the problems facing the Corps in the long-term future were presented and discussed.

* * * * *

The Corps has been consulted over the possibility of providing temporary fly-overs at busy junctions to relieve traffic congestion by using service bridging equipment, and schemes are being studied for their erection should the word to go ahead be received.

* * * * *

Officers of the Corps will be distressed to learn of the death of A. C. Hartley, Esq, CBE, BSc(Eng), MICE, MIMechE, FCGI, President of the Institution of Civil Engineers, and remember his valued services on the Royal Engineer Advisory Board of which he was a foundation member.

They will also be distressed to learn of the death of Sir Giles Gilbert Scott, Kt, OM, RA, FRIBA, DCL, the President of the Royal Institute of British Architects from 1933 to 1935 and an Honorary Member of the Institution of Royal Engineers since 1935.

RE War Memorial Homes

In May 1945 Lieut-General Sir J. Ronald Charles, KCB, CMG, DSO, the Chief Royal Engineer, sent to all ranks of the Corps a circular letter saying that, with final victory in sight, the thoughts of everyone must be turning to the consideration of doing honour to their Comrades who had fallen in the war. With a view to converting these thoughts into action a War Memorial Committee had been set up to investigate the provision of a fitting, tangible memorial and an appeal for funds was being launched.

As a result of seeking the general opinion of the Corps it was decided in 1946 that the war memorial should take the form of a certain number of houses for disabled ex-members of the Corps and their families or widows under the auspices of the British Legion "Haig Homes".

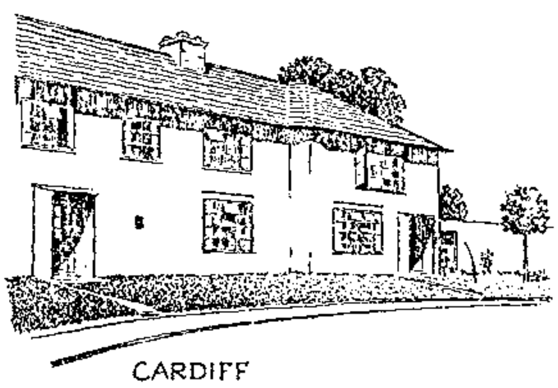
From donations received from all ranks of the Corps thirty-three RE Memorial Homes were built at Belfast, Cardiff, Chalfont St Peter, Edinburgh, Gloucester, Leeds, Norwich and Portsmouth.

Sketches of some of these homes by Major-General C. de L. Gaussen, CB, MC, are reproduced facing this page.

The maintenance of the homes is now in the hands of the Haig Homes and liaison is maintained by the presence of a Haig Homes representative on the RE Memorial Homes Council and of an RE officer on the Council of the Haig Homes.

The Corps War Memorial
World War II

Thirty three R.E. Homes were built at selected places. A bronze plaque, inscribed as above, is fixed on the front of each.



CARDIFF
- 21 & 22 Beaumaris Road, Rumney estate.
  Nos 29 & 31 are similar, situated to the right of the picture.

EDINBURGH
Nos 2 & 4 Saughton Mains Terrace
Nos 81 & 83 Saughton Mains Street

CHALFONT St PETER
Nos 7 to 12 Morris Close.
Nos 1 to 6 are facing these, the whole comprising a self-contained group.

PORTSMOUTH
Nos 9 to 12 Fitzpatrick Court, Paulsgrove,
a Douglas Haig homes close, at the foot of Portsdown.

BELFAST
Nos 98 & 104 Mount Merrion Avenue,
Cregagh Estate.

NORWICH
Nos 16, 18, 20, 22 Douglas Haig Road
West Earlham.

Other Homes are at
LEEDS. 7, 8, 9 Harewood Court.
GLOUCESTER. 24 & 42 Rissington Rd.

Christmas Island Nuclear Trials 1958

By Brigadier R. B. Muir, CBE, BSc, MICE,
AMIMechE, AMIEE, AMIStructE

Introduction

This article deals with the nuclear trials held at Christmas Island in 1958. The aim of the article is to describe the part played in these trials by the Army in general, the Royal Engineers in particular, and an attempt will be made to point the lessons learned. Over two-thirds of the military garrison on Christmas Island were Royal Engineers.

Task Force Grapple

Grapple was the name given to the Joint Task Force, charged with responsibility for setting up and executing nuclear tests in the Christmas Island area. This joint force, which was commanded by an air vice marshal, comprised four task groups—Naval, Army, Air and Scientific. Briefly the Royal Navy were responsible for logistic support, weather reporting and sea search, and for sea communication with the adjacent islands of Fanning, Malden and Penryhn, on which meteorological and scientific recording detachments of the Task Force were stationed. The Royal Air Force, in addition to weather reporting and area search, were responsible for delivery and firing of the weapon, flying Canberra sorties for cloud sampling after each test explosion; maintaining regular air communication using Hastings and Dakota aircraft with the advanced base at Honolulu, the adjacent Islands, Australia and UK, and also for general administration on Christmas Island, including the feeding of all troops ashore. The Scientific Group from the Atomic Weapons Research Establishment, Aldermaston, provided the weapon, assembled and tested it, and were responsible also for health physics control and for recording, collation and assessment of scientific test data.

The Task Force Headquarters included four staffs serving the four task groups. It was located in the Air Ministry and, with the exception of a rear headquarter component, moved to Christmas Island for the duration of each test series. The military staff was headed by a Chief Military Planner (Colonel) who was also Commander of the Army Task Group. His staff consisted of two elements—a military logistics staff, under an AA & QMG, which dealt with the provisioning of stores and plant, movement and personnel matters and an RE planning team, under a staff officer Royal Engineers Grade I, which was responsible for the detailed development of plans for major works projects.

Christmas Island

Christmas Island is situated in the mid-Pacific, about two degrees north of the Equator, and some 1,200 miles due south of Honolulu in the Hawaiian Islands. It is a classic coral island, and the largest coral atoll in the world. Its maximum length is just over thirty-five miles from NW to SE, and it varies in width from about twenty miles at its broadest point to just under three miles at the SE tongue. Of its total area of 350 square miles enclosed by its coast line, more than 250 square miles are water in the form of lagoons. The island is fringed by a reef at from 50 to 150 yards from the shore and, beyond the reef, the sea bed drops very steeply into extremely deep water. Sea transport, carrying supplies, stores and plant had to anchor about two miles out in the lee of the island and cargoes were transferred into lighters and DUKWS for carriage into the port through a gap in the reef. During the months of October to January the swell was sometimes so severe that the channel into the port had to be closed for several days.

The ground is flat and the maximum height above sea level does not exceed 30 ft. Vegetation consists of sporadic coarse grass, prolific evergreen bushes and a number of coconut plantations. Coconut palms were first planted by Captain Cook when he discovered Christmas Island on Christmas Eve 1777. The island abounds with a variety of sea birds, principally terns, frigate and booby birds, many of which are migratory. The terns nest twice a year in colonies of several million birds, and these can constitute a hazard to low flying aircraft. Wild life is completely harmless, and consists principally of jerboa rats and numerous land and hermit crabs.

Temperature varies little throughout the year. Day temperature averages 88°F with a drop of about ten degrees at night. Humidity is always very high —in the region of 98 per cent. Yet the climate is far from unpleasant, mainly because of the trade winds which blow almost continuously from the north-east at speeds of from eight to twenty-five knots. Rainfall is quite unpredictable, and can range from nil in one year to six inches in eight hours.

There is no indigenous population, but about 200 Gilbertese and their families are imported from islands of the Gilbert and Ellice Group to work on the local copra industry. They usually spend about two years on the island but some families have now been there for over ten years.

Army Task Group Grapple

Task. There were two main Army tasks:—

(*a*) Preparation for the tests, and close support to the RAF and scientists during the actual tests. (Preparatory work included the provision of facilities for delivering the weapon; weapon assembly buildings, laboratories and decontamination centres; and the setting up each time of an elaborate ground system of telemetry and effects measurement.)

(*b*) Development of Christmas Island base. (This task consisted principally of the construction of a hutted camp to house approximately 3,000 all ranks; road development; and the provision of workshops and covered storage to meet inter-service requirements.)

Composition. The Army Task Group comprised:—

Headquarters
HQ 38 Corps Engineer Regiment
- 48 Field Squadron RE
- 59 Field Squadron RE
- 61 Field Squadron RE
- 63 Field Park Squadron RE

12 (Independent) Field Squadron RE

73 (Christmas Island) Squadron RE
Two Construction Troops, Fijian Military Forces
One Transportation Troop, 51 Port Squadron RE
504 Postal Unit RE
2 Special Air Formation Signal Squadron, R Sigs
94 Company RASC (MT)
RASC Services
RAOC Services
2 Special Engineer Workshops REME

Role. The Commander Army Task Group, in addition to being Chief Military Planner in the Task Force Headquarters, was also Chief Engineer to the Task Force, an arrangement which worked well. The Army Task Group Headquarter staff on the island consisted of a DAA & QMG and a small works staff comprising an SORE 2 (Works); SORE 3 (Works); SORE 2 (E & M) and an SORE 3 (Resources). The Army Task Group Commander held a co-ordinating conference of all unit commanders once a month, and a works progress meeting once a week with sapper unit commanders. Representatives of the other three task groups also attended these meetings, as clearly the closest inter-service liaison was essential.

The engineer field units listed above together with the construction troops of the Fijian Military Forces were placed under command of 38 Corps Engineer Regiment which was responsible for the execution of new works projects. A small pool of six Clerks of Works (Construction, Electrical and Mechanical) was allotted by Army Task Group Headquarters to field squadrons, according to the type of work in hand. The Christmas Island Squadron Royal Engineers, which was organized on an E & M basis, was concerned mainly with the operation of utilities and with the maintenance of completed buildings and installations. The field park squadron integral with the engineer regiment supported all of the sapper squadrons by providing heavy plant, such as earth moving equipment and cranes; workshop facilities; and materials, such as crushed aggregate and prefabricated stores. A Command Engineer Stores Depot was set up to receive, unpack, identify, record, hold and issue imported stores. In order to avoid critical shortages, policy on controlled stores was laid down by HQ Army Task Group. This varied necessarily from time to time, depending upon timings of operational requirements, changes in shipping programmes, and the ability to economize in stores in short supply by the use of substitute materials.

The transportation troop provided the stevedore organization for unloading sea transports at open anchorage. The activity was controlled by a Port Commandant who acted also as DAA & QMG (Movements) to the Army Task Group Commander. Each ship required about three weeks to unload after arrival at the island, and the operation was pre-planned from a detailed record of loading, to ensure that, as far as possible, stores came ashore in the order required. In transferring cargo from hold to lighter, and from lighter to wharf, considerable ingenuity was exercised in handling and slinging of awkward loads, some of which weighed up to 25 tons. Whenever feasible, stores were transferred at the wharf from lighter direct into MT for transporting up country in order to avoid unnecessary handling.

504 Postal Unit RE ran the British Forces Post Office 170, which provided both air and sea mail facilities for all personnel in the area. In view of

the impact of this service on morale, emphasis was placed on speed and efficiency of operation. Detailed sorting of mail down to cities and counties in the United Kingdom was carried out on the island before despatch, and a close liaison maintained with all movements staffs to ensure that every available lift was utilized to the full. The introduction of Post Office Savings Bank facilities proved a popular innovation, and the BFPO also carried out a brisk trade in Premium Bonds.

The Special Air Formation Signals Squadron laid and maintained telephonic communications on an island wide basis. Royal Signals personnel were trained to operate a wheeled grader and a mechanical trencher, thus economizing in the Royal Engineer support required. Reduction in signal operating personnel was achieved by combining certain telephone exchanges. The life of signal electronic equipment was substantially increased by introducing air conditioning. The load on communications generally was restricted by emphasis on signal discipline.

94 Company RASC was organized as a headquarters, a HQ platoon, and three transport platoons. The HQ platoon operated a twenty-four hour service at POL points, and also distributed Dieso and oils to the numerous working sites. One transport platoon was absorbed almost entirely on port clearance and transported imported stores, on a two-shift basis, to the CESD and direct to working sites. The other two platoons operated tipper lorries (3 and 10 ton) in close support of the sapper field units, with whom they formed a close association. As a result of a drive on maintenance by the unit, availability of MT increased from 60 to over 90 per cent.

The RASC Services, in addition to manning the DUKWS, ran a field bakery, which provided up to 6,000 lb of fresh bread a day for all personnel ashore and afloat. DUKWS were used to supplement lighters for ferrying stores ashore from the Christmas Island deep water anchorage. They were also of great value in running stores ashore to Task Force detachments stationed on the islands of Malden and Fanning, and at times their drivers displayed considerable skill and courage in manipulating the heavy swell. DUKWS were particularly useful in avoiding double handling, and were proved to be more suitable than any other vehicle for carrying fragile stores, delicate instruments and explosives over rough ground. By fitting an A frame on the stern, loads of up to 5,000 lb could be loaded with the vehicle winch, care being taken to have sufficient ballast in the bow as a counterweight. Efficient servicing was essential, and hulls had to be painted regularly with red oxide to avoid corrosion.

The RAOC Services ran an Ordnance Field Park which provided common user stores and spares. The scaling of plant and vehicle spares had to be kept constantly under review, in the light of experience gained. The RAOC also operated a field laundry for the island, and this laundered some 13,000 sheets a week, as well as articles of personal clothing. Steam presses were installed to process tropical green uniform. Because a field laundry does not normally include this type of plant, the operators had to be trained locally. The load on the laundry was kept to an acceptable level by virtue of working dress being normally a uniform hat (with badges of rank sewn on), a pair of shorts, boots and short puttees. This pattern of dress had the additional advantage of ensuring that skin diseases were kept well under control.

The Special Engineer Regiment Workshop REME supported the Task Group most ably, by carrying out repairs beyond unit resources on vehicles and engineer plant. On one occasion a large gear wheel of seventy teeth on a vital plant was stripped as a result of a clutch failure. REME artificers, working on a continuous shift basis, built up the wheel by metal spraying; machined the teeth; and had the plant in operation again within seventy-two hours. Several light aid detachments from this workshop were deployed at selected sites where there were particularly heavy vehicle or plant concentrations. The Army Task Group operated about 200 vehicles and 300 items of mobile plant.

Planning

Distribution of load. The bulk of the planning on preparatory engineer work required for each test was carried out on the island. There were two main reasons for this. The time factor was acute and, secondly, design was linked closely with local operational, scientific and topographical considerations. On the other hand as much as possible of detailed planning on longer term requirements, such as development of the base, was done in London. Members of the RE planning team from HQ Grapple visited the island as required, when agreement was reached with all concerned on the first key plan of a particular project. Back in England plans were then developed in consultation with the appropriate authorities, e.g. financial and medical. It was important to lay down check points at which partially developed plans were re-submitted to the island for a check on local implications. On two occasions the Army Task Group Commander, in his capacity as Chief Military Planner, flew to England for conferences at Air Ministry and Aldermaston, returning to the island in less than three weeks. Methods of communication between the Army Task Group Commander and his planning staffs at Air Ministry also included teleprinter conversations.

Priorities. Because time was at such a premium it was obviously essential to establish clearly defined priorities. The "desirable" had to be segregated ruthlessly from the "essential". The priority of any particular project could usually only be determined in consultation with the other services at Task Group Commander level.

Requirement investigation. Before planning began, it was necessary to ensure that the requirement was correctly defined by the user. This critical examination was usually conducted by asking the user "What do you want to do?" and *not* "What do you want?" The user will frequently have strong convictions on what he wants but unless a preliminary joint exercise is carried out on the lines suggested, the final product may be surprisingly disappointing from the user's point of view. This investigation should result not only in the requirement being met with the minimum effort, but also in a satisfied customer. Another factor often worth considering at this stage was the possibility of future development.

Planning plan. The planning plan was then formulated, and this included target dates for the various stages of planning and execution. There was sometimes a tendency to place undue emphasis on the projected date of start of a work on the ground. It is by no means certain that the job which starts first will finish first. The aim was to complete the job in time, with the least expenditure of resources.

Flexibility. During planning it was essential to maintain an element of flexibility. However much finality was achieved in the initial definition of the requirement, changes during planning were liable to be proposed by the planners as well as the users. Clearly a major consideration was the impact of a suggested change both on the date of completion, as well as on the efficiency of operation of the final product. Exceptionally, a relatively major change may be capable of being implemented with a very small additional effort which is out of all proportion to the value which will accrue. Generally, however, a change in plan as a result of second thoughts leads only to delay and frustration. A vital consideration always was the possible effect of a proposed change on the morale of hard-pressed planning staffs and on units executing the work. Obviously, changes which constituted refinements or frills were resisted strongly. The best is indeed the enemy of the good.

Rationalization. Considerable economy in time and effort was achieved by rationalization, as far as possible, of user requirements for such items as laboratories, decontamination facilities, offices and messes. This enabled the basic structure to be provided by using a standard design. Standardized timber trusses (24 ft span) and wall panel frames were manufactured locally in RE workshops, on mass production lines, using jigs. This reduced substantially the erection time as well as the number of skilled workmen required on a site. As an extension to this principle, specially designed standard hutting for personnel accommodation was prefabricated subsequently in the United Kingdom, and shipped to the island.

Work study. Within the limitations of the time available, work study techniques were employed to devise the best means of execution. Highly repetitive work, such as the erection of prefabricated hutting sections, was carried out in phased construction using locally trained specialist teams. Again, the assembly of steel shelters involved considerable welding of high workmanship. Time was saved, and the load on skilled tradesmen reduced, by centralizing this welding operation in RE workshops on a line production pattern. Simple alignment aids designed for the assembly of complicated plant and structures also saved much time.

Site organization. Detailed pre-planning of the organization of each work site was the only way of avoiding waiting time for either plant or labour, both of which were at a premium. The aim was to complete the setting out, and the optimum layout of initial stores, before working parties arrived on the site. Maximum use was made of mechanical aids during construction. RAF mobile platform equipment, which can be adjusted pneumatically, was invaluable for high building work. Realistic yardsticks of production were evolved, and this inspired a healthy competitive spirit between working parties. Safety precautions during construction were strictly enforced and, in spite of the intense activity, the accident rate was negligible.

Typical Engineer Tasks

Roads. The foundation of the roads on Christmas Island is coral mud which, when laid and compacted at the optimum moisture content, sets into a very hard surface. Suitable deposits of this mud are fairly widespread in the inner lagoons of the island, but in winning it care had to be taken to avoid plant becoming bogged. For this reason, the usual method employed was a dragline excavator, as very rarely was the bearing capacity adequate to use Euclid scrapers. The bearing capacity of these coral mud roads reduced rapidly with a change in the moisture content. This could occur either as a result of intensive rain or a prolonged drought, either of which were liable to happen. Consequently corrugations and potholes developed with alarming rapidity, and the maintenance effort necessary to keep the roads at acceptable standards became quite prohibitive.

Bituminous surfacing. For this reason it was decided to embark on a bituminous surfacing programme of the main road network. The bituminous surface was laid to an average depth of 2½ in and the mix selected was:—

Coarse aggregate (1½–¾ in)	28.2 per cent
Medium grade (¾–3/16 in)	28.2 per cent
Quarry rejects	11.7 per cent
Fines	23.4 per cent
Cement	2.5 per cent
Bitumen (60/70)	6 per cent

Because of the absence of frost action, it was unnecessary to lay a sealing surface on the binding course. The resultant surface wore extremely well and the edges of the carpet set very hard, and stood up well to the occasional vehicle which had to pull off the road. This was important as there were no kerbs or containing shoulders.

A limiting factor on the rate of laying was the production of aggregate. A batch of four 20-ton Parker crushers were located near the NE point, and coral stone was scooped from above the high-water mark and fed to these machines, using dozers and bucket excavators. An *ad hoc* quarry troop of one officer and eighty-three other ranks was formed under command of the field park squadron. It operated the following plant in addition to the crushers:—

19 RB	4
BK 50	2
8-yd scraper	1
D7 with winch	1
D4 with winch	1
Size II dozers	4

By introducing shift work, output finally reached the figure of 1,400 tons of crushed aggregate per day. This figure was just adequate to meet the requirement for roads, airfields and building construction works.

The bitumen mix was produced at a Starmix 40 plant located near the main airfield which required a working party of one officer and twenty-eight other ranks to operate. Subsidiary plant comprised one 19 RB, one Lorain, one Size II dozer, and two 1-cu yd dumpers. Owing to the high moisture content of the coral aggregate which was never less than 10 per cent, the output of the Starmix drier proved inadequate. This was increased to a satisfactory level by blowing compressed air into the drier and stepping up fuel consumption. Local modifications were also carried out on the control panel so as to avoid by mechanical means the possibility of error in operation. Shift work paid big dividends and, because of the advantages of continuous production, the output for two double shifts was more than twice the normal single shift figure.

Originally the operators for this plant were trained in England. Subsequently, training was carried out *ab-initio* on Christmas Island and on balance this system of training was preferable. Within a period of six weeks, teams to operate the different types of plant could be trained to adequate standards.

In addition, a party of twenty-six other ranks was required to operate the bitumen heating tank farm in support of the Starmix 40. The plant for this consisted of nine bitumen kettles (1,000-gallon), three bowsers (1,000-gallon), one Jumbo crane, and one Matbro fork-lift truck. The bitumen was heated to 350° F in tar kettles, and the final mix produced at 300 to 330°F.

Marshall test results were satisfactory over a wide range of bitumen contents as will be seen from the following table.

	Specified	Average test results
Stability	$\nless$ 1,800 lb (Marshall)	2,600 lb
Flow	$\ngtr$ 0.16 in (Marshall)	0.11 in
Density	125 lb/cu ft	130 lb/cu ft

The bitumen mix was conveyed to the Barber-Greene layers by tipper trucks and no difficulty was experienced in transporting the mix for distances as far as 30 miles. The numbers required to operate a Barber-Greene were sixteen men per shift including two surveyors. The subsidiary plant comprised one stand-by Barber-Greene, two tandem road rollers, one Fordson tractor, one bowser (1,000-gallon) for pre-spray, and one water truck. Accurate grading of the formation was essential in order to avoid an extravagant use of asphalt. After the formation was graded and consolidated, the base was sprayed with MC1 at a temperature of 170 to 190°F before laying began. Asphalt mixes have a tendency to drag and extra shovel men were required to scatter asphalt over the laid surfaces in front of the Barber-Greene to fill the voids. The surface was laid in two strips of 12 ft width by Barber-Greene layers, with a minimum of a 6 ft wide berm on either side. The temperature of the mix during laying was 250 to 300°F and rolling was carried out at 175 to 190°F. The rate of laying per machine averaged three-quarters to one mile of single strip per day.

Airfields. There were two main requirements:—

(*a*) To increase the surfaced hard standings at the main airfield from approximately 100,000 ft super to 1 million ft super.

(*b*) To construct an entirely new airfield on virgin ground at the SE corner capable of taking Valiants.

Clearly the laying of bituminous surfaced hard standings called for a higher degree of accuracy than for laying roads, but little difficulty was experienced in bringing the operators up to the required standard of accuracy. The most satisfactory sequence of rolling, and in fact the only way of avoiding camber, was to roll from the inside outwards. Wooden blocks were surveyed to guide levels at approximately 30 ft intervals. In rolling the outside edge it was important to ensure that the temperature of the mix did not drop to below 170°F before final rolling, otherwise there was a tendency for the edges to break off.

For the new airfield a bituminous surfaced strip was required of 2,000 yds in length, and 100 ft in width, with a minimum of 50 ft hard shoulders on either side. By using lagoon mud which was won entirely from below the water table, the chemical setting action produced CBR values of the order of seventy. In spite of interruptions to the work caused by the tests, the earth work for this new air-strip was completed by one plant troop within three months. Asphalt surfacing was laid at a minimum thickness of 3½ in, the main purpose being to seal the base against rain and to provide a surface resistant to wear. Marshall tests on the bituminous mix were made at least four times daily.

Concrete work. Coral aggregate produced by the island quarry was used for all quality concrete work which was graded as follows:—

Grade I	not less than 3,500 psi after twenty-eight days
Grade II	not less than 2,500 psi after twenty-eight days
Grade III	not less than 1,500 psi after twenty-eight days

Natural coral sand was generally clean and reasonably sharp. The crushed aggregate was quite porous and the cement water ratio averaged about 0.55. Plums were used in mass concrete work to economize in cement and crushed aggregate. Deposits of natural gravel were located above the high water mark. This gravel was fairly well graded and was used for low grade mass concrete. Concrete was laid at times at a rate of 40 cu yds/day in two shifts. Metal formwork of unit construction was widely used. It was extremely adaptable, easy to erect with unskilled labour, and well suited to high precision work.

A major requirement was the construction of an anchorage complex from which balloons could be flown for carrying out tests of the smaller weapons. These anchorages were heavily reinforced and varied in strength from 15 tons to over 40 tons. The surfaces of each anchorage block had to be flush with the asphalt surface, in order to ensure that movement of winch lorries on the site was not impeded. Excavations were required to a depth of 5 ft, and, with a water table at a depth of 2 ft, pumping arrangements were necessary to ensure that concrete was laid in the dry. A central weigh batching plant was set up to deal with the considerable quantities of concrete required, and dry mixes were supplied in dumpers to each site, where the correct quantity of water was added in the mixer. High quality control was imposed by means of a concrete laboratory set up on the site. Strength of test cubes reached over 4,000 psi at fourteen days. Elaborate earthing of these anchorages was an obvious requirement. The final megger tests on the copper strip earthing gave an average reading of 0.73 ohms which was well within the permissible maximum of 7 ohms.

Covered storage. A number of EDD sheds were built to provide covered storage and workshop facilities. The construction of one shed (150 ft by 50 ft) with aluminium sheet cladding and concrete floor absorbed one troop for six weeks. These sheds had previously been in use in England, and erection difficulties were increased by distortion in the steel framework as a result of damage during dismantling and in transit. A Bellman hangar of more than double the area (16,800 ft sup) with portal frame steelwork was completed by one troop in ten weeks.

As an experiment, Conder prefabricated steel framework was imported from England. This proved to be economical and extremely adaptable. This type of shed was capable of erection in about a quarter of the time required for EDD sheds. This was an important consideration since over 100,000 ft super of covered accommodation had to be completed within a space of six months.

Laboratories. The various laboratories required were quite complex, and had to be air conditioned to strict tolerance limits. These were built either in standard local prefabricated hutting or in pre-cast concrete block construction. An elaborate piped water system was usually required to provide both fresh and distilled water at a variety of controlled temperatures. The use of flexible plastic piping greatly reduced the plumbing effort involved. A laboratory of about 2,000 ft super was completed by twenty men in seven weeks, and in all about 50,000 ft super of laboratory facilities were provided within nine months.

Hutted Camp. A major project for base development was the erection of a hutted camp to house approximately 3,000 all ranks. Ancillaries included an air conditioned operating theatre, hospital wards and an open-air cinema. In building the tiered amphitheatre for the cinema, empty cement drums, filled with sand and stacked end-on in rows one above the other, proved a cheap and effective method of making retaining walls. Messes and cookhouses were built mainly of local prefabricated hutting. Because huts for sleeping accommodation to replace tents were necessarily on a lower priority, there was time to provide these in hutting prefabricated in the UK. The Junior Ranks Club which consisted of a restaurant, tavern and Junior NCOs Club, was basically a Conder storage shed adapted by local design. JRC buildings aggregating 150,000 ft super were ready for occupation within eight weeks from the start of work.

Communal mess buildings were built in the form of an open square overlooking the beach, and sleeping accommodation was sited to take full advantage of the prevailing wind. The two churches in the main camp were rebuilt largely by volunteer labour. Their walls were of coral stone taken direct from the beach and, combined with glass-louvred windows, the resultant appearance was most effective. Recreational facilities were provided by laying bituminous surfaces for hockey pitches, tennis courts and basket-ball pitches. Because the ground was so flat, and peak periods of rainfall so intense, drainage was a major consideration. Elaborate and extensive soak pits were constructed. Particularly low lying areas were avoided entirely for building. With heavy rainfall interspersed at times with long periods of drought, appearances could be most misleading, particularly when differences in level amounting to one or two feet could be critical. It was thus important to record accurately areas of flooding as these occurred, and diagnose the cause.

Miscellaneous tasks. Steel latticed masts. The erection of a number of steel latticed masts (averaging 150 ft in height) was another feature of test preparations. One of their uses was in connexion with the provision of closed television circuit facilities between the test area and central control. As was the case for a number of tasks, sappers had to be trained *ab initio.* There was never any shortage of volunteers for unusual jobs. One sapper who had developed into a highly skilled erector was asked why he had volunteered. He replied "I always did have a fear of heights, and I decided now is my chance."

Fuel storage. In the tank farm adjacent to the port there was a requirement for storage tanks of 3,000 barrel capacity. These were of bolted steel sections, three stories high, and totally enclosed. Local modifications were required to draw off moisture condensate. A tank, including foundations and erection, could be completed in nine weeks with a working party of eighteen. Pipes were laid from the wharf side so that fuel could be pumped direct from lighters. With a view to reducing the number of bowsers, the advisability of laying a pipeline from the tank farm to the main airfield was investigated, but the amounts consumed, although considerable, did not justify the cost and effort involved. A smaller tank farm was provided at the main airfield.

Port maintenance. Both coast erosion and anti-silting measures had to be implemented at the port. In conjunction with Admiralty Civil Engineers, the behaviour of currents and drift were investigated over a period by observing the movements of a variety of coloured stones placed at selected points along the beaches. As a short term measure, groynes, to counteract silting of the channel into the port, were built by using a series of wire gabions. The material was square mesh reinforcement which was bent and spot welded to form rectangular baskets. These baskets were then placed in the required position on the beach, secured with pickets, and filled with coral stone. Groynes of this nature can be just as effective as pile-driven groynes, they are very much quicker to produce, and require no plant or skilled labour on the site.

Cold storage. Two 50-ton cold stores were erected in the port area in order to economize in refrigeration space afloat, thus reducing shipping requirements. Each had a standby refrigeration unit and efficiency was increased by housing the whole installation inside a structure built up from standard local prefabricated hutting units. One 50 cold store could be completed by twelve men within nine weeks.

Utilities. Power. As scientific and base facilities built up so the requirement for power and light increased greatly. A new power station of eight 300 kW diesel generating units was built at the main camp. In the test area alone, nearly a hundred generating stations had to be set up and operated at different localities. In rear areas, the number of separate power stations was reduced by rationalization, to economize in manpower and running costs. Because of the distances involved, it was decided to change over from low tension to high tension distribution, and a start was made on this project towards the end of the year. At the main airfield planning was completed for an underground high tension ring main. The high rate of corrosion, and earthing as a result of salt in suspension in the air, resulted in a heavy maintenance commitment on electrical distribution lines. In order to keep resultant interference with user supplies to a minimum, it was important to sectionalize circuits to permit local isolation of faulty areas. Stand-by sets were provided at vital points to serve the operating theatre, the airfield control tower and laboratories which required continuous operation.

Water. The source of indigenous water on Christmas Island is shallow wells scooped to about eight feet in depth. These were covered over to reduce growth of algae and losses from evaporation. The fresh water layer lies on the top of the salt water table and in places was only a few inches in depth. The depth of the salt water table was influenced by tidal movement. It was thus vital to control rigidly the rate of pumping, otherwise the fresh water layer will become contaminated and may remain so for months on end. At peak strength the Task Force consumed approximately half a million gallons of water a week, the bulk of which was pumped to the user through a piped distribution system. Ground water sources were supplemented by vapour compression distillation plants since there was a scientific requirement for this type of water. The salinity of the fresh water sources averaged fifty parts per million, which was well within accepted standards. It can be recalled that the salinity of the Tobruk wells, used by the besieged garrison during the last war, was of the order of 1,500 parts per million. During the year, as an insurance against drought, the principal source of ground water for the main camp was duplicated, by providing an entirely new water point outside the sphere of influence of the original source.

Sewage. Initially, sanitation requirements were provided in the form of elsan type chemical closets. The effluent was conveyed in special vehicles for disposal by pumping out to sea. As part of the hutted camp development, a water borne sewage system was installed. Because the ground is so flat, the sewage had to be pumped under pressure. This required the construction of a number of totally enclosed collecting and pumping stations in reinforced concrete. Sewage was discharged direct into the sea from an outfall built over the reef at about three miles from the main camp. The use of treated asbestos piping for main and subsidiary sewers greatly reduced the effort involved. Piping was laid at an average depth of 3 ft. Garbage was burned and buried at a disposal area several miles downwind of the main camp. Operation of this area tied up completely one dragline excavator and one dozer. Flies and insects were kept very much under control by both air and ground spraying of insecticides.

Damage Control

Damage Control Headquarters. Army Task Group set up a Damage Control Headquarters at the Joint Operations Centre. This covered medical, radiological, fire, and damage protective and remedial measures, during the period shortly before and after the explosion. The function of this Damage Control Headquarters was

(*a*) To record the immediate physical effects of the explosion.

(*b*) To deploy stand-by parties to take remedial action as required. Both radio and line communications were used to control these activities.

Personnel Safety. A comprehensive Personnel Safety Plan was implemented by the Joint Task Force Headquarters to cover all eventualities. In addition to operational rehearsals for scientific reasons, rehearsals of the safety plan were essential. Area commanders, appointed beforehand from the services, were responsible for deployment, accounting, and safety of their men under direction of the Joint Operations Centre. The Gilbertese population were evacuated from the island each time. This was a universally popular exercise for the entire village, and the Gilbertese much enjoyed the film shows arranged for them by the Royal Navy whilst afloat. Clearly everyone on the island had to be within hearing distance of the count-down and count-up which was relayed over a tannoy system set up for the occasion. Flash protective clothing was worn as required. At the time of burst all personnel had their backs to ground zero, with eyes covered to avoid flash damage to the retina of the eye. Subsequently personnel were warned to brace themselves for the blast waves. Re-entry into possible contaminated areas was strictly controlled, and was always preceded by scientific monitoring teams. There were no personnel casualties as a result of any test explosion.

Fire damage. The immediate target area was isolated by dozing a fire lane across the island. Stores, equipment and plant, which were liable to start induced fires, were redeployed or suitably screened. All electrical circuits not in use were isolated. Fire fighting equipment was deployed at strategic locations such as petrol points and tank farms, and fire fighting parties were held in readiness to be directed to affected areas by Damage Control Headquarters. In consultation with the other services, installations, buildings and essential services were categorized beforehand in accordance with their particular function. This ensured that fire fighting action was implemented strictly in accordance with operational priorities. In the event, no difficulty was experienced in keeping induced fires under control in occupied areas. A feature of area bush fires was the ferocity with which the luscious green

Photo 1. A representative Army Task Group Guard paraded for inspection by Major-General H. H. C. Sugden, CB, CBE, DSO, Engineer-in-Chief, on the occasion of his visit to Christmas Island.

Photo 2. An aerial view of initial development of the hutted camp showing Officers' and Sergeants' messes sited overlooking the beach.

Christmas island nulear trials 1958 1,2

Photo 3. The forecourt of the Junior Ranks Club looking from the beach.

Photo 4. A live broadcast by volunteers over the Christmas Island Broadcasting Service.

Christmas island nulear trials 1958 3,4

Photo 5. A typical test result as seen from a Canberra.

Photo 6. Troops with their backs to ground zero and wearing flash protective clothing during the count-down for a megaton firing.

Christmas island nulear trials 1958 5, 6

vegetation burned once a fire was started. In preventing such fires from spreading to occupied areas, air reconnaissance by helicopter was invaluable.

Blast damage. Clearly the most economical method of avoiding blast damage to buildings and installations was to take this factor into account during the design and building stages whenever possible. A number of high priority buildings such as weapon assembly sheds and laboratories were designed so that panels could be removed just before the time of burst and then quickly reinstated. The problem was slightly complicated by air conditioning requirements. The effort to vent existing buildings and installations was quite considerable, but paid large dividends. The aim was to provide 30 per cent venting space on all walls, partitions and ceilings. Certain buildings were also suitably strengthened, and additional anchorage provided for high structures. The weapon assembly building for the low yield weapons, which were fired suspended from balloons, was necessarily very close to ground zero. There was thus no question of being able to avoid complete destruction. However, the effort required on preparatory work for each subsequent low yield test was much reduced by designing the stanchion holding down bolts so that these were capable of being removed immediately before an explosion. The result was that the structure was blown clear of the concrete foundation and floor. With very little remedial action, a new weapon assembly building was able to be erected on the original site, thus avoiding the considerable work of laying a new concrete base. Other precautions included ensuring that large fuel and water storage tanks were at least three-quarters full to minimize differential pressure effects. For high yield tests, all serviceable aircraft were airborne at the time of burst, and plant and vehicles positioned end on to ground zero. To avoid damage by secondary blast effect, loose materials were stacked and weighted down with sand-bags. Wire mesh cages were placed over vital electronic equipment, and certain delicate equipment also required dust protection. Immediately after the all clear, RE reconnaissance parties, which had been deployed at strategic points, made a survey of high priority installations, buildings and essential services. First aid repair parties were then called forward as required.

Factors Affecting the Task

Time. Grapple Operations were similar to an operation in war in that time was the essence of the contract. The time factor was very tight indeed and was only met by a vigorous and at times fairly ruthless approach. Maintenance of the objective was pressed to the almost complete exclusion of second thoughts, however attractive these were. Results were achieved on the ground in about a quarter of the planning time which holds good for design and execution of work under peace-time conditions.

Weather. Intensive wet weather slowed down building work, particularly high grade concreting. It restricted the quarry output by interfering with the segregation of the various sizes of crushed aggregate. Heavy rainfall also reduced the output of the Starmix bitumen plant, because of the excessive moisture which had to be extracted in the drier. Extremely dry weather, which was equally liable to occur, resulted in more effort having to be diverted to ensure that adequate water supplies were available. Again, fires were more readily induced by test explosions as a result.

Morale. Morale was clearly the most important single influence. Soldiers knew why they were carrying out a task and in what way it contributed to the success of each test. Periodic briefings were given to units, particularly by the scientists, in explanation of the various facets of the operation. Officers and NCOs were given plenty of responsibility. Emphasis was placed on man-management, and junior officers took a keen personal interest in their men's welfare both on the island and in relation to their families at home. There were no families on the island and the length of tour did not exceed one year. The mail service, which clearly can have a big impact on morale, was maintained at a high level of efficiency. The scale of rations was better than at any other station for British troops, and catering by the RAF was of a high standard. Health was good. The total all in sick rate, including both hospital and casual sick cases, averaged 0.9 per cent for the Army Task Group. Every effort was made to ensure that all ranks had a minimum of one week's leave off the island during their tour. This was taken in Hawaii, Fiji or the adjacent islands. Except during brief stand-downs, the troops had little more than one day off work per week. A large variety of recreational pursuits was taken full advantage of by all ranks. These included soccer, hockey, cricket, tennis, volley ball, basket ball, swimming, dinghy sailing, fishing and water ski-ing. Hobby activities were also provided for, and photography and bird-watching were particularly popular. A Christmas Island Broadcasting Service was introduced, and its nightly programme, run on entirely voluntary lines, had a wide and appreciative audience. The interchange of a few NCOs and men for several days with personnel from Royal Naval ships proved a popular innovation. These men took their place as working numbers afloat, as did their naval counterparts in army units ashore.

Materials. With the one exception of stone, all materials had to be imported in bulk by sea either from the United Kingdom, Australia, or exceptionally from America. This called for a considerable degree of forward planning, based at times on the crystal ball. In view of the large quantities handled, it was important to avoid tying up an undue proportion of the available manpower in the stores organization. This was tackled by devoting attention primarily to the method of dispatch of stores from their place of origin. As far as possible, limitations were imposed on the maximum weight and size of individual bundles. Packaging was reviewed, with the object of ensuring adequate climatic and handling protection. Probably the biggest dividend of all came from insistence on readily identifiable markings. With the wide variety and complexity of imported stores, identification of inadequately marked items could be very time consuming. A certain number of small stores and spares were imported by air, but clearly this line of supply had to be used sparingly, with freight costs being approximately one pound sterling for each pound by weight.

Equipment. The attrition rate on plant and vehicles was high for these reasons:—

(*a*) The tempo demanded shift work. Thus plant and vehicles were worked at times sixteen hours a day for six days a week.

(*b*) Climatic conditions induced heavy corrosion, and dust caused abrasion on moving parts. Salt water was liable to seep into bearings and emulsify the lubricating oil.

(*c*) The majority of operators had to be trained on the job, and this added inescapably to wear and tear.

The only antidote was constant pressure on preventative maintenance. Much of the routine daily maintenance on plant and vehicles was carried out by specialist teams working during the night. Breakdowns were recorded, and analysed in order to trace the cause.

Summary of Main Lessons

The most outstanding lesson of Operation Grapple was that the British troop of today is well capable of maintaining and enhancing the reputation of his predecessors. His capacity to undertake heavy and arduous work, very willingly and effectively, was well proven. It is of course important that he understands always what he is doing, and why he is doing it. It would be inappropriate if this opportunity was not taken to pay a tribute to the magnificent example set by the officers, WOs, NCOs and men of the Army Task Group during these Grapple operations.

High morale should always be cultivated deliberately and, once attained, effort devoted continuously to maintain it. The more arduous the conditions and the task, the more important it is, not only that the load is shared equitably by all ranks, but that it is apparent to all that this is so. There is practically no limit to the enthusiasm with which a good British unit will respond to challenging conditions.

The flexibility and resilience of RE field units is most impressive. Given the necessary backing in planning potential, a small supervisory element of clerks of works, and a few specialist tradesmen, the good sapper field unit can tackle successfully complicated projects which are extremely diverse in nature, and require a high degree of precision. It might be of interest that engineer work in support of the American nuclear tests at Eniwetoke was carried out by specialist civilian contractors. Provided a hard core of trained personnel is available, there are many advantages in carrying out training on unfamiliar plant or in new techniques in the area of operation.

Time spent on planning ought seldom to be wasted, but a pre-requisite to the start of planning should always be a critical examination of the requirement. This joint exercise, carried out by planner and user together, is the only real insurance against abortive planning and an unsatisfactory end product. Having agreed the requirement in this way, excellent reasons will practically always be advanced for departing from it subsequently. Particularly when time is short the price payable for change resulting from second thoughts can be high, and, more often than not, is prohibitive. The best is the enemy of the good, and, when time is at a premium, undue emphasis on the good may result in not even the adequate being attained. This does not imply that standards should be lowered. Nothing is more wasteful in manpower or disastrous to morale than acceptance of shoddy workmanship. It is largely a question of scope. The only criterion is a satisfied customer, but his satisfaction counts for little until the job is physically completed.

Working in such close contact with the Royal Navy and Royal Air Force provided a valuable contribution to preparedness for an active service role. A very real and enduring mutual respect was induced at all levels between the three services. The trend of inter-service dependence is inevitably, and rightly, on the increase. The training value of joint operations such as Grapple is indisputable, and it would seem that training of this nature should be extended on a much wider scale than obtains at present.

An important bi-product of these trials was the indoctrination of the troops taking part into the effects of nuclear weapons. As always there is no substitute for experience. We have arrived in the nuclear age, and we can neither ignore nor avoid its impact. The advent of nuclear weapons introduces a change in scale transcending that of any new weapon or technique previously known to man. However, it is not only a question of a gigantic increase in scale. Commanders and staffs are now faced with the entirely new problem of dealing with radiological hazards in the field. The military implications of this complex problem afford much food for thought.

The Kedah Roads Project

By LIEUT-COLONEL R. A. BLAKEWAY, OBE, RE

INTRODUCTION

THIS road construction project was carried out under Emergency conditions in Malayan jungles, by field units. For over two years they were employed on a "real engineering" task; Officers designed and built permanent RC bridges; Sappers supervised gangs of labourers; Squadron Workshops for once were really busy with men "working at their trade"; and everyone, from Squadron Commander to Sapper, had the satisfaction of seeing the results of his work in permanent form.

We started as amateurs. Many of the lessons we learnt and relearnt would probably be self-evident to any PWD junior engineer, some were doubtless learnt by our fathers on the North-West Frontier and earlier "Emergency Roads", some have already been mentioned in the *Journal*. I do not intend to labour them in this article.

We met no problems that could not be solved by unit Officers, with the advice available to them; neither did we meet any problems of great technical interest. Those excellent Military Engineering volumes on Roads, Bridging, and Concrete, were often consulted and seldom found wanting.

The main interest of the project, in fact, lay in the way it provided an example of a comparatively large engineering task carried out by field units in peacetime. It demonstrated the advantages and disadvantages of such tasks as training for war, and showed to what extent field units, with the equipment and backing at present available, are capable of undertaking them.

BACKGROUND

Kedah is a State in North Malaya (See Map) on the Siamese border. Its capital, Alor Star, is some 290 miles from Kuala Lumpur, the Federal capital of Malaya, and 540 miles, or a day and night train journey, from Singapore.

Early in 1957 the Director of Emergency Operations appreciated that it would be some time before sufficient troops could be spared from other priority operations in Malaya, to deal with the Communist Terrorists in Kedah. It was suggested as an alternative that an extensive road building programme, coupled with administrative development, with the aim of bringing Government to some isolated villages in the centre and east of the State, would do much towards curtailing the Terrorists' activities and would assist in their eventual destruction.

In April, 1957, the Chief Engineer, Malaya Command (Brigadier J. T. S. Tutton), arranged for the proposed roads to be reconnoitred by Captain J. F. Newton, RAE, of 11 Indep Fd Sqn RE, assisted by Captain G. N. Ritchie of 50 Gurkha Fd Engr Regt. This recce, which was carried out in haste along existing jungle tracks and made no attempt to fix a detailed road alignment, confirmed that road construction was practicable.

It was estimated that the cost to Government of the 64 miles of laterite surfaced roads, running through primary and secondary jungle (at times very hilly), rubber estates and a few padi fields, and crossing one large river and many small streams, would be some £300,000, and that construction would take two to two and a half years with one field squadron, one plant troop and additional pool plant. In the event this estimate proved surprisingly accurate, though it was soon decided to employ two field squadrons on the task at a time, except during the rainy season from late September to early December 1958 when roadwork was reduced to a minimum.

A plan was then prepared, based on the Chief Engineer's recommendation, for the construction of 55 miles of road (later reduced to 52 by improved alignments) by military engineers, and the remainder by the PWD. The Emergency Operations Council, under the Prime Minister's Chairmanship, approved this plan and estimate; a camp was built and plant assembled, and work began on 1 August 1957.

General Organization

Command and Control, Allotment of Troops. As financial control of the project was vested in the Federation Government, and as practically the whole of the work was to be carried out after Independence, technical control was given to me as Chief Engineer, Federation Army. I welcomed this, as it gave me an excellent chance to see that the Federation Government became thoroughly aware of the capabilities of the country's military engineers. I naturally worked in very close touch with Brigadier Tutton and his staff, since the great majority of the plant, and about half the field engineers, came from the Overseas Commonwealth Forces.

It was decided from the start that field engineer units would be allotted on a shared basis, between the Commonwealth Forces and the Federation Army, and that each squadron would be given a definite task which could be completed in about four months.

The units employed were:—

11 Independent Field Squadron RE, (including a RAE Troop) Majors W. F. Cooper and B. C. Elgood	August–December 1957 May–September 1959.
2 Engineer Squadron, Federation Engineers Majors D. M. Panton and W. A. B. Chappel	December 1957–April 1958 January–May 1959.
1 Engineer Squadron, Federation Engineers Majors E. Hughes and J. A. Coombs	April–September 1958 with a detachment to December 1958. May–September 1959.

67 Gurkha Field Squadron Major M. J. A. Campbell	April–September 1958
68 Gurkha Field Squadron Major J. R. Radford	January–June 1959
410 Independent Plant Troop RE Captains A. Bellizzi, J. N. P. Vann, Major E. F. S. Pike	August 1957–September 1959 with a break from October–December 1958.
Plant Troop, 74 Field Park Squadron RE Captain A. Rees	April 1958–June 1959.

Each Field Squadron Commander was in charge of all work in his sector. Plant Troops, REME, British and Federation ASC and Works Section detachments, irrespective of nationality, were placed under command or in support of the squadron.

Squadrons served some four immediate masters, for instance:—

Operational command	Local Federal Infantry Brigade
Technical control	myself
Local Administration	Commonwealth Infantry Brigade
Discipline etc	Parent Regiment or Formation

This, of course, is nothing new for a squadron, and few difficulties were experienced.

Protection—Civilian labour. The Emergency was still in force, bands of armed terrorists were known to be in the area. In past road building tasks half the available engineer effort had been whittled away on local protection, verge patrols etc. It was agreed from the start, therefore, that engineer troops would be armed but would not be used for protection duties. Some eighty civil field force police were allotted to each squadron for this task and lived with them.

In the past, also, trained Sappers had been misemployed on coolie tasks. For this project, however, it was agreed that maximum use would be made of civilian labour, and funds were allotted for this purpose. Thus, at one stroke, two of the major obstacles to economical progress and to the training value of such projects were removed. The unskilled labourers came from local villages, were very poor and undernourished, and were not good at hard manual tasks. Their wages were about 8s 6d a day each. Without them, however, progress would have been slow indeed. Due to underposting, and to the reorganization of the Gurkha Field Engineer Regiment, Troop working strengths were sometimes in single figures.

Works Service Assistance. The Works Service helped in two ways. Firstly, CRE North Malaya built three of the five project camps on an Agency basis. Secondly, a small number of Officers, Clerks of Work, Technical Storemen etc were attached to a squadron from time to time to supplement the squadron's own resources. This help was most valuable, but would not I think be essential with British units under normal conditions.

Finance. All funds were controlled by me, subject to audit by the Treasury Auditor. Each squadron ran a bank account and submitted monthly statements in the form of Imprest Accounts, which were examined and audited in the normal manner. Squadrons also kept a simple double entry account to show the state of expenditure on each sector of the road, major bridge etc at any moment. At the beginning of each task, a squadron was allotted a provisional sum to budget on. It later submitted a revised estimate for approval. When approved, this estimate could not be exceeded.

All military manpower, vehicles, plant, fuel, explosives etc were provided on a no cost basis by the Commonwealth and Federation Forces. British Army stores on loan, e.g. Bailey equipment, rafts, were also provided free. British Army stores incorporated in the project were paid for. Stores from civilian sources, e.g. RC beams and piles, cement etc, and all civilian labour, were provided by contractors. Single-tender action was allowed, provided that the prices could be certified as "fair and reasonable".

I was thus able to make best use of the available funds without difficulty or delay. This, of course, was because the project was in support of the Emergency in Malaya, and the above procedure could be justified on grounds of operational necessity and urgency.

Specification

The roads were built to the following specification, laid down in the original plan:—

Formation width between ditches—34 ft
Minimum width of surfaced area—14 ft
(6 in of laterite)
Ruling gradient, camber, each—1 in 30
Bridges—Class 24 permanent construction, with 14 ft carriageway
Cleared area—66 ft minimum, 99 ft in primary jungle.

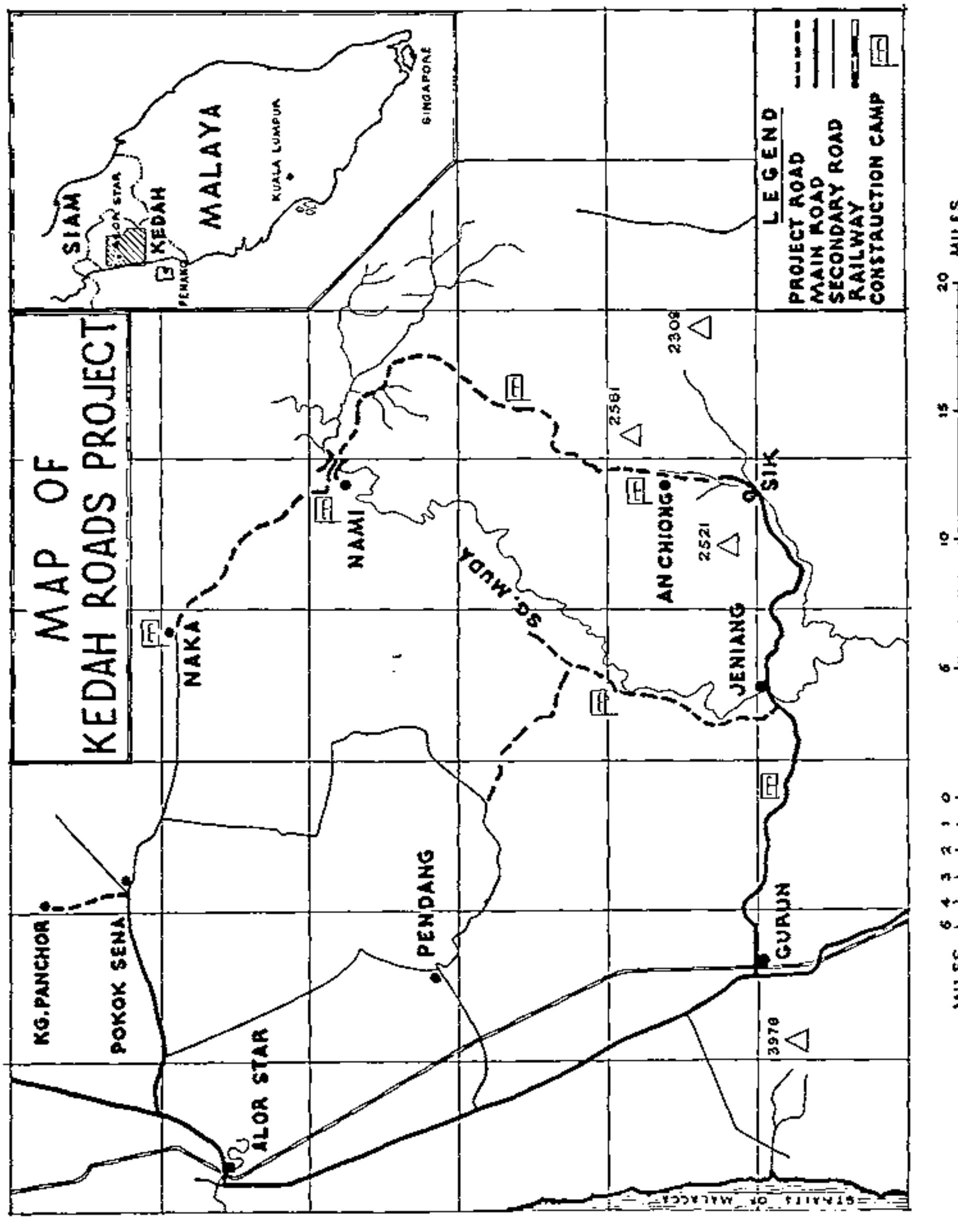
Stretches of steep side-hill cut, and embankments passing through swamp, had the formation width reduced to 22 ft, and relatively steep gradients up to 1 in 12 were accepted in difficult country. The majority of these latter stretches were given a sealing coat and wearing surface of bitumen and chippings. At PWD request, bridges under 40 ft in length were so constructed, with widened abutments, that their carriageway could be widened to 22 ft if necessary at a later date.

Any curve that could take a Scammel and low loader was accepted. In practice it was found that Project Officers, without exception, took a very natural pride in their work and were affected by what became known as the "Roman Road complex". As a result they had to be forcibly restrained at times from excavating vast quantities of rock and earth to produce 90 mph Autobahns.

Road Construction

Squadron Tasks and Organization. The average Squadron task was six or seven miles of road and one to five bridges, to be completed in four to five months. Squadrons worked from project camps which were moved as required.

Each Squadron Commander controlled, in addition to his squadron:—
A Plant Troop,
A REME, RAOC, RASC or equivalent Federation Army detachments,
An officer and two or three Works Service NCOs,
A Police Field Force Unit, and
150 to 250 unskilled labourers, and up to 25 skilled civilian tradesmen, mainly plant fitters and operators, and a few concretors, carpenters etc.


MAP OF
KEDAH ROADS PROJECT
SIAM
ALOR STAR
KEDAH
PENANG
MALAYA
KUALA LUMPUR
SINGAPORE
LEGEND
PROJECT ROAD
MAIN ROAD
SECONDARY ROAD
RAILWAY
CONSTRUCTION CAMP
KG. PANCHOR
POKOK SENA
ALOR STAR
NAKA
NAMI
PENDANG
SG. MUDA
ANCHIONG
SIK
JENIANG
GURUN
2581
2309
2521
3978
STRAITS OF MALACCA
MILES 5 4 3 2 1 0 5 10 15 20 MILES

A suitable Troop Commander was invariably appointed "Project Officer" (for all except the first squadron, when a Works Service Officer was attached). He was made responsible for all road survey, detailed bridge and culvert design, and stores estimating. Although techniques varied, most squadrons held some form of daily conference, at which work was organized for the following day, and labour, police, store and transport requirements were arranged.

Whenever possible, Project Officers were attached to the previous squadron a month or so before their own task began; to learn their job, order stores in advance, and carry out preliminary survey.

Sequence of construction. Much of the jungle was very dense and maps were inaccurate. It was usually impossible to decide on the best alignment until at least some undergrowth had been cleared. The normal sequence of construction was therefore as follows.

First, an "access track" was made by two dozers and a grader, preferably uphill of the final alignment so as not to interfere with clearance, and so that it could later be used as a step for sidehill cut, or as a catchwater drain. It was built to a "fair-weather Class 9 wheels Class 24 tracks" standard; with timber, brushwood or Armco culverts and timber or Bailey bridges. The Project Officer then set out a provisional alignment for clearance. Trees and undergrowth were cleared by Size I tractors and explosive (in primary jungle), or by hand in swamp and steep side-hill cut. Occasionally a contractor was employed to remove rubber plantations.

The Project Officer then produced mass diagrams and set out the final alignment and levels. Topsoil and roots were cleared by blades and scrapers, or by excavators in swamp. Culverts were then built, and the road formation constructed with blades and scrapers, with excavators in steep side-hill cut. 4½-yd dumpers, coupled to excavators, were used effectively at times in lieu of motorized scrapers, for hauls of over 1,000 ft. Rock was removed by compressors and explosive. A heavy rooter proved useful when shale or loose rock was present, provided that the operator was guided by a second experienced man. Graders completed the shaping and ditching and a surfacing team excavated, laid, spread and rolled the laterite surface. Labour gangs grassed or "pegged" embankments and cuttings, dug catchwater drains and run-offs for surface water, tidied up ditches and dealt with the inevitable slips and slides that occurred on the more hilly stretches.

Rate of Progress. Progress varied from three or more miles a month per Squadron, on easy stretches in good weather, to half a mile or less on difficult stretches in bad weather, and averaged about one and a half miles a month per Squadron. These figures would have been considerably improved if the plant serviceability rate had been higher, and if the right plant for the job had been available. In that event it would have been possible to employ additional DEL, or contractors, to speed up all manual tasks without overstraining the squadron organization, and without exceeding our budget. Squadrons, in fact, were seldom really economically employed, due to plant defects and deficiencies.

Plant. Over 125 pieces were allotted, including six Size I and twenty-four Size II tractors. These tractors were, of course, the most important single factor on which progress depended, and everything possible was done, with REME and RAOC assistance, to try and keep them operating for the maximum possible hours of plant daylight, seven days a week.

We were up against it from the start. A high rate of serviceability demands a first class system of unit inspections and servicing, experienced Officers and NCOs and good plant operators. I was always very impressed by the way the operators and unit fitters, British, Gurkha, Malay, Chinese and Indian, worked long hours cheerfully in hot, humid and often very dusty conditions. The majority of them however, especially the British, arrived inexperienced and were trained on the job. We had few NCOs, and fewer Officers, with previous experience of "real" plant projects; the SME courses are excellent, but they are no substitute for experience.

A good repair organization is also essential. Very few REME NCOs and men had any real previous experience or training on "C" vehicles, and there were never enough available. We would have foundered if we had not been able to employ civilian fitters.

Plant spares for machines from over twenty different manufacturers, varying in age from "prototypes" with inadequate scaling, to "non retention" or "prewar" in which everyone at times seemed to lose interest, at the end of a 600 mile L of C, produced a problem that required very energetic handling. A "Priority" issue system operated from the start; a RAOC stores detachment, built up to seven large binned trailers (with about 4,000 different items to supplement the 1,500 carried in unit "FAMTO"), provided spares on site, and spares from the Singapore Base Ordnance Depot arrived within three days *if* available and *if* correctly identified.

We were very well supported by Captain W. J. Slattery, the SO3RE Resources, who did his utmost to keep all concerned up to the mark. Often however, in spite of his efforts, and in spite of making full use of local purchase from civilian agents, of squadron workshops for the manufacture of "bits and pieces", and of cannibalization, delays of a month or more accumulated. It was seldom any use "BLR-ing" a machine, since replacements were very hard to come by. In the later stages of the project, about 15 per cent of all demands for spares not available on site were still taking over ten days to arrive.

The problem of spares provision, in fact, was never really solved. It was aggravated because much of the plant was not sufficiently robust or powerful enough for the job, or had exceeded its economic life, or suffered from teething troubles. It was little consolation to be told by a visiting expert: "We know *all* about the defects of that Mark, the new model will be *much* better." A few motorized scrapers and many more robust Size I tractors, in lieu of the Size IIs, would have made a considerable difference.

The result of all this was that it was most unusual for more than 70 per cent of prime movers to be available for work, and the figure often dropped to 50 per cent or less. The true serviceability rate, defined as plant hours spent on operation, maintenance, or routine inspections, as a percentage of total available working hours, was often as low as 30 per cent, due to temporary stoppages, movement between jobs, etc. This 30 per cent represented the serviceability, by and large, of inadequately powerful machines.

I of course realize that the little money available to buy post-war machines has had to be spent in the United Kingdom, spread over the wide variety of plant required for peacetime and wartime tasks. Provision is clearly difficult given these conditions, but it is as well to appreciate the results that followed in what was essentially a peacetime operation. I venture to think that, had we been engaged in real war, chaos over plant would have been inevitable.

These difficulties, of course, by no means reduced the training value of the project. On the contrary, it was most striking to see how young Officers and NCOs of the right type learnt their lessons, did their best to solve or alleviate the problems, and quickly developed confidence and powers of leadership.

As a tail-piece to our plant troubles, we met one problem not mentioned in the manuals—ghosts. At one place the alignment crossed a pile of stones, the home of a "kramat" or spirit. In spite of a careful diversion to avoid him, and in spite of propitiatory offerings, in the form of more stones for his pile, made by all visiting senior Officers, he was obviously extremely angry that his primeval peace had been disturbed, and vented his anger on the plant working nearby. This resulted in a Fowler and two scrapers falling over the hill-side, a D8 breaking its mainspring, and two 19 RB excavators running bearings on successive days.

Culverts. Two hundred permanent culverts were built. The great majority, ranging from single 2 ft to double 5 ft, were reinforced concrete pipes. A few, including three 7 ft diameter, were Armco protected with a bitumastic compound, to compare installation and maintenance costs. All had head and wing walls, and aprons or catchpits. Average costs, for 50-ft long culverts, excluding the cost of military labour and transport were:—

2 ft RC	£109
2 ft Armco	£115
5 ft RC	£408
7 ft Armco	£827

A typical culvert would be built by a Lance Corporal or Corporal, two or three Sappers, and a gang of ten to twenty coolies, in a fortnight or so. We learnt very quickly that much time, effort, and money could be wasted in building culverts on "wet" sites during a rainy season, and that it was much better to curb our impatience and wait until the rains stopped and the site dried. This was a lesson that had constantly to be stressed; it is difficult to teach an Officer who has been brought up to feel that time is all important and that "the tanks must get through", that he can sometimes leave a task and come back to it in a couple of months.

Miscellaneous Matters. The clearance of primary jungle demands Size I tractors, preferably with cable-operated blades: nothing smaller is any use. Our few Size I were normally employed on this and were seldom available for the road formation. It was found to be essential for the machines to have overhead protection, to cope with rotten branches and trees, and with trees pulled down unexpectedly by creepers.

The "jungle giants", trees often 200 ft high, with trunks 20 ft in circumference, vast buttress roots, and of very hard wood, were demolished with explosives. The best method was to dig a lifting charge in as near the centre of the root system as possible, and to place borehole or cutting charges on the buttress roots. In all, for trees, rock clearance and quarry work, we used some 50,000 lb of explosive.

Our one old 3-ton Coles crane was in great demand for stores handling, and we could have done with more. Other cranes proved too large and heavy, or lacked sufficient mobility on a project of this nature.

Photo 1. A typical double 5 ft RC culvert.

Photo 2. A "jungle giant" after demolition.

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Bridges

Nineteen of the twenty permanent bridges are described below. A separate note follows on Nami Bridge, which spanned the only large river.

Design. These bridges varied in length from 25 to 137 ft, the average being 65 ft. One was a post-stressed 66-ft single-span; the remainder each had one to five 20–40 ft bays, constructed either of prestressed RC beams (nine bridges), or of surplus Marston Shedding gantry girders supporting a concrete deck (nine bridges). Abutments were built of mass concrete, with RC piled foundations where necessary.

Piers were either mass concrete when on a rock foundation, or RC pile bents. After much trouble with prestressed piles, which were too fragile for field conditions and the 19 RB pile driving rigs, we reverted to slightly more expensive ordinary RC piles.

The design of any particular bridge depended on the usual factors: time, cost, and ease of construction with semi-skilled military labour. In addition, although the Marston girders eventually proved cheaper provided that they did not necessitate an additional pier (they were 25 ft long, compared with the 30-ft or longer prestressed beams), it was some time before they were available and before a fair surplus price had been agreed for them. We also wanted to "try everything once" and to give each squadron as much variety as possible. In particular, we were very keen to build a post-stressed bridge and jumped at the first reasonable excuse.

Prestressed Beams (See Sketch 1). The prestressed beams, designed and constructed by Hume Industries (Far East) Ltd, were inverted T-beams made by the long-line process, using the Gifford-Udall system, to a nominal 1:1½:3 mix with a minimum cube strength of 6,000 lb/sq in. Each beam contained a number of 0.200 in diameter wires, with an ultimate strength of 100–110 tons/sq in, and a design working stress of 145,000 lb/sq in, giving an initial prestress of 4,500 lb per wire.

They were railed from Singapore to North Malaya, and travelled up to a further 50 miles on a low loader with a specially built platform (see Photo 3). The sixteen beams for each bay were lifted by crane on to the abutments or piers. This required good crane operation, and good control by NCOs. One bay could be placed in about three hours. No beams were broken, but it must be realized that they are "fragile" compared with, say, RSJs, require more careful handling and stacking, and are more difficult to move on rough access tracks.

The deck was laid in two stages. A lean mix concrete was first placed in the gaps between the beams to within an inch of their tops and allowed to set. The final deck, reinforced with BRC, was then laid to a 1 : 2 : 4 mix and tamped to give the required camber and hog. Kerbs and handrails were added, and the concrete allowed to cure for fourteen days before the bridge was opened to traffic.

Post-stressed Beams (See Sketch 2). The blocks making up these beams were also designed and constructed by Humes and came from Singapore. Eight beams laid side by side, with a concrete fill between and on top of them, formed the deck. Each beam was made of nine intermediate hollow blocks (6 ft 3 in long, 2 ft wide and 2 ft 9 in deep, weight ½ ton), and two solid end blocks (4 ft 9 in long, weight 1 ton) to anchor the stressing cables. The blocks were placed in position by a 19 RB crane, on falsework of two spans of eight Marston girders on a Christchurch crib pier and abutments, seated on concrete. Timber 9×3 was laid at intervals across the girders as end supports for each block. The blocks had to be perfectly level before stressing, and the lowering of each block on to the falsework, by using the winch brake of the 19 RB, required very careful and expert work by the operator to avoid damage.

Longitudinal stressing for each beam was provided by two cables (each of twelve 0.276 in diameter wires) on each side, held in position in a parabolic curve by mild-steel bars projecting horizontally from the side of each block. Since these bars were at varying heights, all blocks were numbered and lettered before any were placed in position. The ½-in gap between blocks was filled with a rich concrete mix left to harden before stressing.

Post-stressing was carried out by the Freyssinet system, by the unit under the technical supervision of a representative of Humes. Care was taken to ensure that the cables, when placed in position and fixed at each end with cones, were not twisted.

Two cables diagonally opposite to each other on a beam were tensioned simultaneously with hydraulic jacks to approx 48 tons each, the stress being checked by the pressure dial of the pumps and the elongation of the cables. The jack then drove the cones home to anchor the cables. Transverse stressing was carried out similarly, by passing a cable (of eight 0.200 in diameter wires) through each set of blocks and stressing to approx 27 tons after the space between each beam had been filled with concrete.

Finally the deck and kerbs were laid and the falsework winched out with a Scammel (the hog on each beam was about 1½ in) and the bridge opened to traffic after fourteen days curing time.

This bridge was built by a troop of 2 Engineer Squadron, Federation Engineers, under a British Officer, between March and August 1958. It took a long time to build, partly because bad weather and unit reliefs interfered with construction of the abutments and falsework, partly because three damaged blocks had to be replaced, and partly through trepidation—we thought the task to be more difficult than it was and "took it slowly".

Cost. The cost of the post-stressed bridge was:—

Blocks	£1,587
Other stores and materials	£551
Coolies (851 man days)	£357
Total	£2,495

The cost of a typical 90-ft three-span prestressed beam bridge on mass concrete piers and abutments was:—

Beams	£1,375
Other stores and materials	£850
Coolies (926 man days)	£414
Total	£2,639

Photo 3. Low loader with platform for 40 ft prestressed RC beams.

Photo 4. Before—a jungle footbridge.

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Photo 5. After—a 90-ft, three-span, prestressed beam bridge on mass concrete piers.

Photo 6. A 137-ft, five-span, prestressed beam bridge on piled piers.

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Nami Bridge

This bridge was built by 1 Engineer Squadron, assisted at times by plant from 410 Independent Plant Troop RE and men from 2 Engineer Squadron, between 1 May and 16 December 1958. It was 451 ft long, with a 14-ft roadway and two 1-ft kerbs.

Design (See Sketch 3). The site on the River Muda had a water gap of 210 ft, a flood plain of 170 ft, and steep banks on either side rising to 25–30 ft above normal water level. The river was known to rise up to 25 ft in sudden floods during the monsoon season.

Various alternative designs of Irish bridges, and a low level bridge with a causeway over the flood plain, were rejected on PWD advice, mainly because of the probable heavy cost of repairing damage through scour etc, and because of the unacceptably long period the bridge was likely to be submerged. A high level bridge, always above water, was rejected in view of its high cost. Finally, fortified by advice on site from the Engineer-in-Chief, we decided to build a submersible bridge, but sufficiently high level so that it would only be under water for a few days at the most in abnormal flood conditions.

Major (then Captain) J. A. Robinson and Captain G. M. Davies were responsible for the original design; the latter and, later, Captain I. G. Graham were responsible for amendments as work proceeded. Major E. Hughes was the Squadron Commander in charge of the work.

Mackintosh probes found firm rock at depths of 2–10 ft across the gap. It was decided that the design must be such that complicated shuttering could be avoided, and the bridge constructed by field engineers as quickly as possible, with assistance as necessary from a few skilled civilian tradesmen.

The final design was for twelve piers; with six 40-ft bays over the river and seven 30-ft bays over the flood plain, all using the prestressed beams described earlier. The piers were excavated to bed-rock, with a mass concrete base tied into the rock on the upstream side. From this base the capsill was supported on two 14-ft RC columns, formed inside light RC culvert pipes (with ogee ends to give stability when pouring) used as permanent shuttering. These two columns were joined by a RC web wall, thus forming a girder to resist the turning moment when the bridge was submerged.

The capsills were two modified Marston girders, bolted to the columns, each girder supporting one end of a span and encased in concrete for appearance. The sixteen deck beams were tied down by a 1-in MS bar through their carrying holes, welded to the capsills. The abutments, on silty soil, each consisted of a ground beam supported on a RC mat, itself supported on three piles made by boring down to rock level with an auger, placing reinforcement and filling with concrete.

Plan. It was originally planned to build half the bridge, over the flood plain, in May to September 1958, withdraw the Squadron for retraining when the rains started in September, span the river gap with a temporary Bailey bridge, and complete the bridge during the really dry season early in 1959. This was partly due to lack of sufficient funds for 1958, and partly because only one Troop was immediately available for the work and I did not think it possible to complete all pier foundations in the "semi-dry" season between May and September.

However, the river behaved itself, more money became available, the Squadron worked extremely well, and at the end of June it was decided to press on and leave a rear party (mainly the Plant/Park Troop) after September under Captain Graham, to complete the bridge before Christmas.

Organization of Work. The average working strength of the Troop increased gradually from twenty-one in May to forty-four in September, as Sections of another Troop became available. After September, when the Squadron left, it decreased to eighteen but was reinforced by MT and Plant Sections for a few hours each day. An average of thirty-five civilians were employed. Work continued seven days a week, for the first six weeks in daylight only. When concreting started a shift system was introduced, by Sections, and in July and up to 18 August soldiers worked twenty-four hours a day. Thereafter, with work in progress along the whole length of the bridge, the shift system was stopped and civilians were distributed to Section or half-Section tasks as required.

The Troop Commander, with advice and guidance from the Project Officer and OC, planned all work, and prepared a weekly forecast of materials and stores required and a weekly and daily works table. The latter was explained to all Section Commanders each day before work started. The Squadron Workshops were kept very busy on the large amount of reinforcement bar-bending and timber formwork required, and on helping to maintain and repair machinery and plant.

The main problem was one of supervision, particularly during shift work and when NCOs were learning their jobs. The strain on Officers was considerable by the time shift work ended, but the enthusiasm and keenness of all ranks was terrific, and more than made up for any errors due to lack of training or experience.

Construction. Space does not allow me to describe the construction in detail, so I will only mention a few of the more interesting aspects.

The best revetment for the excavation of the flood-plain piers, strong, simple, and cheap, proved to be horizontal frames of pinang (betel-nut) palm, with unsplit upright bamboo "runners" which were lowered as excavation proceeded.

The river had a gravel bottom, and varied in depth from 2 to 5 ft when not in flood. The river piers were constructed by diverting the stream, by dozing the gravel into coulees and building up a coffer round the piers as necessary. A low level 100-ft Bailey was later built on to a bund in midstream to provide access for concreting and for placing the beams by crane. At times, when the river rose, the coffer broke and had to be remade. Later on, in the heavy autumn rains, the Bailey had to be continuously delaunched and launched, often by night at considerable hazard. It was finally dispensed with on 19 October.

Pumping had to be continuous on most of the pier excavations. Over 14 million gallons were pumped in all, by a "team" of six pulsometers, one Broomewade, one Patterson, one Mather Platt fire pump and one or two Johnson pumps. A bottom-opening skip, made in Squadron Workshops, used with a 19 RB or Jones crane, proved to be the best way to place concrete in the foundations. River aggregate was tested, found to give a twenty-eight-day strength of 4,400 lb/sq in, and used for all piers, thus producing a large saving in money, labour and transport. For the foundations, the aggregate was dug and stockpiled by a 19 RB, mixed with cement, and placed. For the columns and webs, graded aggregate was moved from the crusher to the mixers by dumper.

The piers were completed by 30 September, and the beams were all in position by early November. The beams were placed by a 19 RB crane until the low-level Bailey had to be finally delaunched. By then a minimum of four beams had been placed on all incomplete spans. Decauville track was then laid along the bridge, and the skip mountings were removed from two trolleys, which were run out with a beam supported at the ends on each. The beams were then jacked up and lifted into position by davits clamped on to the capsills.

The deck slab thickness required great care, since it had to compensate for irregularities in the hog of the 30- and 40-ft beams, and had to be predetermined every 5 ft, and at times every 2½ ft, along the whole length of the bridge. The mix and water content had to be carefully supervised, as indeed it was throughout the task. During one very rainy period deck concreting was carried out under a long tent erected over three spans of the bridge.

The method of constructing the kerbs was debated at length. The appearance of previous smaller bridges had been spoilt by "wavy" kerbs and handrails, which had provoked visiting Chief Engineers to say "We did better in the Sappers and Miners". Finally, small blocks were cast at 10-ft intervals along the bridge, along a line set in with a theodolite. Shuttering was clamped to these blocks and carefully braced. The result was eminently satisfactory.

Cost. The cost of the bridge was:—

Materials	£14,650
Labour and services	£4,500

This is cheap by any standard, but, of course, makes no allowance for all the military "no cost" effort.

Overall Cost

The overall cost of the military part of the project to Government, exclusive of all military labour and services, will be:—

Road and culvert construction	£150,050 or	£2,915 per mile
Bridges	£57,140 or	£34 per ft
Camps	£34,365	
Sundries, e.g. training materials, project stores etc.	£990	
Total	£242,545	

This compares with an original allotment of £265,000, the military share of the £300,000 approved for the whole project.

Co-operation With the Public Works Department

Sections of the roads were handed over to the PWD for future maintenance and, we hoped, for permanent surfacing as soon as possible, immediately after completion.

We decided from the start to consult them informally on any problems that arose and to accept their advice whenever possible; to obtain their approval to all bridge designs in advance of construction, and to carry out any improvements to the road formation, drainage etc, requested by them, before we handed over each section.

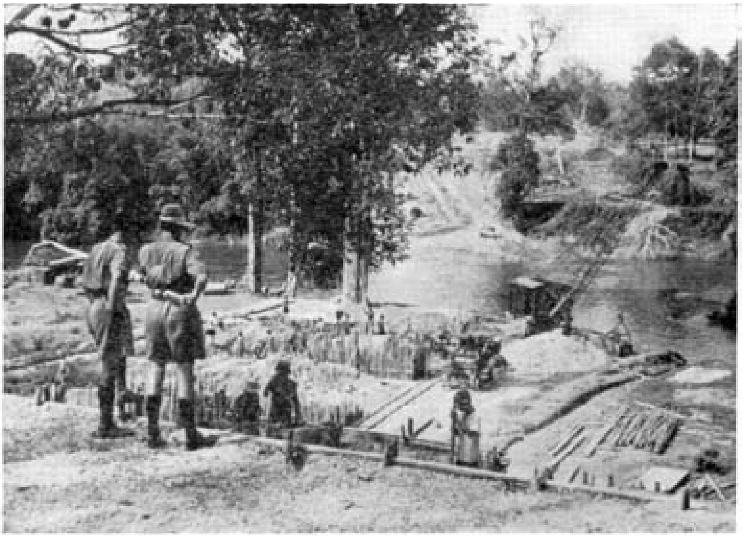


Photo 7. Nami Bridge, excavations for flood-bank piers.

Photo 8. Nami Bridge, river piers under construction.

Photo 9. Nami Bridge, deck beams being placed.

Photo 10. Nami Bridge, showing completed piers, before cement-wash treatment.

The Kedah Roads Project 9,10

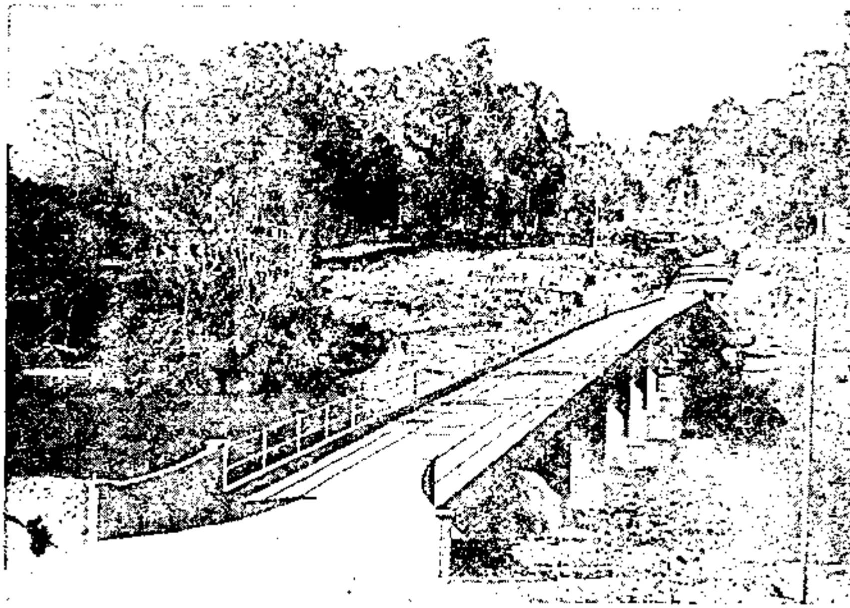


Photo 11. Nami Bridge—later renamed "Sultan Abdul Halim Bridge".

We were not bound officially to follow this policy, but we adopted it deliberately to try and improve the somewhat strained relations that had grown up between the PWD and military engineers during the stress of the Emergency. It paid dividends. Apart from the useful advice we received, we had much help from them over the provision of materials. Last, but not least, as a result of the confidence the PWD gained in our ability to build permanent bridges, the Federation Engineers have now been given the task of constructing a 1,260-ft permanent RC bridge on the east coast of Malaya.

Opening Ceremony

The roads and bridges were officially opened by His Highness the Sultan of Kedah on 7 September 1959, in the presence of many distinguished guests including the Minister of Defence and other Ministers of the Federation, and the Commanders of the Overseas Commonwealth and Federation Forces in Malaya. In the course of the ceremony the Sultan named Nami Bridge "Sultan Abdul Halim Bridge" after himself, and presented inscribed Kris to British Engineer Units and a silver salver to the Federation Engineers.

The Training Value of the Project

A Troop Commander, perhaps newly arrived in the theatre from JO training, found himself responsible at any one time for the construction of a mile or two of road, half a dozen culverts and a permanent bridge. At times he might have been given a task on his own, opening up an access track or starting off a new section of road, with very little direct squadron supervision. One Troop Commander was for over two months in entire charge of the 450-ft Nami Bridge.

Photo 11. Nami Bridge—later renamed "Sultan Abdul Halim Bridge".

Section Commanders for the first time in their lives assumed responsibility for preparing works tables, estimating for and ordering stores, and occasionally controlling plant. Lance Corporals with a motley civilian gang delaunched 80-ft Bailey bridges. Even the SG5 Sapper often acted as foreman of a labour gang.

As a result, it was a pleasure to see the way officers and men, British, Australian, Gurkha, Malay, Chinese and Indian, acquired confidence and knowledge.

Junior Officers and NCOs are seldom given sufficient responsibility in peacetime to be properly tested and to learn from their mistakes. The project gave them this responsibility, and made them feel that they had a really worthwhile task. All the normal Field Engineer skills were required, and tested, with the exception of mine warfare, modern equipment bridging, and field defences. Very often individual tasks had to be completed against time, and there was a continual sense of urgency.

On the other hand many of the more soldier-like qualities on which our military efficiency depends were inclined to go by the board, and it was one of the main tasks of Squadron Commanders to ensure that units did not become too "jungly". A four or five month task for each Squadron was ideal; if it had been longer much of the sense of urgency would have been lost, and units would have had to spend much more time, at the expense of the project, on military training.

The Independent Plant Troop remained throughout the project, except for one three months' break for re-training, and bore the brunt of the work. They were, however, doing their normal job; but their administration would undoubtedly have benefited from longer periods off for "make and mend".

Conclusion

To sum up, projects of this nature provide excellent training for field units: training in organization, in field engineering, and all other unit trades. The effect on morale, and on the peacetime reputation of the Corps, of carrying out useful tasks of lasting value is beyond assessment.

If possible, however, individual units should not remain so long on them that they forget they are soldiers as well as engineers. The ideal annual training cycle for a Sapper unit should include a four-month period on some such engineering project.

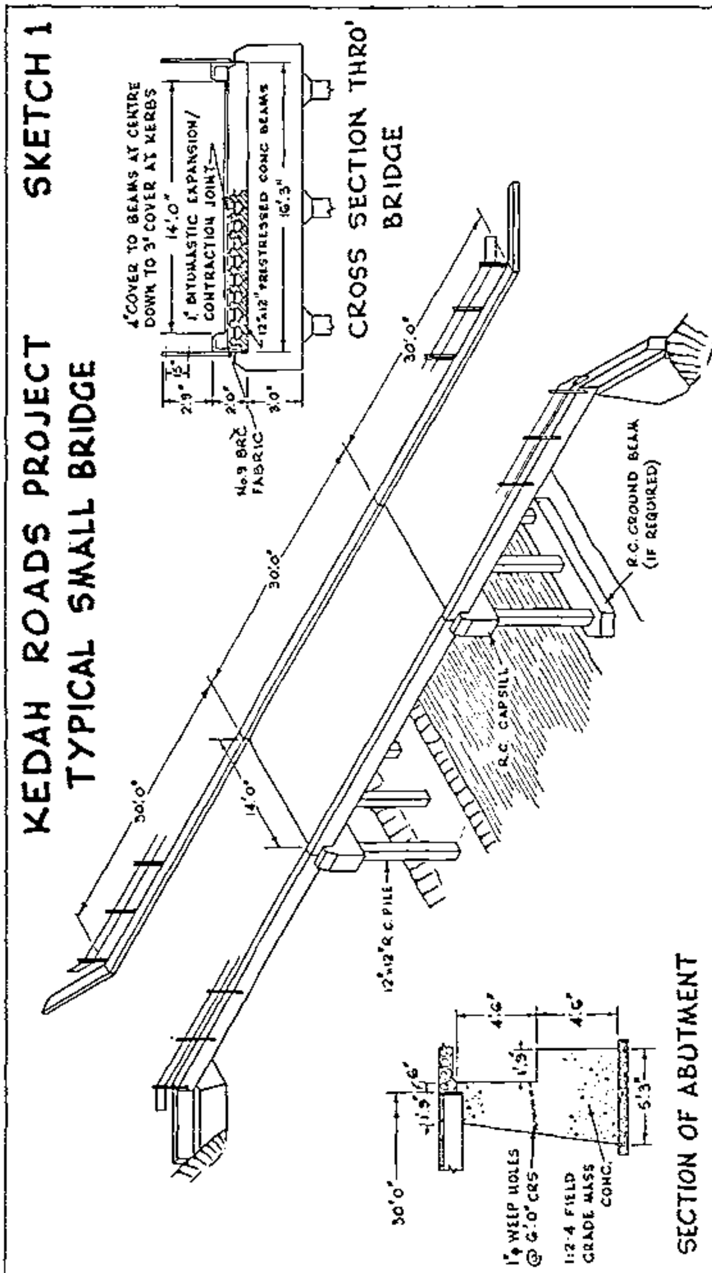
The difficulties facing us at the moment must not be glossed over. These projects cannot be undertaken economically without adequate civilian labour to supplement the small working strengths of field troops, and they highlight the fact that the Corps cannot be expected to do its job in war, or to compete in peacetime with civilian firms or Government Departments until:—

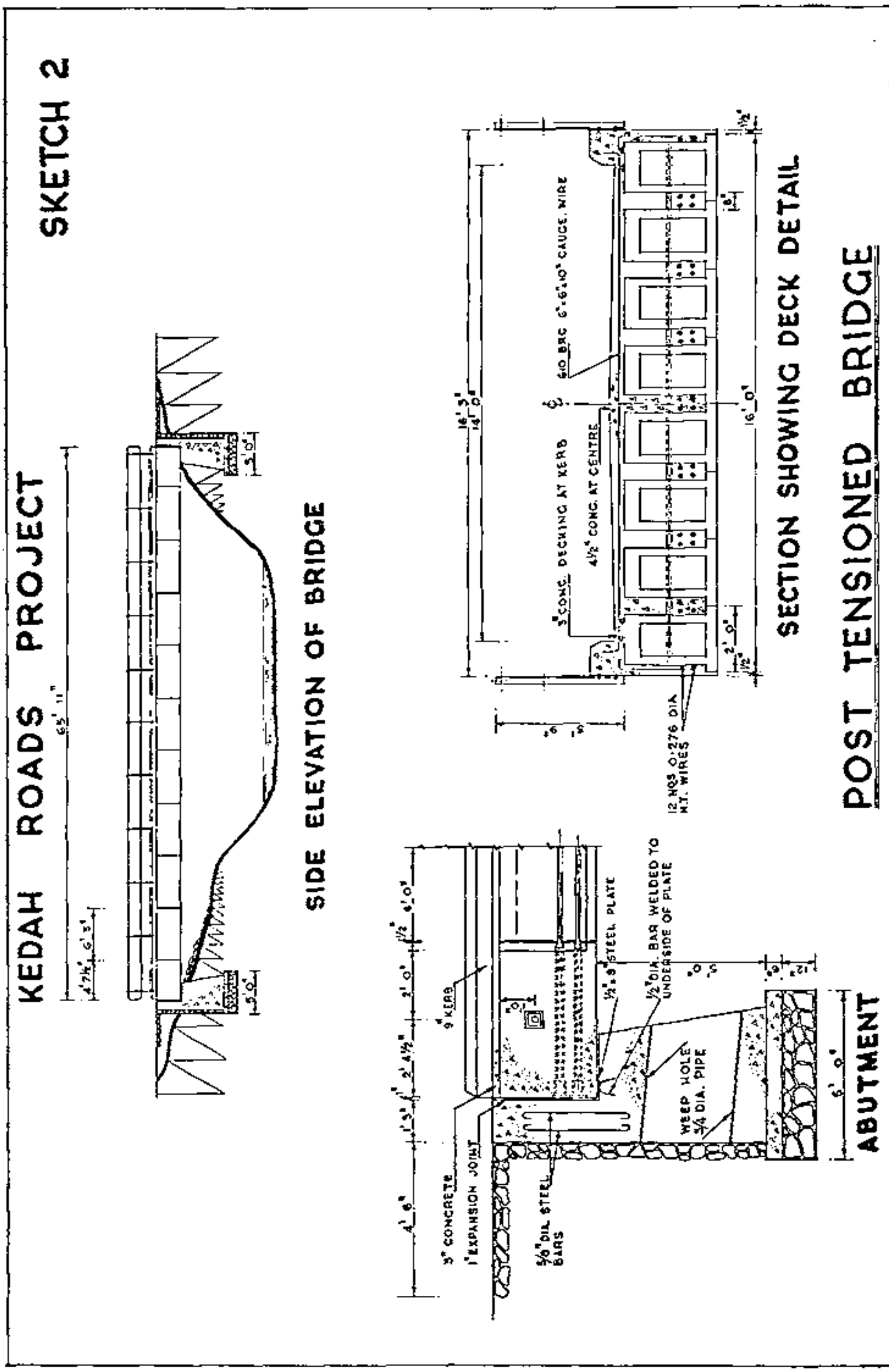
(*a*) We have the right plant for the task, robust and big enough;
(*b*) Types are standardized within theatres;
(*c*) We have a proper repair and spares organization to back us up; and
(*d*) we have a nucleus of really experienced "plant minded" Officers and NCOs available.

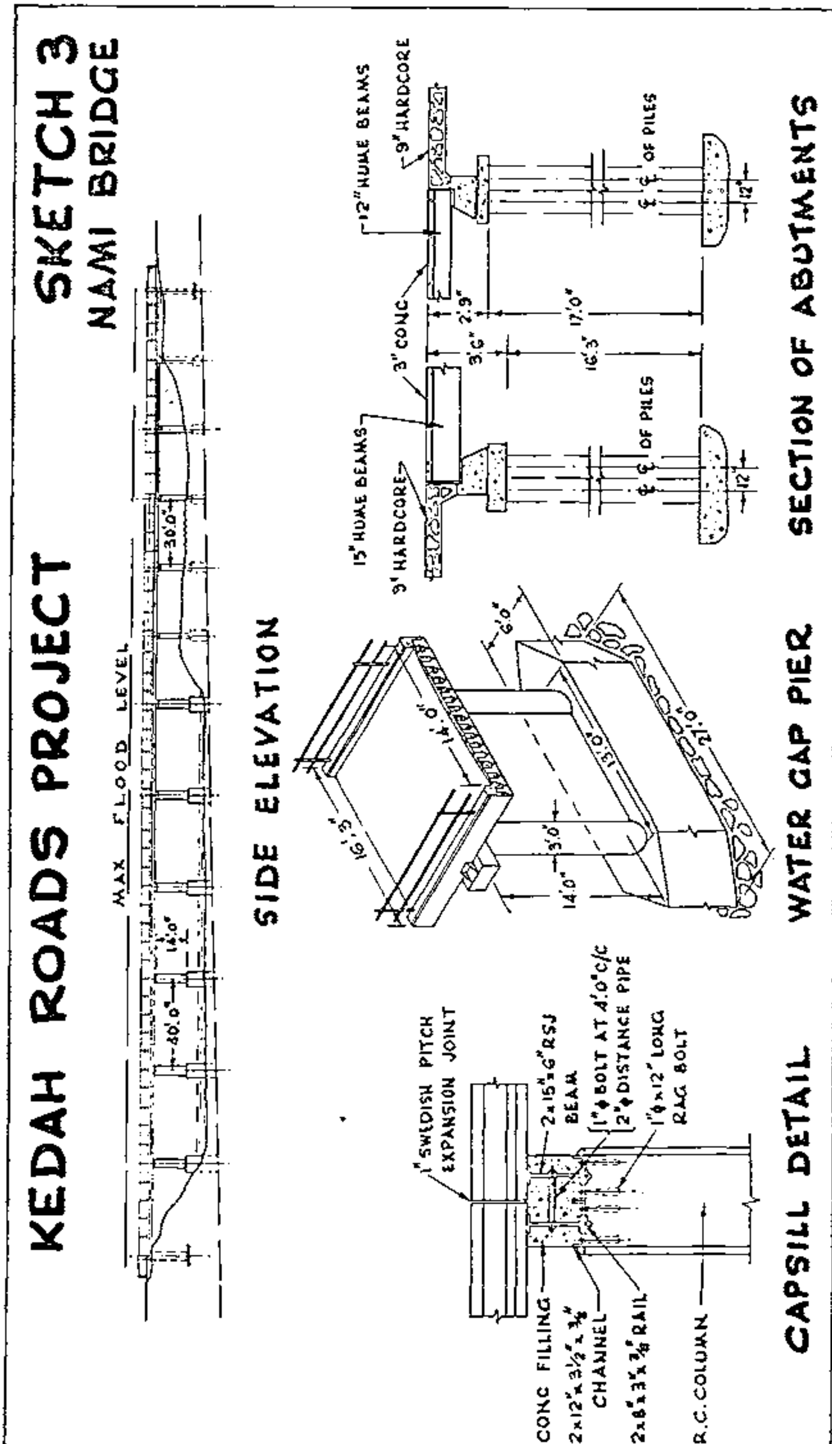
If these difficulties could be overcome, and if civil engineering projects could become a regular feature of the annual training of all units, then the beneficial effect on recruitment, training and morale would become apparent at once.

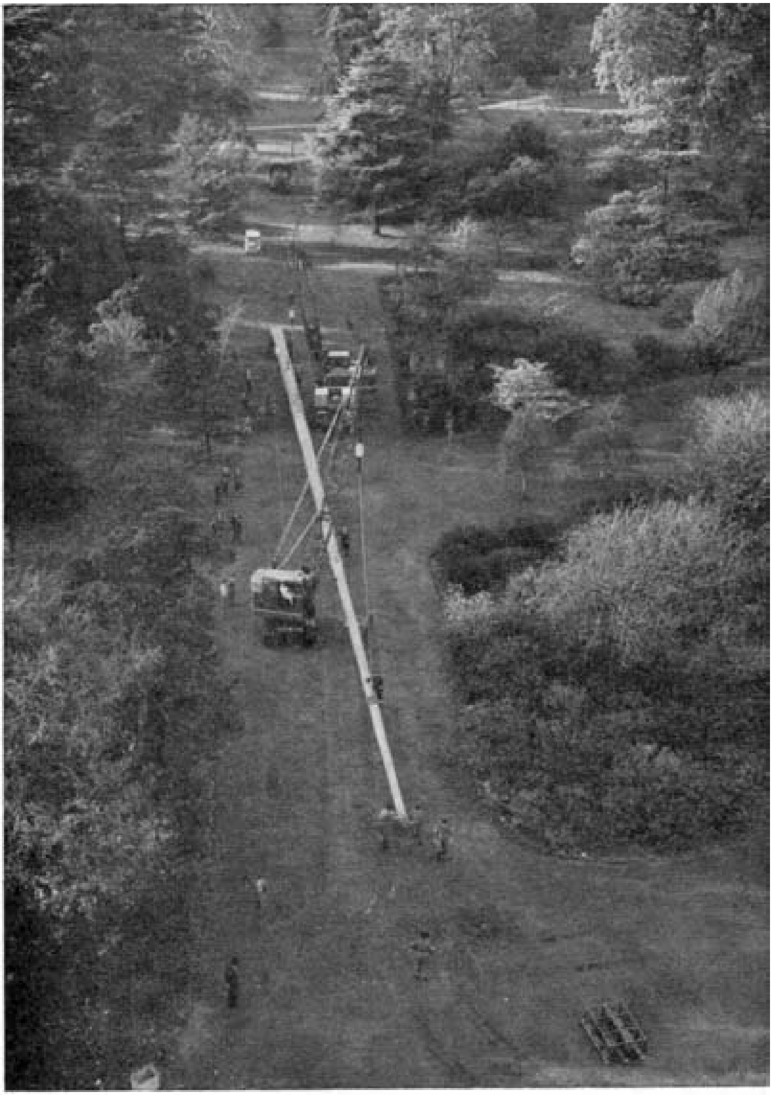
ACKNOWLEDGEMENT

In writing this article, I have made full use of the Completion Reports submitted by Squadron and Plant Troop Commanders on their individual tasks, and I must also acknowledge the help given by Hume Industries (Far East) Ltd in providing details of their RC beams.




KEDAH ROADS PROJECT
SKETCH 2
SIDE ELEVATION OF BRIDGE
SECTION SHOWING DECK DETAIL
POST TENSIONED BRIDGE
ABUTMENT
3" CONC. DECKING AT KERB
4½" CONC. AT CENTRE
12 NOS 0·276 DIA H.T. WIRES
WEEP HOLE ¾ DIA. PIPE
3" CONCRETE
1" EXPANSION JOINT
⅝" DIA. STEEL BARS
STEEL PLATE


KEDAH ROADS PROJECT
SKETCH 3
NAMI BRIDGE
MAX FLOOD LEVEL
40'0"
14'0"
30'0"
SIDE ELEVATION
9" HARDCORE
12" HUME BEAMS
3" CONC
15" HUME BEAMS
9" HARDCORE
℄ ℄ OF PILES
12"
2'9"
3'6"
17'0"
16'3"
SECTION OF ABUTMENTS
16'3"
14'0"
6'0"
13'0"
21'0"
3'0"
14'0"
WATER GAP PIER
1" SWEDISH PITCH EXPANSION JOINT
2×15"×6" RSJ BEAM
1"φ BOLT AT 4'0" C/C
2"φ DISTANCE PIPE
1"φ×12" LONG RAG BOLT
CONC FILLING
2×12"×3½"×⅜" CHANNEL
2×8"×3"×⅜" RAIL
R.C. COLUMN
CAPSILL DETAIL



By courtesy of The George Cohen 600 Group Ltd, London, N.W 10

"Team work."

The Kedah Roads Project, Teamwork

Operation Kewstaff 1959

By 2ND LIEUTENANT R. M. BERRY, RE

INTRODUCTION

To mark the celebration of the British victory at Minden on 1 August 1759 a mound in Kew Gardens was named Victory Mound and a temple was built upon it. A hundred years later, in 1859, it was proposed to replace the temple by a flagstaff from which could be flown, on appropriate occasions, the Union Flag and the Royal Standard. A mast of 118 feet in length was donated to the gardens and work on its erection began. Unfortunately the pole had been damaged on its journey up the Thames and subsequently when the hoisting apparatus was blown over in a high wind the mast fell and broke into three pieces. The donor thereupon offered a replacement and eventually in 1861 this pole, some 159 ft high, was erected.

In the course of time the pole deteriorated and shortly before World War I it was decided that a replacement was necessary. The Province of British Columbia offered and provided a fine tree which they shaped into a flagstaff 214 feet high and this was brought to Kew. Because of the war, however, it was not until 1919 that the third mast was erected. Time and the elements took their toll and the height had to be reduced by 84 feet in 1958. Immediately the British Columbian Logging Association offered a replacement and in April 1958 a giant 370 years-old Douglas fir, 225 feet in height was delivered to Kew.

In April 1959 it was confirmed that 23 Field Squadron RE of 3 Divisional Engineers should be given the task of lowering the old flagstaff, moving the new one to the site and erecting it. In many ways it is fitting that this task should have been given to a Royal Engineer unit. Firstly, it provides excellent training. Secondly, because of the military significance of the memorial, in this the bicentenary anniversary of the Battle of Minden. Thirdly, because of the historical connexions of the Corps with British Columbia.

THE PROBLEM

The flagstaff erected in 1919 was 214 feet high. Sixteen feet above the butt, which was a 2 feet 9 inch square, the section changed from square to octagonal. The upper 68 feet had a circular section. The Ministry of Works decided that the new flagstaff should be shaped in exactly the same way but with the circular section 11 feet longer than the previous mast. With a uniform taper the diameter at the tip would be just over 1 foot. Work on this shaping was begun by Messrs Higgs & Hill in June. The weight of the finished pole was the subject of some speculation, however, assuming a density of 35 lb/cu ft, it was calculated to be 13 tons and the lifting calculations were based on that figure. The butt, in which was cut a slot 7 inches wide and 1 foot deep, rested on a $6\frac{3}{4}$ inch square steel trunnion bar. The ends of this bar were turned to 4 inches diameter and supported in two bearings, with detachable caps. The bearings were mounted on channel beams set in the concrete plinth. The trunnion bar and its bearings were to be used for the new flagmast but the eight permanent guys and their mass concrete anchorages were to be renewed.

In 1919 the mast was moved to Victory Mound by hauling over rolling logs, this was a laborious business and took several weeks. Unfortunately the route then used, which was the most direct, had in the last half century been over-planted by many irreplaceable and valuable trees. So in June a team from 13 Survey Squadron RE made a survey of the area of the gardens between the river bank and Victory Mound. The route finally chosen, although longer than the direct approach and involving three turns of more than sixty degrees, made the best use of the broad vistas and thus reduced carriage problems.

A result of using this new approach route was that the new mast would have to be erected in a line at right angles to that used in 1919 and hence the trunnion and its bearings would have to be rotated. The further problem arose: that if we were to use our erection equipment to lower the old pole, thus testing the tackle, then it would be lowered along the line of the trunnion axis and hence there would be no butt restraint.

The Plan

Lowering the old flagmast. To allow the lowering to take place along the line of the trunnion a pivot beam was designed which, in conjunction with footropes, provided an axis of rotation and ensured that the skirt of the butt slot lifted clear of the trunnion bearings as it was lowered. The work of producing this pivot beam and the footrope brackets was undertaken by 6 Field Park Squadron RE.

Moving the new flagmast. Several methods of moving the pole were examined such as mounting it on steerable bogies, but it was soon apparent that by far the easiest and quickest method was to carry it slung from the jibs of two mobile cranes. As no suitable machine was reported available from Army channels, the civilian manufacturers were approached.

K & L Steelfounders had recently had their Jones KL 12–20 crane on Army trials and this 20-ton equipment seemed to be ideal for the task. The firm agreed to help but as there was only one KL 12–20 available we were also offered the loan of one of their newest 6-ton KL 66 machines. The cranes were to be positioned so that with each crane lifting at two points the loads on the cranes would be 10 tons and 3 tons respectively. (See frontispiece.)

Raising the new pole. The governing consideration in designing the lifting equipment was the flexural rigidity of the pole. To keep the maximum bending stress under 1,000 p.s.i. meant supporting the pole in at least four positions during the first part of the lift.

The choice of equipment was governed by:—

1. Simplicity of operation.
2. Use of military equipment.

Time and cost were of secondary importance. The light and heavy derricks were the only lifting equipment the Engineer Stores Depot could supply and as these were much too small it was decided to use a pier made from military bridging equipment.

MEXE had recently been developing the Heavy Girder Bridge pier and, despite the heavy panels, the mechanical erection aid made it relatively easy to construct. For the modest vertical loads to be expected on the pier it was decided to make it of single panel width and support it using guys. This type of construction ensured economy of stores over a fixed base pier, which would have to have had a very wide base, and even more important—it required only a very small grillage (22 × 7 ft) with the minimum of earth movement and interference with the trees.

From the start it was intended to raise the pole by the most straightforward method, by placing the butt on the trunnion using the mobile cranes, and then lifting it straight up with one winch.

Not wanting to build a pier of more than 100 feet meant a winch load in the order of 16 tons. The length of pull would have to be about 140 ft, therefore, to avoid having to rereave the tackle half-way through the lift, the maximum tackle ratio we could use with a 300 feet winch rope would be 2 : 1.

Our next task was to find a winch with a safe pull of about 10 tons and at least 300 feet of winch rope.

A Scammel recovery vehicle was the first choice but this had only just the capacity and, furthermore, it did not have a power pay out and this tendency to snatch might induce very high live loadings during the lowering of the old pole.

The Centurian ARV had the ideal winch but even on a low loader it would not have been appreciated by the Director of the Gardens amongst all his flowering shrubs and turfed lawns. The choice was finally limited to the new Leyland 1119A RV and a specially modified ANTAR, both fitted with a Turner hydraulic winch. The Leyland, being the smaller and more manoeuverable machine, appeared to be ideal. However only two of these vehicles were in existence both, at that time, engaged on intensive trials. After explaining our problem to the FVRDE and REME it was agreed we should have the vehicle from Technical Services, Arborfield.

With a 350 foot rope of 1 inch diameter the safe working load for recovery was 20 tons. However, for the design of the lifting tackle a safety factor of 5 for SWR was used throughout and, therefore, it was decided not to exceed 10 tons on the winch. Even so, this enabled the height of the pier to be reduced to seven bays (90 ft including capsill and grillage) which would mean a main rope load of 18 tons with 10 tons on the winch using 2 : 1 tackle.

A criticism which might be levelled at this scheme was that we were using a steam hammer to crack a nut. In 1919 the previous pole, which was approximately the same weight, was raised by lifting from a slender timber tower over the centre of gravity of the pole and skidding the butt on to the trunnion during the first half of the lift. To do this they used three hand-operated crab winches and it was obviously a very complicated operation. The actual lift took two and a half days.

With our equipment the lift took half an hour. As we had a steam hammer and no qualms about making the job look simple we are happy to accept this criticism.

Training

It was soon apparent that by far the most difficult part of the operation would be the building of the pier. So far no one had ever built a HGB pier to this height and never of this design, therefore it was essential that an erection team should be trained.

At the beginning of September, the operation having finally been approved and the starting date fixed for 19 October, 2 Troop went to the SME to practise building the pier. After the usual snags which one would expect to find with a new piece of equipment, a drill was developed. The troop was very lucky in having a good team of NCOs and Sappers who were quite happy to work at height. After a week the average building time was 2 hours per bay excluding preparing a grillage. The only parts of the pier that had not been fitted were the capsill pulleys. It was originally intended to fix pulleys on the pier capsills but this would have been unnecessarily heavy and MEXE, who undertook to make this special piece of equipment, finally produced a much neater design. They mounted the pulley on bracing frames which bolted in the usual way on the top end of each pair of panels.

Brigade exercises occupied the Squadron for the next few weeks but in the first week of October the pier was built again at Chisledon—this time building the grillage on a slope to simulate the positioning of the pier on the side of Victory Mound. By then the erection drill was even slicker and fully justified the claim that it was as easy to erect as a 100 feet derrick or tower crane.

Operation Kewstaff

Work began on 19 October. After the grillage had been prepared the pier took two days to erect. One of the several new pieces of equipment being used on this operation was the Molex "screw in" ground anchor. Used in conjunction with Tirfor jacks these proved ideal for the pier guys. The capacity of the anchor to take its maximum load of 5 tons in any direction allowed those guys to be very steep. The anchors were also used with great success, for the footropes and for the Leyland winch tackle. Both items are in our opinion, essential pieces of military equipment and reports to this effect have been forwarded to the War Office.

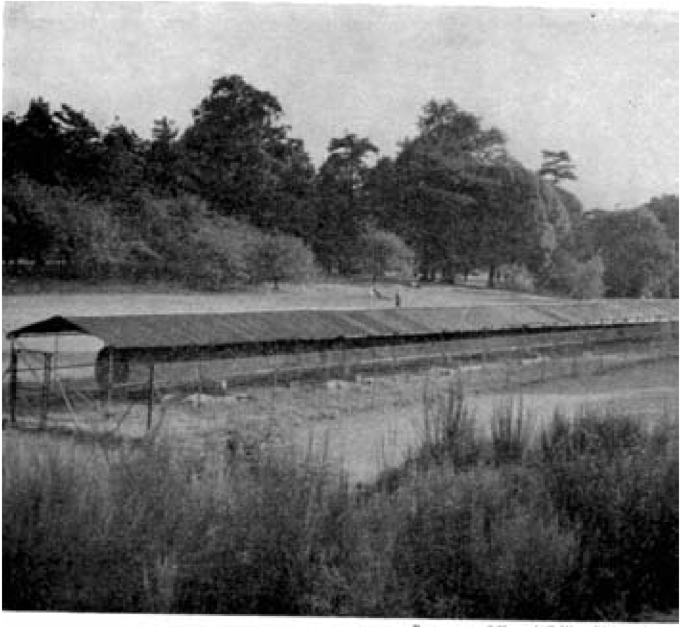
The four pre-erection pieces were built level with the trunnion using 2 inch scaffolding and Bailey chesses.

On 26 October the old flagmast was lowered. After the top had been removed the mast was only supported by the four lower guys. A snatch block was placed over the guy in line with the pre-erection piers and pulled in using a 3-ton Tirfor winch jack. This initial pull was necessary to force the butt on to the pivot beam. The mast was then lowered using the Leyland with 2 : 1 tackle and with the main 5 inch SWR cable attached to one collar 85 feet above the butt. This collar which was the largest of the four collars specially made for the lifting tackle by 32 Base Workshops REME weighed over 1½ cwt and was fitted from an outrigger platform built out with scaffolding from the HGB pier.

The restoring moment of this heavy tackle was such that the Tirfor and leading block had to pull the pole through 10 degrees before it could be lowered on the main winch.

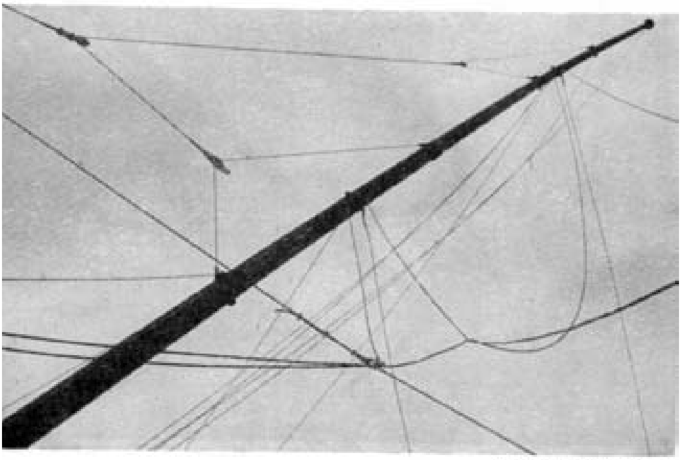
On 21 October the new flagmast was lifted from the shaping gantry with the two Jones cranes. Each crane was fitted with a Dynamometer and it was a relief to find that the pole weighed exactly 13 tons as predicted. The move to the erection site took two days. During the move the grass vistas were still very hard after the unusually dry summer. However on the second day the weather broke and although tracking was used in one or two places we would have had to use SMT throughout the route had we delayed the move another week. The movement through the vistas was a splendid piece of precision crane operating by the Jones crews. Total damage was limited to some slight rutting and the removal of one branch.

As soon as it had been lowered the old pole was lifted from the pre-



By courtesy of Kenneth Collier, Richmond, Surr

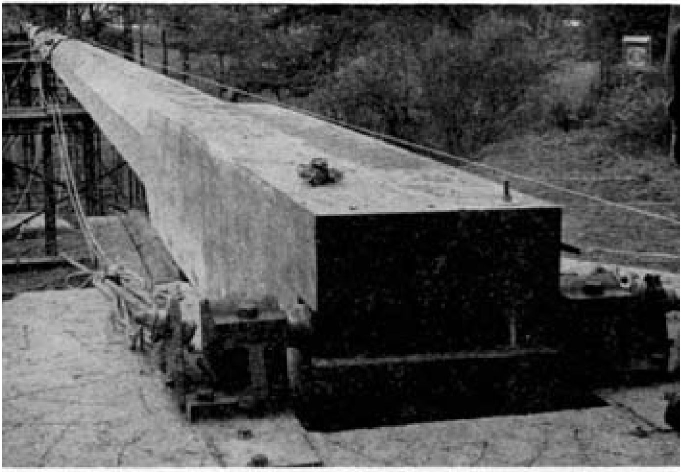
Photo 1. "Caged monster."



By courtesy of "The Craftsman"

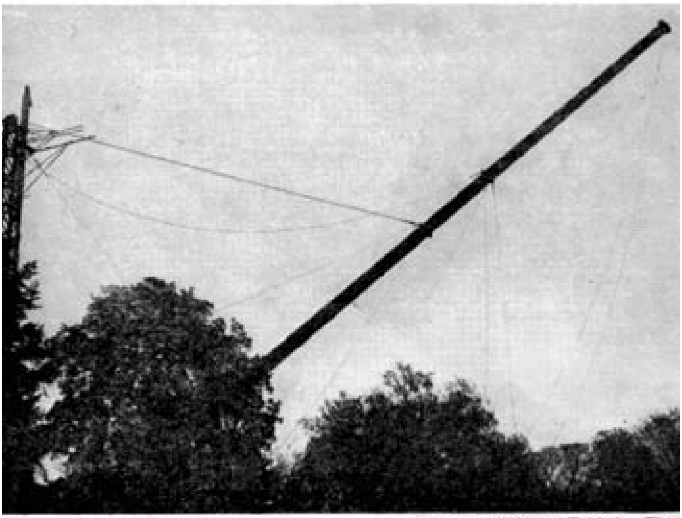
Photo 2. "Oh what a tangled web we mortals weave."

Operation Kewstaff 1959 1,2



By courtesy of "The Craftsman"

Photo 3. "Lying like a log."



By courtesy "Richmond Twickenham Times

Photo 4. "High Port."

Operation Kewstaff 1959 3,4

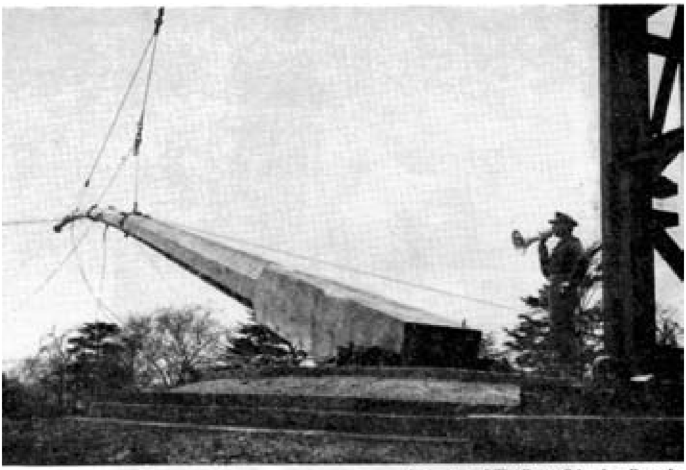
By courtesy of The George Cohen 600 Group Ltd

Photo 5. "Hands on—lift up."

By courtesy of "The Craftsman"

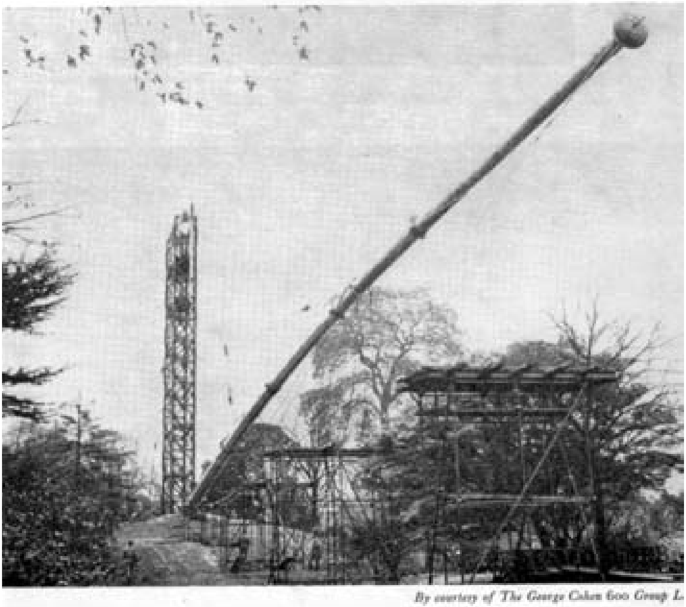
Photo 6. "Man v. machine."

Operation Kewstaff 1959 5,6



By courtesy of The George Cohen 600 Group Li

Photo 7. "Some bite."



By courtesy of The George Cohen 600 Group L

Photo 8. "Bending moment"

Operation Kewstaff 1959 7,8

By courtesy of "The Craftsman"

Photo 9. "Ups and downs"

erection piers with the two cranes and cut up with a compressor saw. Breaking up the old concrete and resetting the trunnion took three days.

On 3 November the new pole was lifted on to the pre-erection piers. The outermost pier was 18 feet high and to lift the flagmast to this height with each crane, using double slinging points, meant adding extra 20 feet jib sections to the cranes. This reduced their lifting capacity and the lift was a very delicate operation with both cranes theoretically over loaded.

By 4 November the new concrete at the trunnion—which would have to take a horizontal load of 14 tons during the first part of the lift, had now had six days to harden and everything was ready for the final lift.

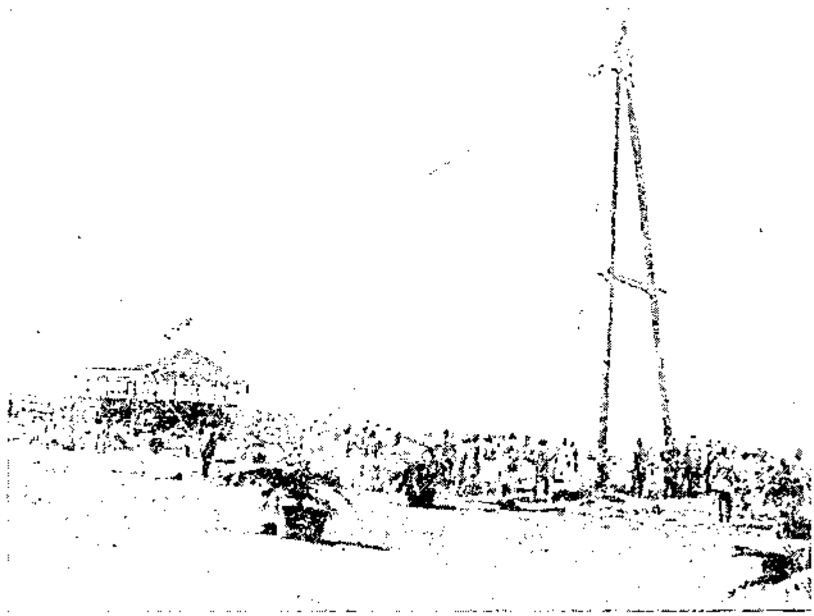
At 1000 hrs on 5 November, on the time and date originally planned, the Leyland started taking in.

The centre section of the mast left the piers quickly enough but there was a somewhat breathtaking pause before the tip followed suit. Although the bending stress was nowhere greater than 850 p.s.i. the deflection was most spectacular.

By 1030 hrs the mast was within 10 deg off the vertical and was then straightened up using the two Tirfor winching guys which had been used to provide lateral control during the lift.

Half an hour later the largest Union Flag in the country was flying high above the gardens of Kew.

"That change which never changes"
Edwin Arnold *Light of Aria*



Raising of flagstaff by No 2 Field Company 1st KGO Sappers and Miners in the Amphitheatre, Delhi for the Coronation Durban 1911.

Administration in Future Wars

By Brigadier R. E. Bagnall-Wild, CBE, Retd

Introduction

When Sir Walter Scott wrote, "This rock shall fly from its firm base as soon as I", he was not thinking of wise or obstinate administrators who cling to a firm base or an outdated system, nor of the possibility of air supply, but taken out of its context this quotation can be applied in several different senses to the study of administration in future wars. In an article in the *Royal Engineers Journal* for September 1959, Major White called for such a study, and briefly suggested the need for mobile reserves. There is of course nothing new in the idea of mobile reserves, not only in the Royal Navy but in the Army; railway trains loaded with ammunition and supplies have been held *en cas mobile*; the word "train" in the military sense goes back a long way before the invention of railways; on an even lower scale of mobility, no doubt bowmen sometimes set off carrying an extra haversack ration and a spare quiver of arrows. Reserves on wheels, or afloat, may be the only answer to the administrative problem in nuclear warfare, but they do involve the use, or misuse, of some form of transport for a purpose not wholly connected with movement. There is always in war a shortage of shipping, lorries, and other forms of transport, and although it may be essential to misuse transport as a mobile reserve, it can only be done at the expense of something else, and a study of the use and consequences of the use of railway wagons *en cas mobile* in the First World War is not encouraging. Turning to a Second World War example of mobile reserves, an Admiral complained that there were too many lighters in a certain port for the traffic handled, and a shortage in other ports; he knew, because he had flown low over the port and counted them; what he didn't know, and what had to be explained tactfully, was that a large number of those lighters were not in use for the work at the port, but were immobilized by the orders of his own staff as a floating reserve of naval ammunition. Reserves held afloat as a mobile floating base for land operations suffer from the disadvantage that the operation of transferring the stores from the vessels to land or air transport can only be carried out in very sheltered water, or in exceptionally calm weather. The areas of sheltered water are well known and therefore become potential targets for nuclear missiles with a surface or under water burst. Mobile reserves are not, therefore, an easy answer to the problem, and it is necessary, as Major White suggested, to consider the matter in more detail than was possible in the scope of an essay dealing mainly with tactical problems, and to do so effectively it will help to consider separately the various types of warfare that may have to be fought by this country in the future.

Non-Nuclear War

It is probable that small "fire brigade" wars and possible that "proxy" wars will be non-nuclear. It is also conceivable, despite the statements of many politicians of different countries, that there might be a major war in which the opposing parties both fear to use nuclear weapons, tactical or strategic, as the opponents in the Second World War feared to use chemical warfare. At first sight one would say that administration in non-nuclear war will be "the mixture as before", but there have been developments in recent years, both tactical developments towards greater cross country mobility and increased fire power, leading to greater daily demands for fuel and ammunition, and developments in transport, particularly heavy transport aircraft and helicopters. One of the main characteristics of traditional administration since the Battle of Ctesiphon has been the vast stocks of supplies and warlike stores that have to be built up in bases and at various points along the lines of communication before a commander feels administratively safe to launch an offensive. These stocks, made up of reserves to cover interruptions of the supply route, and working margins to cover the period from demand to arrival of replenishment, will become even greater if the daily tactical demands from fast-moving, hard-hitting battle groups increase. Air supply is certainly not the whole answer to the problem; the ability of air transport to supply isolated forces is already proved, but its extra speed as a factor in reducing the working margins to be held is partially upset by a slow bidding procedure, and in many cases its unreliability in poor weather causes a feeling that the reserve element in total stocks should be increased. A more realistic approach to the question of cutting down these base and L of C stocks is to consider the holding of a transport reserve, preferably of long range freight aircraft, and helicopters for the forward areas; an air reserve for preference rather than a surface reserve, because of the greater flexibility of air transport, but the essential point is a reserve of transport. It is odd that a good commander never considers himself safe without a tactical reserve, and if his reserves are all committed he holds up his offensive to regroup, but never will he willingly allow his administrator a reserve of transport; the whole lot, land, sea and air, must be fully committed from the initiation of the plan to the end of the campaign. Hence the date of the offensive, or the invasion has to be postponed in order not only to build up vast reserves, but often to import cement and steel to house the reserves. Even if the administrator tries to take a strong line with his commander, he comes under pressure from the other millstones, the Admiralty, the Air Ministry, the Ministry of Transport, and the Directors of the Transport and Transportation Services; they love a good load factor and hate idle transport. These millstones must be educated to understand the administrative object. This object is to reduce the number of days' stock considered necessary in bases on the L of C and elsewhere; the means of doing so, in order of importance are, first, a reserve of transport, preferably air transport, second a more rapid and flexible bidding system, and, third, the use of air supply to save journey time, but this comes a long way below the first two; the rapid and flexible bidding system could well be a fruitful subject for a series of staff studies, and will be referred to again later in this paper.

A War Using Tactical Nuclear Weapons but with both Opponents Refraining from Strategical Nuclear Warfare

It is not easy to imagine conditions that might lead to a situation in which armies in the field would employ tactical nuclear weapons, but the opponents, through fear of the results, would refrain from strategic nuclear warfare; but it is just vaguely possible that this might happen in a "proxy" war, probably in a desert or thinly populated area. The case should not be dismissed as something that could never happen, as war has a knack of assuming an unexpected form. In such a war the tactical developments may well be on the lines suggested by Major White, while the base, possibly 500 or more miles in rear of the battle, could be conventional. Between the two, and particularly on the more forward areas of the lines of communication, obviously Major White's idea of mobile reserve groups is the best solution. It would, however, be essential to keep the number of days held in these mobile reserves to an absolute minimum; just as the bowman referred to previously would sag at the knees and become immobile if ordered to carry too many days' food and too many spare quivers of arrows, so would large mobile supply groups bog down in a vast and vulnerable concourse of transport. Equally there would be a need to keep stocks to a minimum in a base, which would probably have to be set up in a poorly developed country at short notice and be subject to conventional strategic bombing by modern aircraft. Here again one sees the necessity of a flexible reserve of transport, particularly helicopters in the forward areas, and a rapid and flexible system of bidding and allotment of priorities. The series of staff studies needed to work out this system and to assess the consequent reductions in days' stock held at the various points would be almost identical with those suggested in the previous section.

Total Nuclear War

It is not easy to visualize the damage that can be wrought with hydrogen bombs delivered by planes, submarines and ballistic missiles. The tables and cigar-shaped diagrams fit easily into a printed page, but they fail adequately to depict the devastation that would occur throughout the civilized world. On the other hand it is almost certainly as wrong to take the defeatist attitude that no one would survive, so why worry, as it is to take the optimistic view that no one will ever start so terrible a war. The primary object of such a war, if started, must be to destroy the enemy's ability to resist before he destroys ours. With long range weapons of mass destruction the frontier of Britain is no longer in Flanders, or Germany, or Suez; there are no frontiers because the major powers can reach round the world. The defensive problem is, therefore, no longer tactical in the military sense, but one of what is generally referred to as Civil Defence. Not Civil Defence in the sense of wardens pulling people out of burning buildings, but a major problem of preserving our offensive launching sites, some at least of our essential industries, some at least of our population, and adequate reserves of food, water and fuel held underground; a military organization would also be necessary to preserve law and order among survivors, and probably to undertake the administrative tasks connected with survival and recovery. This is a problem of great proportions and immense cost, but if it is seriously thought that there is the slightest chance of total nuclear war, it ought to be given first priority. And what of our forces overseas, our frontier guards who are so necessary in any other type of warfare? They will no doubt, like everyone else, fight for survival, with whatever reserves they may have; but until the strategic nuclear war is won, their use in a tactical role is pointless. They should, of course, be provided in peace time with adequate reserves, well dispersed, not only for their role in non-nuclear war, but also to give them a chance of survival while the world as we know it, with its refineries and factories, is crumbling to ruin. There may well of course be a financial and political "pull devil pull baker" between the demands for our forces in the non-nuclear role and for Civil Defence in the larger sense outlined above, but this only accentuates the need to streamline our tail requirements in the ways suggested previously.

Administrative Planning

This study of administrative problems in different types of future wars has produced a number of points for further detailed study, many of them common to more than one type of war. There is the need to build up reserves in peace time, both in this country and in overseas bases, and these of course should be reasonably well dispersed so as not to present too attractive a target even to conventional bombing. There is the need for organizing reserves on wheels in the form of supply groups to operate in the forward areas in a nuclear tactical war. There is the need to keep stocks at all points, whether in bases or on the lines of communication, to a minimum by the use of a reserve of transport. There is the need for more air transport, including helicopters in the forward zones, not only in the supply role but even more importantly to provide this reserve of transport. Finally, there is a need for a more rapid and flexible system of bidding and priority machinery in order to make full use of the flexibility that can be provided by a reserve of air transport. The principles of administrative bidding remain the same: the user formation or service knows what it wants; the staff forward settles the priorities; the services at the base know what they have got; the staff at the base implements the priorities. The machinery, however, must be much more rapid, and accounting niceties about what happens to indents and other paper work may have to be scrapped. It is by no means a major task to invent a bidding and priorities system to fit a situation; during the Second World War it was necessary to discard preconceived notions based on a static war in France and make new systems adapted to a highly mobile long range war in the Western Desert, or to supply across beaches in an invasion. There will of course be opposition from people who are set in their ways, who will say that despite a reserve of transport they still need 30, 60, 120 or 180 days' stocks in their particular service which is different from all others. Such opposition must be overcome. A series of suitably set staff exercises should produce the necessary results, but these exercises should be on a large scale, not compressed into a week-end, and should enjoy the co-operation of the General Staff both in setting and control.

To sum up, the most important lesson is that in future wars, a reserve of general administrative transport, preferably air transport, will be as important as tactical and strategic reserves of fighting troops.

Infantry Field Defences and the Battle Shelter Concept

By MAJOR F. W. E. FURSDON, MBE, RE

FOR several years now, save for the unusual conditions of Korea, the subject of field defences has been treated generally throughout the field army as the Cinderella of the modern tactical battlefield. The time and effort involved, restrictions on digging in many training areas, the bother of filling in any trenches which have been allowed, the whole business of estimating, indenting for, drawing, transporting, distributing and inquiring into the losses of field defence stores that inevitably occur, have understandably made many units reluctant to include much practical digging in either section training or on major exercises. "But everyone knows how to dig", "There's nothing to it, really", "It's a complete waste of time digging these days"—are all popular cries. The trouble is that such remarks idly passed are fallacious, often interpreted wrongly by the ill-informed and are, therefore, potentially dangerous. Correct digging is not easy without experience and training. It must not be treated just as a chore, but as a basic skill-at-arms. Furthermore, how often, if it has been difficult to dig outside through restrictions or appalling weather, has the instruction been given in the classroom, or have suitable training aids been available to prevent such indoor training in field defences from being deadly boring?

Far from being a Cinderella, throughout military history field fortification has been considered as an art. We have all seen examples of the early Briton and Roman field defences, with their rings of outer fortifications and *vallums*. Coming to comparatively more recent times, Peter Whitehorne (1550–63) was the first English writer on fortifications. The seventeenth century produced other great works such as Matthias Dögen's *L'Architecture Militaire Moderne ou Fortification*, and Balthazar Gerbier's *Military Architecture or Fortifications*, both in 1648. Robert Morden's *Fortification and Military Discipline* was published in 1688 and, with its somewhat surprising double title, is of particular interest. Like most contemporary exponents of the art, he places an overriding emphasis firstly on the basic geometry of any fortification's design, and secondly how study of the art of fortification was the key to success in the tactics of the reduction and capture of an enemy's defended positions. The examples given are all of pentagons, hexagons, and other regular symmetrical figures, catering well for all round defence. He gives figures for the correct proportions of moat depth to breastwork height, and deals with both regular and irregular types of positions. His standard trench is 4 ft deep (as in 1959!) twelve to fourteen feet wide at the top, tapering to six to eight at the bottom. Illustrations show many items still now in current British Army issue, such as the use of canvas bags of earth, 18 in long and 1 ft in diameter, and list the family of field defence tools as being shovels, spades, pickaxes, wheelbarrows, handbarrows and rammers. Revetting is catered for by gabions (hollow frames three to four feet in diameter, five to six feet high which are filled with earth) and candileers (frames for faggots). The "Military Discipline" part of the book, unlike the modern conception, deals in great detail with the drills and formations which the Army should adopt for the various phases of war, i.e. breaching a fortification.

Many engineers will be familiar with the work of Maréchal de Vauban, Directeur General de Fortifications du Royaume, published in 1737 under the title *Traite de l'Attaque et de la Defense des Places.* Once again, there is the pick, the shovel and the sand bag. One special technique worthy of mention is that of digging a deep trench by working four "sapeurs" in echelon. Each man excavated to a given depth only, and so the working end of the trench always progressed rather as a flight of shallow steps. The first "sapeur" was also responsible for unrolling consecutive sections of a wattle screen fence as he went forward, which presumably gave the working party cover from direct enemy observation. Perhaps the most fascinating aspect of Maréchal de Vauban's work is that in 1954 the Viet Minh forces were his most faithful disciples, and employed his very same ideas against the French Army with great success, particularly at Dien Bien Phu.

From the military intelligence point of view, the plans of many of the main forts of significance throughout Europe were often published in these books as examples, so that in fact a potential attacker could have given considerable thought to his plan of campaign before leaving home!

As might be expected, Wellington was also very conscious of the need to have digging tools, and the means of using local materials. In 1809 we find that each regiment had an official mule "for the carriage of the entrenching tools" in direct charge of the Quarter Master, and that "he must be exchanged by the Commissary if the exchange should be necessary, which it ought not to be". In May of that same year "Regiments are to make a requisition on the Quarter Master General for billhooks, in the proportion of one for every 10 men: these billhooks are to be carried by the soldiers, under the straps of the knapsack, outside. The troops will very soon experience the use of them, and must take the greatest care of them: they must be produced by the men at every inspection of necessaries".

In December 1811 a General Order directed that:—

"The soldiers of the Regiments of the 1st, 3rd, 4th and the Light Divisions, together with Brigadier General Pack's Brigade . . . be employed in making fascines and gabions and picquets of the following dimensions:—

Fascines of 1 foot thick and 6 feet in length.

Gabions 3 feet in height by 2 feet 3 inches in diameter, of the same number as there will be of fascines.

Twice as many picquets as there will be fascines, 3 feet 6 inches long."

The order went on to state that an Officer of the Royal Engineers would be sent round to inspect the articles, and pay those who had made them! When completed, these field defence stores had to be kept available at Regimental HQs. At Madrid, on 14 August 1812, 2,000 gabions, 200 fascines and 1,400 pickets were urgently required. A working party of 150 men from 3 Division were ordered to parade "this day at 12 o'clock at the Custom House" to make them, and Lieutenant Rae, of 3 Bn Royal Scots, was detailed to "act as Engineer"—possibly thereby becoming one of the earliest Assault Pioneer Officers!

The actual entrenching tools of Wellington's day were still based on the conventional pick and shovel, and in 1815 the scale of issue per regiment was :—

five spades	five pick axes
five shovels	five felling axes

all carried by the bât horse (as opposed to a bât man) allowed for on the establishment.

By the latter half of the nineteenth century, official training manuals on field defences written by the School of Military Engineering were a normal issue. We find that field fortifications and tactics were rated joint first in apportioning the time to be spent on instructing potential staff officers. With the changes in tactics brought about by new weapons, so the digging pattern altered. In principle, the factors which were considered apply just as much today as they did nearly a hundred years ago. There is no need to alter even one word from the original:—

"In providing cover, of whatever material, regard must always be had to the projectiles expected to be encountered, the time for construction, as well as of intended duration, and the character of the defence, whether active or passive."

The actual designs of the types of dug position had changed, and there is a clear distinction made between those required for "active defence", termed shelter trenches, as opposed to those to be used in "passive defence"—the main division being one of the time available for construction. These shelter trenches were excavated with pick and shovel, or by a light entrenching tool carried by each man. The individual was expected to dig out a protected kneeling fire position trench in 1 hour. The standard length of shelter was "two paces per man", with the provision that "dimensions can be altered by each individual to suit himself."

The scale of tools for the Infantry had increased considerably from Wellington's day, and in 1877 the Battalion tool wagon contained:—

Light picks	150	Felling axes	25
Light shovels	150	Billhooks	50
Spades	10	Crowbars	4

Any soldier was expected to use a felling axe, and the timings given for "two untrained soldiers" (what a sensible description!) to cut down average trees were:—

Diameter of tree in inches	4	6	9	12	18
Time to fell in minutes	1	3	5	9	15

There is no need to dwell on the elaborate static trench systems and bunkers of the First World War, nor on the basic slit trench pattern of the Second World War, save to mention that although explosives were sometimes used in the latter to assist in excavating the bigger positions, the pick and shovel remained the infantryman's basic means of excavation.

Some conclusions from early studies of the effects of nuclear weapons on field defences led firstly to a new War Office policy directive in June 1955 and subsequently to the replacement of the 1951 Manual by the issue in 1957 of the present *Field Engineer and Mine Warfare Pamphlet No 2—Field Defences Part I.* This was the first time field defences had been related to the nuclear weapon, and consequently some changes were needed. The SME designed bent corrugated iron "hairpin" made its debut, combining a strong earth supporting bridge with an automatic side wall revetment. The aim was to simplify and quicken both construction and the range of defence stores. The thermal screen appeared for the first time as the initial protective covering. Designs for extensive overhead protection were given, not only for the shelters but also for the fire bays.

This cover was to give protection not only against airbursts but also to reduce the combined effects of heat, blast and radiation. The need for rapid digging was emphasized, the section on explosives was revised (plastic explosive being substituted for the Hawkins grenade) and the possibility of using mechanical plant for tasks other than just a dozer helping to dig in a tank, was introduced for the first time. A subsequent change of War Office policy relegated the idea of providing overhead protection over the fire bays, and further trial work by a Field Engineer Regiment and the Field Engineer School of the SME with anti personnel mines and 4 oz charges enabled explosives to be used in assisting the excavation of narrow two-man fire trenches.

From the nuclear side, various field defences and related stores had been first tested on Operation Totem in 1953, with the aim of producing basic experimental data to confirm theoretical predictions of radiation dose distribution and blast effects. Some of the suggested designs due to be publicized in the new 1957 Manual were put to test in Operation Buffalo at Maralinga in September and October 1956, with varying degress of success; the final report on this trial, unfortunately, was not published until August 1959.

Many people, however, were still appalled at the time and effort required, particularly logistically, to dig in a field formation to standard contemporary designs. This had been demonstrated most effectively by an Infantry Division on Salisbury Plain in the autumn of 1955, when the tonnages for even the initial positions ran well into four figures. Speed of excavation being always a high priority factor, thoughts turned instinctively to the extension of the use of mechanical plant as a direct aid, particularly with the large Command Post designs.

Logically, both field defences and machines being traditionally engineer subjects, the SME at Chatham were asked by the War Office in the autumn of 1957 to study the problem of using machine power to aid in the rapid digging of all arms field defences. This was to be in two parts: Phase I the basic evaluation of the potential performances and possible uses of various types, and Phase II the actual field trial of those which showed promise in digging in a battalion position tactically. It was later agreed that Phase II would be carried out by the School of Infantry. The main conclusions from this primarily technical assessment were that owing to the great scope and variety of the task, no one general type of machine was entirely adequate and, therefore, the answer appeared to lie in a family of machines, ranging from the manpack powered pick/shovel, through the wheeled trenchers to a form of larger excavator.

March 1958 saw the first meeting of the Engineer Tripartite Working Party on Field Defences held in Canada, where in particular the basic design criteria were discussed.

In September 1958, in appallingly wet weather conditions, a strange rather Emett-like collection of both military and civilian plant was assembled at Warminster for Phase II of the War Office trials, with the object of assessing:—

(*a*) The range of tasks for which mechanical digging assistance is acceptable and should be considered.

(*b*) The potentialities of certain types of machines to meet the requirement.

(*c*) The scale of issue that will be necessary.

The machines ranged from the large service BK 50 lorry mounted excavator, down through a representative array of commercial ditch diggers and tractors, to the Atlas Copco manpacked "Cobra".

The first week was devoted to trying out the various machines and excavating techniques, by both day and night, against a set of current field defence excavations such as would be found within the Infantry Battalion. In addition, the larger machines were given some "dug in" vehicle pits to master. This basic session served to reveal the limitations of the various equipments, in regard to such things as the size and type of cut, general agility and manoeuvrability, cross-country achievement, noise level, operator vision and degree of control, and the magnitude of hand-finishing that would be demanded of the occupants. At night, for instance, the operators of the larger machines had great difficulty in seeing where their buckets were! With others, the first "bite" tore away the marking tapes, and repeated "grabs" weakened the surrounding earth so much that revetting was essential. One small machine had been designed only to be driven with the driver sitting sideways to the machine, facing inwards, and that at the near rear side. Its performance by day, yet alone by night, can well be imagined! The opportunity was taken during this trial to gain further experience of explosive methods, and compare them both against the machine and the basic pick and shovel methods.

During the second week, the machines were deployed to dig the dispersed positions required by an Infantry Battalion in a tactical nuclear setting—both by day and night. The various problems of reconnaissance, rendezvous, route marking, guides, marking out, extensive track marks and excessive noise in the forward platoon areas, moving on from one position in the dark to dig the next, presented themselves all too clearly to those responsible.

Briefly, the main conclusions from this trial were:—

1. In this day and age, against a background of tactical nuclear war, it is fundamentally wrong to reject the principle of mechanical assistance in the digging of infantry field defences. After all, it is already accepted both by Allies and potential enemies.

2. A complete Infantry Battalion must be capable of being dug in, with overhead protection, camouflaged and ready to fight, within a maximum of six hours of darkness.

3. For various tactical and other practical reasons, there is a critical limit to the number of digging machines which are both acceptable and economic in the forward area.

It follows, therefore, that machines, invaluable as they may be, must not be regarded as more than one of a family of excavating techniques. In the provision of alternative and deceptive positions in reserve company, battalion and brigade areas, however, mechanical power would be of the utmost use. Indeed, it is probable that only by such means most of these would ever be dug at all.

4. For the Infantry in particular, the family of official excavation techniques should include the use of the Atlas Copco "Cobra" mechanical spade/pick, and of the Thumper with explosives. Both of these methods have been developed, extensively tested, and are now taught by both the Schools of Military Engineering and Infantry.

5. None of the digging machines provided for the trial were really satisfactory for the task of excavating the current family of Infantry field defences. They all failed individually on one or more aspects of tactical or mechanical limitation. On the other hand, it became equally clear that the current designs of field defences were in many cases quite unsuitable for satisfactory rapid excavation by any machine.

It was this last point of unsuitability that caught the imagination of those responsible for the trial. Thinking about it, and being convinced that mechanical power, when and where it could be made available, had such a potential as an excavation means, the only possible answer was to recommend that the whole current family of field defences be redesigned against this background as a matter of urgency. Furthermore, a suitable machine had to be designed specifically for this task which might one day become organic to the Infantry Battalion/Battle Group. The trials had shown the bucket-trencher type, suitably modified, to be the most hopeful pattern for this.

Working from this start point, it was but a very short step to appreciate that here was the golden opportunity for redesign also on account of the two other very pressing factors. Firstly, the current designs and construction times did not fit at all readily into the new tactical nuclear thoughts which were becoming part of the everyday environment of Tactical Wing. Secondly, the logistical load imposed by field defence materials for one defensive position (e.g. 60–70 tons per infantry battalion), let alone a set of frequent moves to new ones, seemed quite unrealistic. As these last two factors seemed particularly relevant to the Infantry, it seemed right that the School of Infantry should initiate its own study on these problems, calling in only such outside engineer specialist advice, at this preliminary stage, as it required. It was as a result of this work in January 1959 that the "Combat Emplacement" or "Mobile Hole" Concept, as it was popularly christened, originated.

As a result of favourable comment on this concept by the School of Military Engineering and others interested, by March 1959 the War Office had agreed in principle that a Joint Working Party should be set up under the chairmanship of the Commandant of the School of Infantry, Brigadier C. H. P. Harington, CBE, DSO, MC. This party was to consider the general policy for infantry field defences, including their function, and co-ordinate the design of a family of positions for use in all parts of the world in either nuclear or non-nuclear war, taking into full account the three factors which had prompted the original School recommendations.

The first full meeting was held at Warminster on 19 May 1959, and the final report and recommendations were forwarded to the War Office on 2 October 1959. In general terms, the recommendations incorporated and, in some cases, extended the original "Combat Emplacement" Concept to cover an even broader field than was envisaged in original War Office terms of reference. The reason for this was that once deeply involved in the subject, it would have been wrong not to follow up and comment on the many additional aspects of infantry field defences such as protective clothing, camouflage, tools and examination of the actual design of field defence materials, all of which must have a direct influence on both policy and design.

The "Battle Shelter" Concept—the title finally recommended—is directly related to *infantry* field defences. This latter term can be considered to include all positions covered by the operational functions of an Infantry Battalion up to and including such as are required for the Battalion Command and Regimental Aid Posts. The first point to make, however, is that since other arms and services, particularly in the forward combat area, normally use similar stores to, and derive their own designs from such of the Infantry ones as are suitable, it would not be out of place here to try and outline the thoughts behind the new concept. Whether the War Office eventually accept the proposals or not is immaterial, since it is both essential for and the purpose of this article to prompt every soldier to think about the subject for himself. The second basic point is that battle shelters, although primarily designed for use in the tactical nuclear setting, are not for nuclear conditions only. They would also be of great advantage in non-nuclear war, and a bonus on internal security duty. Thirdly, there is no question of "killing" the current Field Defence pamphlet. The relationship is that battle shelters are the new rapid simple positions designed for construction by the Infantry in the forward combat area with the minimum of light-weight stores: this is to differentiate them from the designs and improvisations published in the current pamphlet, for which there may still be a requirement in conditions where the problems of time and materials may more readily be overcome.

The fundamental assumption is that despite the advent of the Armoured Personnel Carrier, and the greater need for mobility, the Infantry must still retain the *capacity* to dig in quickly. After all, the soldiers may not live in, or actually fight from, their APCs. These vehicles are liable to damage, and are not infallible mechanically. They may not always be tactically acceptable in a company area, nor may it be wise for men to stay inside them when static at night. Unless an Army can afford to ignore large losses both of men and vehicles, therefore, to base protection solely on mobility is a fallacy. Any alternative must afford a degree of protection for the men against the major hazards which they may be called upon to endure or else morale will quickly fall. These can be summarized today as being all the known effects of nuclear weapons, together with non-nuclear battle missiles fired from small arms, mortar, artillery, rocket or aircraft sources. To be able to dig, therefore, offers the only practical insurance to survival. It follows on from these two requirements that in any future war, a Commander's digging policy may well be the most influential factor in saving lives.

What are the principal factors to be considered? These can be listed as:—

Protection	Concealment
Function	Life below ground
Speed of Excavation	Logistics and Materials
Economy of Effort	

What about priorities—and surely some of these factors will conflict? The priorities will certainly vary in different circumstances, and it is very true that some factors will always conflict. In general, though, tactical realism will demand that the speed of obtaining an initial degree of protection at all, which may be increased later whilst protected should opportunity occur, is preferable than to risk exposing men for much longer periods in the hope of obtaining much greater protection eventually. The only sensible answer is that the Commander on the spot will invariably appreciate the situation as he finds it, and his actual dug positions will represent the best compromise. It is from critical examination of these principal factors against the tactical background, that the chief characteristics of the "Battle Shelter" Concept emerge. Very briefly, these are:—

Protection

The individual's person must be protected by suitable thermal clothing or material at all times against both the initial and repetitive thermal effects of successive nuclear weapons. Such clothing or material must permit him to remain fully operational as a soldier, whatever his arm. Remember the extreme vulnerability of a man on the surface, just starting to dig. Against radiation, he must be well below ground, and the narrower and deeper the hole, the better the protection. Earth cover will help to attenuate the effect. For fallout, a form of light cover is needed which can be removed and replaced when contaminated. Against blast, there should be the minimum of projection above ground level: the angle of any face that does have to project should not exceed 30 deg. Any construction materials, which of course are liable to be dislodged by a blast wave, must not of themselves be lethal. The best protection against non-airburst missiles is to make the hole as small as possible: against airbursts, additional protection is given by adding overhead protection, but not on all occasions is it either realistic or economic to provide as much as was thought in the past.

Function

Suffice it to say here that the function is to enable the Infantry Battalion to fight, live and operate with the maximum possible protection. The detailed designs required are built up on a brick system, starting with the basic fire position for two riflemen.

Economy of Effort

Absolute simplicity—easily memorized by the private soldier—and quick to mark out by day or night. The essential minimum of excavation, and that by the quicker and simplest combination of excavation techniques available. Stores, essentially of small volume, kept to a minimum. No initial revetting, unless soil conditions make this imperative.

Speed of Excavation

The speed of excavation must be related to the threat, be it nuclear or non-nuclear. Non-nuclear weapon response times have been reduced to minutes, and it is only a matter of a few years before nuclear timings are

comparable. Positions must be completed just as quickly as possible certainly in not longer than 30 minutes. It is clear that this standard w be possible by hand methods alone; other techniques are essential, n explosives, machines, power tools (both man-portable and APC pow in addition to hand tools. The important point is that the means of tr with and employing those techniques must be available to the Inf Without them, it is impossible to implement a realistic digging concept

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Camouflage measures must be taken against both ground and ai veillance methods. Turf-stripping will usually impose an unacceptabl delay, and so other methods of concealing the excavated soil are req Open trenches or pits require covering. The better the concealment ach the greater is the chance of escaping detection, and hence the inc chance of avoiding attack, particularly from low-yield nuclear weapons

Life below ground

This factor is somewhat new, for in a nuclear setting men just leave their positions and wander about at will, a perfect target for burst nuclear. Essential movement may have to be staggered. Self con ration packs and expendable trench sanitation containers are req Designs have to be based on the initial minimum acceptable comfo morale standards, and this of course includes weather-proofing. Allo must be made, however, firstly for the individual to modify the sta dimensions (within the limits of his materials) to suit his own pecu of shape, and secondly, should the position be occupied for some ti carry out additional controlled work to increase both his protectio comfort.

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This factor is somewhat new, for in a nuclear setting men just cannot leave their positions and wander about at will, a perfect target for a high burst nuclear. Essential movement may have to be staggered. Self contained ration packs and expendable trench sanitation containers are required. Designs have to be based on the initial minimum acceptable comfort and morale standards, and this of course includes weather-proofing. Allowance must be made, however, firstly for the individual to modify the standard dimensions (within the limits of his materials) to suit his own peculiarity of shape, and secondly, should the position be occupied for some time, to carry out additional controlled work to increase both his protection and comfort.

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Protection

The individual's person must be protected by suitable thermal clothing or material at all times against both the initial and repetitive thermal effects of successive nuclear weapons. Such clothing or material must permit him to remain fully operational as a soldier, whatever his arm. Remember the extreme vulnerability of a man on the surface, just starting to dig. Against radiation, he must be well below ground, and the narrower and deeper the hole, the better the protection. Earth cover will help to attenuate the effect. For fallout, a form of light cover is needed which can be removed and replaced when contaminated. Against blast, there should be the minimum of projection above ground level: the angle of any face that does have to project should not exceed 30 deg. Any construction materials, which of course are liable to be dislodged by a blast wave, must not of themselves be lethal. The best protection against non-airburst missiles is to make the hole as small as possible: against airbursts, additional protection is given by adding overhead protection, but not on all occasions is it either realistic or economic to provide as much as was thought in the past.

Function

Suffice it to say here that the function is to enable the Infantry Battalion to fight, live and operate with the maximum possible protection. The detailed designs required are built up on a brick system, starting with the basic fire position for two riflemen.

Economy of Effort

Absolute simplicity—easily memorized by the private soldier—and quick to mark out by day or night. The essential minimum of excavation, and that by the quicker and simplest combination of excavation techniques available. Stores, essentially of small volume, kept to a minimum. No initial revetting, unless soil conditions make this imperative.

Speed of Excavation

The speed of excavation must be related to the threat, be it nuclear or non-nuclear. Non-nuclear weapon response times have been reduced to minutes, and it is only a matter of a few years before nuclear timings are

comparable. Positions must be completed just as quickly as possible, and certainly in not longer than 30 minutes. It is clear that this standard will not be possible by hand methods alone; other techniques are essential, namely explosives, machines, power tools (both man-portable and APC powered), in addition to hand tools. The important point is that the means of training with and employing those techniques must be available to the Infantry. Without them, it is impossible to implement a realistic digging concept at all.

Concealment

Camouflage measures must be taken against both ground and air surveillance methods. Turf-stripping will usually impose an unacceptable time delay, and so other methods of concealing the excavated soil are required. Open trenches or pits require covering. The better the concealment achieved, the greater is the chance of escaping detection, and hence the increased chance of avoiding attack, particularly from low-yield nuclear weapons.

Life below ground

This factor is somewhat new, for in a nuclear setting men just cannot leave their positions and wander about at will, a perfect target for a high burst nuclear. Essential movement may have to be staggered. Self contained ration packs and expendable trench sanitation containers are required. Designs have to be based on the initial minimum acceptable comfort and morale standards, and this of course includes weather-proofing. Allowance must be made, however, firstly for the individual to modify the standard dimensions (within the limits of his materials) to suit his own peculiarity of shape, and secondly, should the position be occupied for some time, to carry out additional controlled work to increase both his protection and comfort.

Materials and Logistics

Whenever time, availability and the risk of exposing men to nuclear weapons effects permit, local materials will be procured and used for construction. Issue stores will be lightweight and of small volume, yet capable of supporting the maximum overhead cover envisaged. Such issue stores as are required by an Infantry Battalion must be carried on its organic transport. It is quite unrealistic any more to expect fleets of RASC transport to bring up tons and tons of defence stores into the forward positions. The stores for the rifle section positions must be able to be operationally man-portable by the occupants, should the situation demand it. All these stores must be easily recoverable and capable of re-use from one position to another.

* * * * *

It will be readily apparent that responsibility for the detail of what defences or adaptations from the basic family are dug, together with the degree of overhead protection to be provided will now rest entirely with the unit or even sub-unit Commander. No longer will he be able just to turn to the book and quote chapter and verse. He has a firm responsibility to his men that he himself is properly trained, and knows the capabilities and limitations of the new excavation techniques and construction materials. When the time comes, he will have to appreciate the enemy threat and weapon effects, the general tactical situation, the time both of expected occupancy and construction (remember the quote from the old *Field Defence Manual*) and the ground—

What are the principal factors to be considered? These can be listed as:—

Protection	Concealment
Function	Life below ground
Speed of Excavation	Logistics and Materials
Economy of Effort	

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both tactically and for ease of digging. Truly at times this will be no simple task. It would be out of place here to comment on any of the detailed designs proposed, but in general they are based on a trench width of 2 feet, a firing bay length of 2 feet 3 inches per man, and no set rules as to the number of individual shelters, nor their orientation, except that they will normally load directly out of the basic length of fire bay.

So far, so good, maybe—but what happens when all this is translated into practical terms of "hardware"? Does it work out in practice? In answer, it is only fair to say that the "Battle Shelter" Concept, although it could be partly applied to the British Army immediately with advantage, demands both new and extensions to existing research and development projects in order to reach full maturity. Anyone connected with the concept would be the first to agree that it was only a beginning, and that a great deal more practical test and trial work, even nuclear tests, were still required in order to learn more about its limitations and dangers. A certain amount of work has already been done unofficially, and it is on the result of this that the concept became a living proposition as opposed to just a theoretical study. Brief notes on the main aspects of this are given below:—

Designs

Four successive Platoon Commanders' Courses in Tactical Wing of the School of Infantry have been used as guinea-pigs for battle shelter designs on their digging exercise "Black Widow" on Salisbury Plain, with increasing degrees of success as more experience was gained and modifications made.

The course in November 1959, digging their way with only pick and shovel through the chalk and flint of Imber Firs cut the School time record for getting underground complete by more than half. They unanimously voted battle shelters, apart from confirming the minimum comfort standards, as being the warmest they had lived in, despite the cold and driving rain that swept the Plain!

Explosives

The equipment set so far developed comprises a Thumper (operated by two men) which drives down a hollow tube with a sliding fit point to a certain depth. The tube is withdrawn, and a standard digging charge inserted. Normally three such charges are fired simultaneously in a fire trench, which is then shovelled out by hand. By this method it has been found practicable on Salisbury Plain that two men, after 15 minutes' work, had excavated a trench 6 ft long, 2 ft wide and 3 ft deep. This gave them a kneeling fire position, or complete "below ground" protection if covered by a groundsheet or an old door. Explosive techniques must be considered as being in the early stages, and there is still room for major improvements in both driving and charge equipment design. It may be of interest to note that even now every infantry soldier passing through the West German School of Infantry at Hammelburg is being taught to use simple explosives, particularly for digging, and that the much-boosted American Foxhole Digger project was recently abandoned. The "Battle Shelter" aim is for every soldier to carry a standard safe digging charge, rather as he now carries a grenade.

Hand tools

As the Army is just in the process of being issued with the new lightweight pick and shovel, it would be inopportune to comment further at this stage.

Within the "Battle Shelter" Concept, however, limited experience of them seems promising. If only one end of the pick had a wider wedge, it would be even better. It is interesting to note that every West German soldier now carries a simple wire saw in the pocket of his entrenching tool, enabling him to cut timber and brushwood for improvisation: these saws are very efficient.

Power hand tools

The Atlas Copco "Cobra" has already been referred to in this article. It was first shown off at the SME in April 1957, and subsequently put to unofficial troop trial a month later. It has been proved that the use of it reduces excavation times considerably, and obviously the harder the ground the better the dividend and the greater the saving of fatigue. It is a little noisy, but it will go manpack wherever an infantryman can go. He can then use it drilling for explosive or merely with its digging and breaking action. Small power saws, and tools driven by power take-off action from an APC are possibilities.

Machines

In general, for economic battle shelter work in terms of speed of excavation, control and simplicity of operation by day or night, it is considered that a machine having a continuous application of the cutting tool to the working face, is best. With the present state of technical "know-how" this reduces the field to the various types of trencher with, possibly, the auger and the Archimedian screw. A machine is undoubtedly an expensive initial cost item, but the more it digs, the cheaper a proposition it becomes. Furthermore, explosive is also expensive, and remember that once fired, there is nothing left to show for the money spent but a hole! Trials with a fixed wheel trencher showed that a rifleman's fire and shelter bay, of overall dimensions 9 feet 3 inches long, 2 feet wide and 4 feet deep could be excavated in one minute. Good timings were also achieved for a medium machine gun and other positions, but of course being a normal commercial machine the chassis mounting was quite unsuitable for military purposes.

Construction Materials

The current range of field defence stores, many of which are excellent in themselves, have obvious shortcomings in the "Battle Shelter" Concept. There is an urgent requirement for a new range of special lightweight non-lethal small volume stores for construction, and those tried to date include a flexible material (popularly known as a "prayer mat") and light alloy pickets. In addition, various wooden mock-ups have been made of other items for use in larger Command Post and RAP positions, in conjunction with the same flexible material.

Camouflage and Protective Materials

Several prototypes of protective clothing exist, but for various reasons some of these are unsuitable for Infantry operational use. Different ideas for a very light nuclear flash-proof camouflage material, spread out in a matter of seconds, are in hand. It must be appreciated, however, that the ability for the Infantry to observe through it is impossible to reconcile with the 100 per cent thermal screening effect that is the ideal—so, as always, the answer is a sensible compromise.

* * * * *

It may be argued with conviction that the aim of the "Battle Shelter"

Concept is too idealistic, and that the British Army could never afford to bring it to reality. The often-quoted answer of the American Army to similar criticisms is—"Can it afford not to?" To implement some parts of it, for example only the designs, would cost nothing. There is no current research and development project for any explosive equipment for digging. It is only by full and extensive field trials that further progress can be made.

Perhaps one of the most important points brought out by the recent studies is that it is the *Infantry* who have been primarily responsible for initiating the policy leading to the future design of *Infantry* field defences, as represented by the "Battle Shelter" Concept, *assisted* as required by the Royal Engineers. It is, after all, the Infantry who have to live and fight from them. Should this precedent not now be followed by other arms, and the results of the joint work be published, not only in the Field Engineer and Mine Warfare All Arms Training manuals, but also briefly in the arm's own tactical pamphlets, particularly at the lower level?

What answer is there to the problems of field defence or battle shelter instruction, briefly mentioned at the start of this article? This is difficult, but surely any normal unit can arrange for a large sand-filled table or floor model, around which the class can gather. The instructor can then create his model trenches in the sand, and explain the various excavation and construction techniques with representative model kit. This method also brings out concealment and soil disposal problems. Single white electric wires can be used for cordtex, and similar odds and ends for the other items. Using rulers, each member of the class can mark out and construct the required design in the sand. Mistakes which might have cost hours of hard work outside can be saved, so that when the soldiers really do go out to dig practically, they should know exactly what is required of them. If it is impossible to dig, through restrictions or weather, then at least they will have had some training in, for instance, the explosive technique, and retain a visual impression of what positions should look like, even though made only by their hands at model scale.

What then, is the conclusion? If the field army is to survive on the modern tactical battlefield, surely it must still retain "the capacity to dig in, and quickly so". To be realistic, techniques must be developed which aim at producing the end result more and more rapidly, until the infinite product of the mobile hole is reached. There is no easy road to this, except initially to make the hole smaller and simpler, accept explosives or mechanical power, and finally to train both officers and men properly. The basic problem of getting underground has not changed in a thousand years—it is only the emphasis and incentive that has altered.

There must be a return by all arms to the art of improvization with natural materials, as practised extensively by armies throughout history. Men must be given the tools and basic stores for this, and the opportunity, to quote Wellington "very soon to experience the use of them" in re-learning the basic skills of axe and saw in the field. In general terms, the "Battle Shelter" Concept is a serious attempt to bring the art of fortification up to date, and to look a little further into the future. No one today would advocate for one moment that Cinderella should be restored once again to being the Princess of the Battlefield. On the other hand, it would be most unwise if she was not quickly promoted to being a Lady-in-Waiting to the present Battlefield Queen, clothed accordingly and with accessories to match.

Photo 1. The Atlas Copco "Cobra" powered pick/spade/driller

Photo 2. A roll of flexible material or "prayer mat" for two men, shown with a foot rule.

Infantry field defences 1 & 2

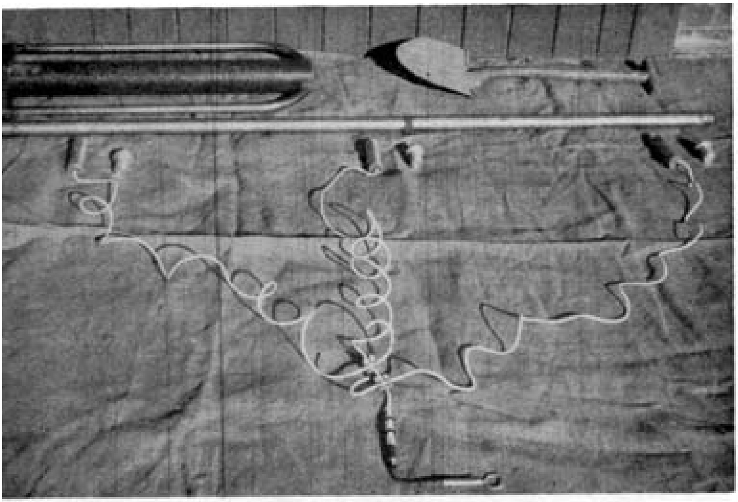


Photo 3. A complete set of digging kit, as required by the present explosive technique.

Photo 4. A 1 : 6 scale model in sand of a fire bay prepared for excavation by the present explosive technique.

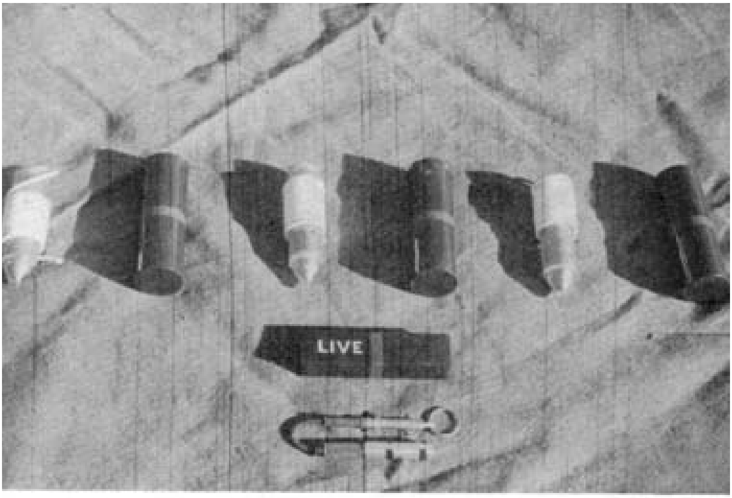


Photo 5. A set of digging charges required for Battle Shelter excavation.

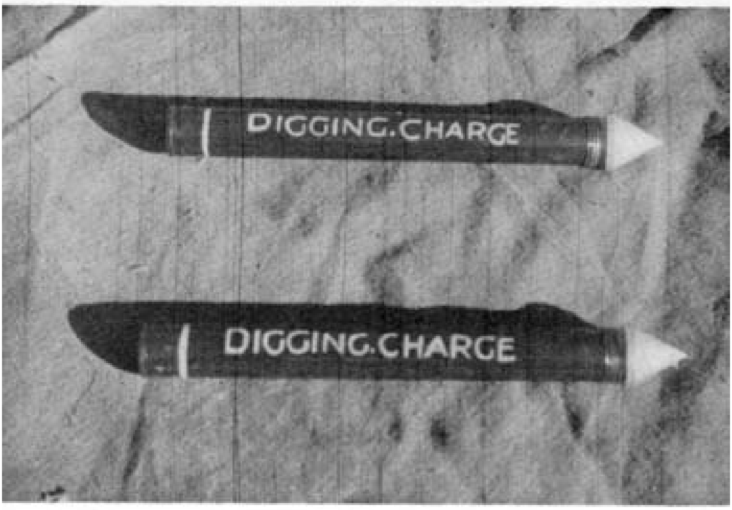


Photo 6. A pair of possible digging devices of the future.

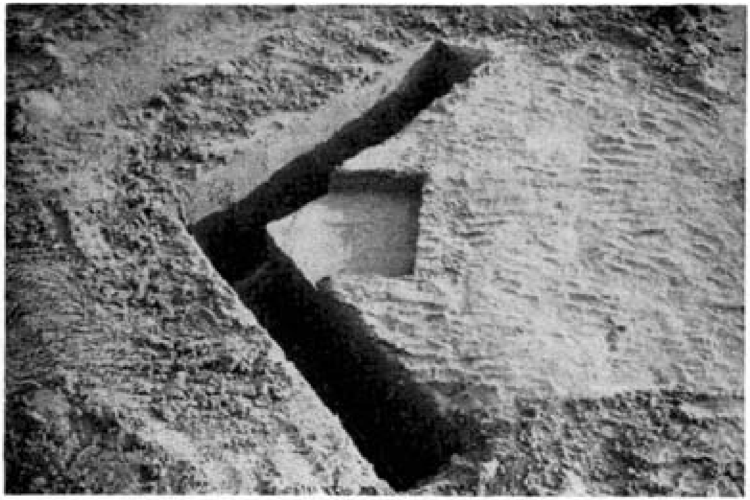


Photo 7. A 1 : 6 scale model in sand of the excavation required for a medium machine gun Battle Shelter.

Photo 8. A 1 : 6 scale model in sand of the excavation required for a typical Battle Shelter for four men.

Infantry field defences 7 & 8

Engineers in Survival Operations

By Colonel M. W. Biggs, OBE

Introduction

In January 1959 Study "Chester" was held at the Civil Defence Staff College at Sunningdale. Its main object was to study the organization and mobilization of the civil engineering industry, and the co-ordination, control and employment of both civil and military engineering resources on essential tasks immediately before and after a nuclear attack on the United Kingdom. The Director General of Civil Defence, Home Office, directed the study, assisted by the Engineer-in-Chief and the Deputy Secretary, Ministry of Works. Over 100 senior sapper officers, officials of the Home Office and Ministry of Works, and the Civil Defence Organization, with representatives of Other Services and Ministries concerned, took part in the study. Among the Regional Directors and Controllers of Civil Defence Regions were a number of distinguished retired officers of all three services, including two ex-sapper Generals. This article is based upon the results of Study "Chester" and, within the limitations of security, outlines the problems which will have to be faced and the manner in which they may best be tackled jointly by military and civil engineers in the event of a nuclear attack on this country.

Scale and Scope of the Problem

Should such a catastrophe for civilization as an unrestricted nuclear war ever be unleashed upon the world, the British Isles must expect to incur severe attack in the thermo-nuclear exchange between East and West. Although the principal adversaries, Russia and America, may endeavour to strike mainly at each other's heartlands, the United Kingdom must also anticipate being a main target of Russian attack through her geographical position of comparative proximity to Soviet air and missile bases, her political position as the second most powerful of the NATO powers and her strategic position as an "unsinkable aircraft carrier" from which both British and American deterrent air forces will operate. If the deterrent fails to deter, or global war breaks out through miscalculation or mistake, the United Kingdom is undoubtedly in for a very thin time indeed. The scale of the destruction and the casualties which may be caused by thermo-nuclear attack on our crowded islands is difficult to comprehend and almost impossible for the normal mind to imagine. The general public, and even many in positions of authority, have not realized what would be involved in a war with thermo-nuclear bombs.

The Government has stated that a single hydrogen bomb on a built-up area would take very heavy toll of life and leave very large numbers of people injured and homeless,[1] and has admitted that there is at present no means of providing adequate protection for the people of this country against the consequences of an attack with nuclear weapons.[2] An American authority, in discussing British defence problems, and pointing out that Great Britain enjoys no such favourable position as the United States or Russia, in that in

[1] Statement on Defence 1955.
[2] Statement on Defence 1957.

a crowded island dispersal of bases is very difficult, has estimated that only a few bombs—perhaps twenty of megaton size—can destroy or disable one-half of the population of Great Britain.[1]

Even though effective defensive measures against enemy inter-continental and intermediate range ballistic misiles may be devised and improved, some of them will get through. The American's estimate may be exaggerated, but it is clear that in the event of nuclear attack on these islands, millions of casualties and vast destruction will be caused in a very short time. A grim struggle for national survival will ensue. Immense problems, including many of an engineering nature, will face the survivors of the onslaught. Among these the restoration and maintenance of communications will be vital, not only to meet the operational needs of the fighting services and of Civil Defence, but also to make possible the organization of supplies and movement.[1] Water supplies, transport, sewerage services, electricity, gas, telephone communications and essential industry will all have a vital part to play, not only immediately after the attack and during the subsequent period when large areas of the country may be contaminated by fall-out, but also for ultimate recovery. Emergency facilities will be needed to replace those in the existing major ports which are likely targets for attack, and to provide for the continued import of food supplies essential to the continued existence of those who survive the onslaught.

Military and Civil Forces

Policy on the Armed Forces. It is stated Government policy that all armed forces, whether regular or reserve, which are in the country at the outbreak of war will have to be prepared to assist in the struggle for survival. The armed forces will be in no sense a substitute for the civil administration; their aim will be to support the civil authorities by all possible means.[2] The majority of troops of both the Regular and Reserve Armies in this country at the time of a nuclear attack on it, whatever their subsequent tasks, are likely to find themselves committed at once to the direct support of the civil authorities in saving life and re-organizing the national resources and manpower to the best advantage.[3] The task of the Army in the United Kingdom will be Home Defence in all its aspects, which includes giving the maximum possible assistance to the civil authorities.[2] In other words, should the attack come with comparatively little warning, before mobilization and the movement of those forces designated for reinforcement of overseas theatres have been carried out, every available soldier, whether Regular, Territorial or Reservist, will most probably become involved in life saving, rescue, and the many other vital tasks which an overwhelmed Civil Defence Organization may find itself unable to cope with alone, or in aid to the civil power in the maintenance of law and order and the restoration, so far as it be possible, of conditions under which the surviving population may continue to exist. This is perhaps not generally appreciated throughout the Army, especially in regular units and others which may be nominated for service overseas in war.

Military Organization. It is a matter of common knowledge to military readers that the Army at home is organized into Commands and Districts, containing units of both the Regular and the Reserve Armies, and that the

[1] Kissinger: "Nuclear Weapons and Foreign Policy".
[2] Defence Policy Statement 1956.
[3] "Military Support in Civil Defence".

Territorial Army is disposed throughout the country in divisions which often, but not always, correspond to Districts, and in brigades, whereas the Army Emergency Reserve has no particular geographic or territorial connexions. At the outbreak of war a GHQ United Kingdom Land Forces will be formed from HQ Eastern Command to control through the static command organization all troops in the country. Although the forces which will be available to UKLF will in the main be drawn from the Reserve Army, it follows from Government policy that all troops, including regulars, whether they be destined as reinforcements for overseas or other purposes, who are in the country when the bombs start dropping will come under command of GHQ UKLF and find themselves engaged in assisting the civil authorities in survival operations.

Civil Defence Organization. The planned organization for the civil control of the country in war is also probably well known to most readers. In brief, under the Central Government England and Wales is to be divided into Civil Defence Regions, each under a Regional Commissioner to be appointed in war, who will direct all civil defence measures in the region, and carry out any other governmental responsibilities which may be devolved upon him, including all measures to ensure the survival of the population. If communications with the Central Government are cut, Regional Commissioners will be prepared to take complete control of the regions. At their Regional Headquarters all Civil Defence services will be represented, including police, fire and health services. The Regions are to be divided into Sub-Regions or groups, under controllers, whilst below them will be Areas and in some cases Sub-Areas, with sector posts comprising five or six warden posts as in the last war as the basic units on the ground. In addition to this static organization there will be a number of mobile control centres to take control where Areas or Sub-Areas are put out of action, and mobile sector controls for emergency use at lower level. Similar arrangements are planned for Scotland. This organization will be mainly staffed by members of the Civil Defence Corps, recruited voluntarily on a territorial basis, whose divisions provide headquarters, warden, rescue, ambulance and casualty collecting, and welfare sections, whose functions are self-evident. Large industries, commercial concerns, public utilities and Government Departments may form their own civil defence units. The existing police, fire and hospital services will be integrated with the Civil Defence Organization. While some of the Civil Defence resources must remain on the ground in the localities they serve, it is planned to position mobile forces at operational bases well outside densely populated areas which may be targets. After attack these mobile forces, which will include police, fire, rescue, ambulance and casualty collection sections, can move inwards from the fringes towards the centres of damage to carry out their life-saving role.

Co-ordination of Military and Civil Organizations. From the highest level where GHQ UKLF will work directly with the Central Government organization, military and civil authorities will operate closely together. The military chain of command and boundaries have been adjusted so that the boundaries of Army Districts and Civil Defence regions coincide, so that Regional and District Headquarters can now plan together in peace, and will be able to operate in war as joint headquarters. Some brigades of the Territorial Army have been nominated to support specific sub-regions, and here also peacetime planning can take place.

Engineer Resources

Civil Resources. The building and civil engineering industries comprises some 100,000 firms employing over a million operatives, of whom 60 per cent are skilled tradesmen, with an ever increasing amount of plant and mechanical equipment, and supported by a highly organized materials supply industry. A high proportion of the industry is dispersed over a large number of very small firms; thus some 80,000 of the firms employ ten men or less, whilst only about 1,500 employ over a hundred men. Whereas the small firms tend to be local and static, flexibility and mobility increase with size. The top 10,000 or so firms are generally mobile, highly mechanized, efficiently organized and competent to tackle most jobs anywhere, except those which may be very specialized. The little local builders stay in their own localities, but the really big firms move their forces around continually, going wherever the big jobs are to be found, taking their plant and often their labour with them. It is not, therefore, possible to tell with any degree of accuracy what concentration of labour and plant may be in any area at a given time. Although it would be possible to keep a check on the movement of plant, it would be an expensive and unpopular task, and it is not practicable to keep any check on the movement of labour.

Mechanical plant is already widely used and its use can be expected to increase. Most materials are available throughout the country, transport being the main limitation. Cement is an exception as its production is localized in limited areas and it is impracticable to stockpile it.

There are also limited highly specialized resources of men and materials directly employed in engineering operations by such industries as fuel and power, and the railways. In addition many local authorities maintain their own forces of direct labour and mechanical plant.

To mobilize these resources before attack and to allocate and co-ordinate them to the best advantage on the most vital tasks after attack a Works and Buildings Emergency Organization was established in 1951 under leaders at Regional, County and Area levels.

Military Resources. While it is not possible for security reasons to discuss in detail the Military Engineer forces which may become available to the C-in-C UKLF on mobilization, it is permissible to divide them generally into the following categories. Initially there will be:—

(*a*) In Districts the divisional engineer regiments of the divisions and independent brigades of the Territorial Army, with field squadrons affiliated to brigades and a field park squadron.

(*b*) Numerous specialist units, both TA and AER, including several engineer groups, each of three or four corps and army engineer regiments and two army field park squadrons, in various parts of the country.

In addition after attack there will become available to the C-in-C UKLF all other troops in the country, among whom will be many engineer units of both general and specialist types. These will include:—

(*c*) Any units, including regular ones, intended for overseas reinforcements, which may not have been despatched at the time attack occurs;

(*d*) base and training units;

(*e*) all other units intended for home service.

The number and type of engineer units which may be in each District Region will depend upon their mobilization locations, and may vary greatly.

Furthermore, the practical availability and state of readiness of all units will depend upon the time between mobilization being decreed and the onset of the attack. All units of the Reserve Army depend upon the call-up either of volunteers and national servicemen or of reservists, to bring them up to strength. Whilst mobilization plans cannot of course be discussed here, it is obvious that it must be several days before units are likely to be fully up to strength in men, to have drawn all their equipment and plant, to have acquired their full scale of transport without which they will not be mobile, and to be ready to move off and take part in active operations.

In general available military engineering resources are small in comparison with those of the nation-wide civil engineering and building industries. The total numbers of trained men in all the units when fully mobilized are not very great. The stocks of engineer stores and equipment held by Army depots and installations are related to the needs of the Army only. These again are small in comparison with civil stocks of similar items, except in the case of field bridging equipment which has no normal civil counterpart. Army reserves of bridging in engineer stores depots and at bridging camps could be made available for civil use in emergency, as it has often been in the past.

On the other hand, Army units have great inherent advantages over similar civil organizations. They have an established chain of command and discipline; they are also trained to react quickly to orders, to move and deploy rapidly on to a job and to work for long periods under strain. They have their own reconnaissance capability, and wireless communications, are highly mobile and flexible, and administratively self-sufficient for a limited period. It is hardly necessary to emphasise for sapper readers the capabilities of divisional field engineer regiments with their balanced scale of equipment, transport and plant, wireless communications down to troops and a good proportion of tradesmen for the performance of the variety of engineer tasks such as road and bridge repair, bridging, water supply, demolitions and debris clearance for which they are trained and might be required in these circumstances. Other engineer units, are organized, trained and equipped for different roles; for example, an army engineer regiment is designed for more deliberate and concentrated tasks, with a larger scale of plant but with wireless communications down to squadrons only. The titles of most of the other engineer units in the Order of Battle—construction regiments and plant squadrons, port and inland water transport operating squadrons, railway squadrons, works sections and so on—indicate what they are designed to do and the functions which they can most effectively carry out.

Before the Attack

Warning Period. It is quite impossible to estimate how long a warning of attack upon this country there might be. On the one hand there are those who expect attack to come as a complete surprise out of the blue of serene skies; on the other are those who predict a long period of increasing international tension such as preceded the last world war, this time with "atom-bomb rattling", threats, bluff and counter-bluff over perhaps weeks or months. Consequently it is equally impossible to estimate how long there may be available between the promulgation of the decree for general mobilization and the actual outbreak of global war and the nuclear exchange, in which to mobilize the armed services and get the Civil Defence services on to a war footing, carry out evacuation schemes and all the other numerous things which will have to be done in the national emergency.

Civil Defence Deployment. It is planned to station balanced mobile forces of dozers, both wheeled and tracked, graders and other plant most suitable for debris clearance, together with operators, near the Civil Defence operational bases outside likely target areas prior to any attack. These civil resources will need to be mobilized and concentrated in their operational positions in the warning period prior to attack. As they will be drawn from local sources this should be swiftly done.

From these positions they will be ready to spear-head the columns of police, firemen, ambulance and other rescue workers in clearing the way inwards from the fringes of a devastated area as far as destruction, fire and contamination will permit. Their task will be to clear one-way routes through, over or round debris to allow the fire engines, ambulances and other rescuing vehicles to get in and carry out their live-saving mission. These forces must go into action fast, immediately after an attack upon a target area, and they are likely to have to work hard for prolonged periods under great strain. As the machines will generally last much longer than their operators without rest, and they must be driven without pause while there is still hope of saving lives, reserve operators will be required to work continuous shifts; they also must be positioned from the start with the force outside the target area.

Should the warning period be prolonged, problems of maintenance of morale during idleness will arise, but these problems will be common to all Civil Defence forces which will have been alerted and may have to stand by for weeks or months doing nothing but wait. Suggestions have been made that all mobile plant and skilled operators in target areas should be removed to other areas for safety during the warning period, so that they should not be lost in the attack but would be available afterwards to reinforce the other forces in tackling the huge tasks of rescue and reconstruction. However, in normal circumstances plant and other resources are fairly widely dispersed anyway. While this might be a wise precaution in the event of a short emergency, the complete stoppage of all construction work in cities and ports which would ensue from such a measure could not be justified if the precautionary period were prolonged over a period like the "phoney war" of 1939–40, and morale might suffer consequently. At worst if he enforced this and similar extreme measures like wholesale evacuation by the threat of attack alone, the enemy might achieve his aims by bringing the economic life of the country to a halt without launching any attack. "Business as usual" may be the best answer in such circumstances.

Military Mobilization. It can only be said here that comprehensive mobilization plans exist to mobilize all military units as fast as it is administratively possible to call the men up, equip them and issue or requisition the transport, plant and other unit equipment needed to complete them to scale. Until these measures have been completed it is obvious that units of the Reserve Army cannot be ready or able to take an effective active part in any operations which may become necessary as a result of surprise attack; the brunt of such operations must, therefore, fall initially upon such regular units as are available. It is most desirable that the mobilization of the Reserve Army should be speeded up and its efficiency increased, so that its units can more quickly take their place in the national defences. To this end the greater the proportion of volunteers and the higher their state of training the quicker will units be fit for their task. The War Office is considering various suggestions for stream-lining mobilization procedure and speeding-up the issue of vehicles and plant.

One such suggestion is that key forces such as engineer units which might be wanted urgently for debris clearance and similar rescue and life-saving tasks, should be activated before general mobilization in a similar way to that in which the air defence of Great Britain was alerted before the 1939–45 war. These measures might include the holding of equipment locally by Territorial Army units or at mobilization centres, but this would involve money and manpower.

Emergency Tasks. Both civil and military authorities will have large numbers of so-called emergency jobs requiring to be done with high priority in the warning period. Such tasks may include construction of command posts, refuges, aid posts and shelters, additional reserve water supplies for fire fighting, and the pre-positioning of bridging equipment. If the warning period proves to be short there will be little chance of carrying out most of them as only minor tasks could be completed in the time. If it is prolonged it should be possible to divert civil resources from less important work and to employ the mobilized military engineer units upon them. It may be felt that the more essential of these tasks should be carried out in peace, and not left till the last moment when it may be too late to do them at all. Considerations of the great cost of these measures if carried out nation-wide and of bad morale effect are advanced against doing this, but it is relevant to observe that the United States and Sweden are prepared to pay this price in peace for survival in war.

Planning. Whether or not emergency tasks can be carried out in peace or the warning period prior to attack, there is an evident need for planning to take place between civil and military engineering authorities in peace not only for the carrying out of these tasks, but also for the co-ordination of all available engineering resources after the outbreak of war. At regional level there must be planning between RE and Ministry of Works representatives in peace, and it is obviously most desirable that these representatives should be the same officers who will carry out the command and control functions of military and civil engineers and advise regional controllers at joint regional/district headquarters when they are set up in war. This peace-time planning may best be carried out in a sub-committee of the Regional Co-ordinating Panel, and might be developed down to Area level. Both the Ministry of Works and the War Office (Engineer-in-Chief) have under consideration the appointment of suitable officers for this planning. On the sapper side the solution is complicated by the civilianization of the Works Services resulting in there no longer being any Chief Engineers at District Headquarters, who would be the obvious choice to plan in peace as they will also command engineer units in the district to carry out the plans in war. Chief engineers are, however, to be appointed to District Headquarters only on mobilization and it, therefore, seems likely that other officers will have to be nominated to do this peace-time planning.

During and Immediately after Attack

Employment of RE Units. The tasks of the Civil Defence Services during and immediately after an attack are quite clear. They are to rush in to the rescue with all the forces they can muster, to save as many lives from the stricken area as they can, to give medical treatment to casualties, to succour the homeless, and to maintain law and order. These are their reasons for existence, and the first tasks of all available civil engineering forces under Civil Defence control will be to help them to force a way into the stricken area, to perform their life-saving mission.

The extent to which RE units, assuming them to be fully mobilized, will be called upon in this life-saving phase is a matter on which opinions differ. It is generally agreed that they would be employed upon special tasks such as bridging or ferrying for which they are particularly suited, and which could not be done equally well by the civil forces available, if such tasks present themselves. There is less agreement as to whether sapper units will in practice be used to reinforce civil forces on debris clearance and heavy rescue tasks. In principle it is felt that they should be reserved for subsequent survival operations for which they will be better suited and only if the Civil Defence Services are overwhelmed and unable to cope with their own resources should military engineers be drawn into this phase of the operation. It is, however, equally probable that these cold reasons may be outweighed by humanitarian and morale considerations which cannot conceive that in the heat of catastrophe striking our cities and ports, formed units of able-bodied men will not inevitably be drawn into the all-out effort to rescue survivors and save life. This is particularly likely where Territorial units are concerned: it is almost inconceivable that a unit of men drawn from a big city can be prevented from joining in the rescue attempts if that city is struck. Civil Defence forces may well be unable to compete with the magnitude of the disaster; indeed many of them may have been involved in it. With their superior organization, discipline, equipment and communications, military engineer units could be invaluable in deploying rapidly where they are most needed, reinforcing exhausted or inadequate civil debris clearance and rescue forces. It is possible that in some cases sappers might even take control of such local forces as survived, and organize any other available plant and labour on to vital tasks. Indeed the early arrival of uniformed troops on the scene of disaster would in any case have a valuable morale effect; this effect on the dazed survivors would be enhanced by those who were able being organized and led in rescue operations of their less fortunate neighbours. The magnitude of the task facing the rescue forces after thermonuclear attack on a city would be so vast as to need every man who could be made available. Tens of thousands would be dead or beyond help, but in the fringe area would be tens of thousands more who might be saved by timely aid.

Infantry brigades of Territorial Army divisions, which are assigned to Regions for the support of the Civil Defence forces would expect to have normal support from the divisional engineers in carrying out this duty. If the brigades are drawn in to assist in maintaining law and order and to help with all kinds of rescue and similar work, they will want their affiliated field squadrons to accompany them. On the other hand there are strong arguments in favour of the divisional engineers, as the first line and the only sapper units immediately available under the control of District HQ, and possibly also being physically nearest to the scene, being committed to the most urgent appropriate engineer tasks under the C'sRE direction. This is a question which is unlikely to be resolved in abstract discussion; the answer may vary in different regions and depend upon several factors, including topography, dispositions of troops in relation to targets and personalities.

Where the divisional engineers are committed in support of brigades or directly under the C'sRE control, additional engineer support if required will have to be requested by regions from the reserves controlled by GHQ UKLF. Such help might be given from the nearest regiments of the engineer groups, or from any other engineer units mobilized in the region which would have come under command of UKLF on attack, depending upon which was nearest. Mobilization and deployment plans are being re-examined by the War Office to obtain the best dispositions in relation to target areas which will facilitate this reinforcement.

Co-operation of RE Units with Civil Defence Forces. When RE units are called upon to take part in this type of operation in support of Civil Defence forces the closest co-operation should be ensured from the start and at all levels. The sapper unit commander should make contact with the Civil Defence Controller concerned, and with other civil forces operating in the area in which he has to work. Liaison Officers can help to maintain this contact. Sapper units should of course be given specific tasks to carry out under their own arrangements, in the accepted manner for military aid to the civil power and not be dispensed in penny packets under civil direction, but it is quite acceptable for them to take under their control any spare civil resources of men and machines which may be made available to supplement their efforts.

In deployment on to the job assigned, normal reconnaissance and deployment drills should be carried out by RE units, but reconnaissance should be made in close co-operation with Civil Defence personnel on the spot, who, being local people will know the area well, and can be of great assistance as guides and advisers. First a quick general reconnaissance should be made by any available means; from the air if it is possible to obtain aircraft and visibility is not obscured by smoke and dust, or by water in harbours where land approaches are blocked, besides the more normal land reconnaissance. Subsequently technical reconnaisance of the task in some detail may be required, although this may have to be delayed if there is contamination until the level of radiation has decayed to a workable intensity.

Naturally sappers must expect to take at least the same risks of exposure to radiation as the Civil Defence personnel alongside whom they will be working. The decision as to what will be the maximum permitted dose will normally rest with Regional Controllers and District Commanders, although in emergency cases unit commanders may find themselves forced to make decisions concerning their own troops when engaged on particularly urgent jobs. The proper organization of work so as to get the maximum value for man-hours spent in radio-active areas, and rapid and efficient methods of decontamination of sites where prolonged work may be required, require study which will be well repaid by the greater results which should be obtained for the expenditure of radiological "life".

Survival and Reconstruction

The life-saving phase of the battle is unlikely to be of long duration. The nuclear bombardment of this country would probably be condensed into a short space of time; indeed experts predict that the global nuclear war is unlikely to last for more than a few weeks at most, leaving both sides the losers, and the survivors to contemplate the destruction of large parts of their homelands. In the fringe areas of the cities and other target areas which have been attacked, those survivors of the actual attacks who have not been rescued within a few days will be beyond succour. Many urban areas will be utterly devastated by the direct effects of the bombs, and the subsequent fires, while fall-out from ground bursts, which may be accidental or deliberate, will contaminate extensive areas otherwise undamaged, causing the evacuation of their inhabitants or their enforced immurement underground in fall-out shelters awaiting the decay of radio-activity, and preventing movement across them. In these circumstances of widespread death, destruction and disorganization, the long last phase of the battle for survival of those still living will be fought. Although millions may have died, millions will still be living, and they will have to be fed and succoured if they are to continue to survive. The maintenance of a semblance of law and order will be the first task of the Services, their next to aid the civil power to keep the surviving population alive.

An immense task of reconstruction is likely to face the combined civil and military engineers after a severe nuclear attack on the country as a whole. It would be quite impossible to tackle immediately all the essential survival tasks at once, either because resources including materials, would be inadequate or because of fall-out over wide areas. Nevertheless from the large and dispersed resources of the civil engineering and building industries together with the small but highly organized and mobile military engineer forces a very useful engineering potential would remain, which, properly organized, could make a start upon the long haul back.

In the confusion and near chaos after heavy and widespread attack, it is quite possible that centralized control may break down. Even if it does not the general disorganization and interruption of communications, together with the magnitude of the calamity and lack of accurate knowledge of the extent of destruction in the attacked areas, will make central direction of effort extremely difficult. Probably, therefore, for some time after the attack all available resources in and around devastated areas will inevitably be completely absorbed in the purely local task of survival of the population in these areas. All available plant, equipment and labour forces, both skilled and unskilled, even if they have not been drawn into the life-saving battle, may be initially seized upon and ultilized by local authorities and Sub-Regional or Area Controllers, to restore local essential services and communications. A speedy return to a higher level of control will, however, be necessary to ensure that nationally important survival tasks can be tackled, but it may in practice take weeks to reimpose this control, and disengage engineers and equipment committed locally. It is thought that the Central Government may exercise this control at first by the issue of general directives to Regional Commissioners giving them priorities for the national tasks which must be tackled in their Regions. These may include the opening up of emergency port facilities to ensure import of food and oil supplies, the restoration of essential through communications by road or rail for distribution purposes, repair of the national electricity grid and main oil pipelines, and other major engineering tasks.

The manner in which the civil engineering and building industries might be reorganized into the existing Works and Buildings Emergency Organization, has been discussed earlier in this paper. What is required is a mobile national force ready and able to move where most required to tackle the priority national tasks. Views vary as to the level and manner in which the force should best be controlled. It could be nationally controlled if central direction is operating, or it could be directed by Regions in accordance with government priorities, as seems more likely. Alternatively it might even be operated under a system of "three-tier" control, whereby the smallest and least mobile resources would be under Area, the medium firms under Region, and the largest firms under national control. This seems rather more complicated than the confused situation may allow.

The role of military engineers in this last phase of survival and reconstruction would appear to be to supplement the civil engineering forces described in the most effective manner possible. RE units should obviously be given tasks for which their organization, training and equipment best suits them. They are likely to be used in all kinds of speedy emergency construction, the restoration of communications by road and rail, including field-type bridging, the opening up and operation of new ports and the expansion of existing small ones and even of beaches, pipe-line repairs and electric power restoration. Some of these tasks they may undertake on their own, as is more desirable, but in others they may be called upon to assist inadequate civil resources. The general principle that all sapper units employed in this type of work should operate under Chief Engineer—C'sRE control should be observed, but it may often be best that a sapper unit engaged upon a highly technical task such as repairs to a power station will need to be advised and assisted by local experts of the facility concerned. The latter would then work in the same manner as Specialist Teams RE are planned to work with and advise general purpose RE units. Furthermore, it should often be possible for the potential of sapper units to be greatly increased by their taking on numbers of directly employed labour both skilled and unskilled to supplement their own numbers.

Finally it should not be forgotten that if the war continues after the main attack all Army units, especially regular ones, may still be required for their primary role of the defence of the United Kingdom or for reinforcements for overseas. Although this may seem unlikely, if it does occur some of the RE units, especially regular ones, will have to carry out their first task of supporting the Army formations to which they belong, and will not be available for reconstruction of the country.

Conclusion

This all presents a very gloomy picture of the future. Let us pray that it never happens. But should such a catastrophe strike our country we must be ready to play our part in mitigating its worst horrors, in helping the survivors to continue to survive and in the re-building of the country after it is over. To this end it is important that all of us should have an idea of the nature of the tasks which may confront us suddenly, and train ourselves and our men to be able to tackle them with confidence.

1959 George Knight Clowes Essay Competition

Subject. The British Regular Army is to be reduced by approximately 50 per cent by 1962—the Infantry of the Line to forty-nine battalions. With this reduction it will not be possible to keep overseas garrisons at, or even near, every trouble spot. Our ability to deal quickly, and firmly, with situations similar to those which arose recently in Aden and Oman, will depend on the speed with which troops can be moved to the area, and concentrated at the actual place, of likely action.

This raises many problems such as the composition and strength, normal location, degree of readiness, equipment, training, and means of movement of forces earmarked for this purpose. Discuss these problems.

The following essay, written by Captain A. J. V. Kendall, RE, was the runner-up in the 1959 competition. The essay was written in March 1959.

STRENGTH THROUGH MOBILITY

Introduction

The flood of unrest pervading many peoples of the world today grows apace. Fanned by an immature but fervent Nationalism, often supported or subversively encouraged by Communism, this upheaval aims at independence for most of the countries hitherto dominated by European rule or influence, and generally assumes an anti-Western or anti-British outlook. With our widespread colonial responsibilities and dependence on imports and unhindered trade routes, we feel the effect more than any other major power, France possibly excepted, in terms of military effort. With the inevitable expansion of this new sense of self-importance among the new nations, and the continuance of the Cold War, our military commitments are likely to increase rather than lessen in the years immediately ahead. Yet the Army, as National Service dwindles to a close in 1962, is becoming far smaller. The current problem, therefore, is how best to meet this situation in terms of the organization, disposition and equipment of the New Army.

The problem is mainly domestic in character, as allied assistance can only be considered as a bonus. To have a reasonable chance of meeting a succession of varying and widespread calls at irregular but not infrequent intervals, the army must possess true global mobility. In other words, units and formations must be held in one or more central bases from which they can move at short notice, by the quickest available means, to any actual or potential trouble area. Not only must they move as fully operational bodies, but must be able to continue as such, without further logistic assistance, for the initial stages of any likely task. This has been national policy for several years, but shortages in manpower and aircraft and the uncertain political future of many overseas bases have seriously retarded its practical fulfilment. How, in fact, with the resources and bases at our disposal for the next decade or so, can this policy best be put into practice?

This paper discusses the major problems involved when considering the size, location, composition, equipment and movement of ground forces earmarked for this role. It will also examine how far we have already progressed in the right direction, and what remains to be done in the future.

The Post-war Period

It is probably reasonable to say that the danger of an all-out atomic war remains small while nuclear parity exists between East and West. Large-scale conventional war is also unlikely, as this would inevitably lead to the use of nuclear weapons. Therefore the Army's main task in the 1960s, apart from permanent NATO commitments in Europe, is likely to be the protection of British interests against "Nationalist" and Cold War outbreaks in various shapes and forms. The general pattern of military operations may well be small, localized actions or internal security tasks in areas where British property, persons, or trade are being threatened, endangered or attacked. In this event the soldier's job will be the maintenance or restoration of law and order in support of the lawful civil authority. Events of this nature, where the requirement is for manpower rather than firepower, have been abundant in the 1950s, and surely they will continue. A glance at a few incidents of recent years will not be out of place.

The situations that arose in Aden and Oman in 1957 were of a familar type. Korea, as a full-scale war, and Malaya, Cyprus and Kenya, as extended emergencies, are in a somewhat different category; but British Guiana, Jordan (both in 1956 and 1958), the Arabian Peninsula and the 1956 Suez crisis each provide a separate example of occasions where troops were required post-haste at or near a trouble spot. Yet only in Jordan last summer has the treatment been truly effective; and it is still worth considering the possible course of events had the request from King Hussein come a month earlier, demanding an operation direct from the UK or Kenya instead of from nearby Cyprus.

On most other occasions the performance has been distinctly unsatisfactory. In no case has it produced properly equipped troops on the required spot at the right time and in the right numbers. Sometimes, due to lack of aircraft, a naval carrier has been diverted from its normal role to act as an emergency troopship. When aircraft have in fact been available, they have normally been service or civilian types capable of carrying little or nothing in the way of troops or heavy equipment; and their limited numbers, allied to a small carrying capacity over long ranges, have normally resulted in a shuttle-service airlift, which in turn means days or weeks before a unit becomes fully operational at its destination.

Furthermore, on no less than four separate occasions since 1951 has the Parachute Brigade been called upon to move quickly to the Middle East to counter some crisis or another. Admittedly this formation is well trained and suitably equipped, but is it sound to call upon it time and again for a job which usually bears no direct relationship to its particular role as our only regular airborne brigade?

Recently we have seen a considerable advance in the creation of a substantial strategic reserve at home. This is composed of infantry brigade groups—and the Parachute Brigade when available—trained in probable Cold War tasks, but even so the concept of a highly mobile, operationally-ready force has been sadly unimpressive when translated into fact: and air movement exercises, too, have merely underlined the need for a radical improvement in this field of operations. With a far smaller Army than hitherto, containing only 49 infantry battalions and with a ceiling of 180,000 in 1963, ensuring that this concept becomes an effective reality will be no easy task.

The scope of our responsibilities and the reduced size of the 1963 Army prevents the maintenance of overseas garrisons at or near every trouble spot. Central reserves of some kind are essential. Before discussing the exact location and nature of these reserves, the likely areas and character of operations must be considered.

Major Areas of Unrest

Since World War II the centre of gravity of world politics has shifted from Europe to Asia and Africa. As the leading global powers now enter the period of "interdependence", the new Afro-Asian nations are at an early stage of independence or self-government. Simultaneously other countries still partially or wholly dependent on a major power are pressing forward by fair means or foul to a measure of political self-sufficiency.

These countries form the danger areas of today and tomorrow but whereas in Asia the majority of younger ones have now passed through the stage of political adolescence, in Africa this period is in its infancy. In Africa, too, the natives have little or no administrative background or ability, and to hand over the reins of government in the immediate future would be no way towards a satisfactory outcome.

This, therefore, is the favourite continent for agitation and unrest for some years ahead. East Africa, Somaliland, Sierra Leone, and Gambia, and the High Commission Territories in the South all come to mind.

What of Asia? The Middle East is still the major danger area—particularly the Arabian Peninsula and Persian Gulf. Our large oil supplies from this area, especially Kuwait, and extensive treaty relations with the Sheikdoms of the Gulf, in addition to Eastern trade routes and Baghdad pact obligations, make it a region imperative to defend. In South-East Asia, now that Malaya has accomplished a smooth transition to independence and near-annihilation of terrorism, Singapore, with its large Chinese majority and important geographical position, and Hong Kong, perched precariously on the doorstep of Red China, seem likely fields for future agitators.

Europe (including the complete Western Mediterranean seaboard) and the Americas provide fewer potential trouble areas. With Cyprus quiet at last, and assuming that a crisis in Berlin could be countered by troops already in BAOR, Malta, Gibraltar and Libya appear to be the only places where internal security tasks are at all foreseeable at present. South America's only British colony, Guiana, is still a potential sore, like its equally intransigent counterpart British Honduras farther north, while the Argentine looks enviously at the Falklands. The young West Indian Federation may also experience political growing pains similar to those in Central Africa today.

The major danger spots, therefore, are Africa and the Middle East, with reservations on colonies and protectorates scattered over the globe. The vast majority are also in the tropics. These points must be borne in mind when discussing the location of our strategic reserves.

Character of Operations

The primary task of ground forces in the event of operations in these areas is likely to be the maintenance of internal security. This may involve the protection of life and property, prevention of inter-racial conflict, and a wide variety of anti-terrorist operations or minor campaigns. Tasks will often be the routine ones of anti-riot drills, searches and guards in the built-up areas, and road blocks, patrols and sweeps in outlying parts—perhaps rugged, undeveloped and inaccessible country ideally suited to the concealment of well-armed hardcore terrorist gangs. Shortage of water, lack of decent roads, and intense heat are as likely as not; desert, mountain and jungle may all be met in turn. The enemy will usually be difficult to track down; he may well be an adept in the art of ambush, the use of small arms and sabotage.

The soldier will thus have a difficult and often unrewarding job, and his morale may be sorely tried. He may not be helped by a hostile or terrorist-intimidated populace, and will need the utmost restraint and self-discipline. Internal security is a hard taskmaster.

More open and widespread conflict such as occurred in Kenya and parts of Arabia may also develop; however the military answer is little more than a wider application of anti-terrorist methods. One hopes, too, that with good intelligence and early action, this situation will not often be allowed to develop.

Type of Ground Forces Required

It is already apparent that the military task on these occasions will be primarily an infantry one. As a corollary to the principle of "minimum force" applied to operations in aid of the civil power, the need for heavy firepower, such as provided by armour and field artillery, is negligible; the mere presence of troops on the ground will often be enough.

However, infantry alone may not suffice. Bearing in mind probable conditions of climate and terrain, engineer and medical support will be particularly needed. Track-making and maintenance, airstrip construction, provision of water and anti-sabotage tasks will call for sappers, while medical backing may be very necessary in the more unhealthy areas, quite apart from normal treatment of both military and civilian casualties. Signals facilities are as important as ever in the anti-terrorist role, while normal logistic support from the services will be needed when operations are extended in scope or duration. Light aircraft and helicopters for reconnaissance and liaison, and also medium helicopter support in hill and jungle for the movement of patrols and snatch parties, will often be invaluable.

The role of artillery and armour is more difficult to define. In rugged country light artillery support, capable of a high trajectory, may be needed, whereas armour is best used in the shape of fast, light scout and armoured cars for road blocks, patrols, convoy and VIP escorts and advance guards. Tanks, though a powerful deterrent in built-up areas, are unlikely to be a necessity, and in any case current types cannot be transported by air.

Formations of all arms of a conventional type will, therefore, prove adequate for the task, with certain modifications. The exact composition may vary from theatre to theatre, but a high proportion of infantry and adequate light support from other arms and services is the basic requirement. Specialist troops such as parachute battalions should not normally be included in these formations; if an operation demands the use of airborne troops, they would be obtained from the regular airborne formation, currently 16 Independent Parachute Brigade Group, normally to be found in reserve either in UK or the Middle East, or from the regular SAS regiment.

Thus the present infantry brigade group is well suited to the "fire-brigade" role, with the exception of the armoured regiment and the field regiment. Tanks could profitably be replaced by armoured cars, and the 25 pounder by a lighter weapon such as the 4.2-in mortar or the new and easily airportable 105 mm howitzer. In this case an airportable armoured car regiment or squadron would replace the armoured regiment, and the field regiment would give way to a light regiment or battery. A further air increment to the formation over and above the normal reconnaissance flight, in the shape of a few medium troop-carrying helicopters of the Wessex or re-engined Whirlwind type would be most valuable; however, limitations in payload would be imposed at high altitudes, and of course these machines cannot be carried in the largest current transport aircraft without being stripped. They would therefore be absent in the early stages of any far-flung operation.

The inclusion of four battalions in the brigade group may not be unrealistic in view of the particular premium on infantry, but the retention of the usual three-decker structure simplifies the allotment of supporting arms in both training and operations. Hence battalion groups may be used quite independently; on such occasions the available airlift will probably be insufficient anyway to carry a complete group in one wave, and infantry will move in first, to be followed by supporting units as and when the situation demands them.

Availability of Air Transport

The various locations of these troops depends firstly on the probable areas of unrest outlined above, and secondly on the size and capacity of the airtransport force available to move them. We have already seen in the past that this force has been grossly inadequate, though there are now encouraging signs of improvement.

Sudden moves to troubled spots must of course be carried out by air to cut delay in arrival to a minimum. In recent years the vast majority of aircraft used have been totally inadequate in numbers, range and payload. The Shackleton, for example, a Coastal Command patrol aircraft, has been used considerably on the UK–Cyprus route; the necessity to pack 33 fully-equipped soldiers on to the floor of a fuselage little larger than that of a wartime Lancaster for long, cold, uncomfortable flights is inconsistent with the concept of real long-distance mobility. The Hastings has done yeoman service as a troop-carrier, but is far from ideal as a mover of vehicles, while the Beverley, though admirable in its specialist role of medium-range transport support, can carry practically no payload over a 2,000-mile haul. Even the RAF Comets have a limited capacity and are, moreover, "passenger only"; and their usefulness is also restricted to airfields with first-class concrete runways. Yet these last three types form the bulk of the Transport Command force in UK, and though charter aircraft are usually available when required, they are unsatisfactory for anything other than routine trooping.

So today the air transport situation is still poor, though admittedly better that it was four years ago, before the advent of Comets and Beverleys. We still await an aircraft which can carry substantial loads of men, vehicles and equipment over long distances (say 2,000 miles or more) without refuelling.

The prospect ahead is rosier, but does not call for complacency. This year the first of over 20 Britannias enter Transport Command. Capable of taking 113 troops or a 35,000 lb payload over stages of 2,500 miles, these will considerably increase the RAF's inter-theatre carrying potential. However, they too are best suited to the passenger role, and will take few light vehicles or trailers, due to the awkward shape of the cargo compartment. Thus the need for a strategic freighter, designed and built solely for military use, remains.

This will eventually be met by the newly-ordered Britannic. A small number of these, which should each carry a maximum of 85,000 lb or fly non-stop for over 4,000 miles with a 25,000 lb payload, will enter service from 1964 onwards, so until then the Britannia shoulders the main burden of strategic movement. The Armstrong Whitworth 660, due to supplement the Beverley from 1961, is well suited to the freighting role, but its range is limited and direct inter-theatre hauls will be beyond its capacity. Finally, the use of the admirable American C-130 Hercules can be discounted, as the sort of operation in question will be normally our own affair.

What do we learn from this situation? Until strategic transports are available in considerable quantity (say in six years time), the airlift available for the global movement of ground forces will be extremely limited. The ideal, therefore, of moving a unit together with a reasonable proportion of its equipment over long distances may not be attained for years, though there is now a steadily expanding fleet of medium transports capable of doing the job over shorter ranges. Not until an adequate long-range force exists could we even consider depending only on a reserve in UK for world-wide commitments. Therefore in the immediate future military reserves must necessarily be positioned in each likely theatre of operations, within striking distance (using Beverley and AW 660 type aircraft) of potential danger areas. These must be backed by a central reserve in this country, to which "strategic" aircraft will be allocated as and when they enter service, thus realising still more medium "tactical" transports for overseas theatres. This will not only facilitate good army/air training in those theatres, but cut out delay in the planning and preparation of quickfire operations.

The Use of Stockpiles

The current programme of keeping large equipment stockpiles in various places abroad can then be gradually reduced. This is little more than a stop-gap at present; apart from the heavy drain on money and manpower for their maintenance, their very use is inefficient. A unit moving from UK for an overseas task demanding speed of action above all else can only do itself justice if it travels complete with its own equipment. Stockpiling, however, presupposes it travelling mainly with personnel only, and drawing up new vehicles and G1098 equipment at the far end. Delay in issue, lack of familiarity with equipment, and often the long distance between a stockpile and the operational area make this an unwieldy and inflexible procedure. Enormous dumps can then give way to smaller logistic bases to provide local backing to theatre strategic reserves.

Actual Location of Reserves

Where, then, might these reserves be best placed? For Europe, the Western and Central Mediterranean and the Caribbean, a force based in England should suffice, whereas both in the Middle and Far East separate theatre reserves are needed. These require, in addition to the air transport facilities already discussed, adequate and varied training areas, good accommodation for both units and married families, and a reasonably stable political situation in the country in which they are based. Operationally a good port is desirable for the despatch of heavy follow-up echelons by sea.

Something approaching this state of affairs already exists. A reserve is in being in UK, together with a small medium-range transport force, though it is very doubtful whether its overall standard of training is anything like high enough, due to constant changes in both units and individuals. The new idea of Southern Command dealing entirely with the training and movement of reserves is sound, as HQ Transport Command and the majority of airfields such as Lyneham and Abingdon are in this sector. Naval and commercial ports abound, and Salisbury Plain and Okehampton provide reasonable local training areas. In the Middle East a brigade group is positioned in Kenya, with a further two battalions in Aden, while Cyprus will eventually house one brigade as well. In the Far East Malaya houses a Gurkha and a Commonwealth Brigade, and Hong-Kong an additional brigade.

One or more such formations are required in each theatre. In overseas theatres numbers may be reduced as the strategic freighters enter service, but there will still be good grounds for keeping a high proportion of reserves abroad. Acclimatization, proximity to trouble areas, "showing the flag" and the many normal advantages of service abroad over soldiering at home are all important factors, as is the indirect stimulus given to recruiting by good prospects of overseas service.

Perhaps two modified, lightly-equipped infantry brigade groups at home, backed by part or all of our one regular airborne formation, is a reasonable figure to aim at. The Middle East will need at least two, and in the Far East one may suffice for the present.

The location of reserves in the Middle East has been a very real problem for some time, though the knotty post-war question of whether Cyprus or Kenya should provide the primary base is now resolved politically in favour of Kenya. Apart from the small numbers of troops allowed in the new Republic of Cyprus, and the inadequacy of training areas, the island is separated from Arabia and the Persian Gulf by the Arab bloc of Syria, Egypt and Iraq, which provides an effective air barrier against direct movement to and fro. Kenya, on the other hand, does represent a fairly satisfactory centre; despite some political agitation the base is well established. Training areas are extensive, there are good airfields near Nairobi, Mombasa provides an excellent port, and direct communications with the Persian Gulf are easy by both sea and air. Whether keeping reserves in Kenya alone is sufficient is not so certain; it is well over 2,000 miles, for instance, from Nairobi to the oilfields at Kuwait, so some sort of reserve is needed in Aden as well. Though far inferior to Kenya as a base, part of the Middle East reserve may have to be positioned here for some time ahead. Battalion groups from Kenya might well do short tours of a year or so in Aden in rotation.

The need in the Far East is less urgent, and soon it will possess a mobile sea-going reserve in the shape of a Marine Commando carrier based on Singapore. Our land-based reserve is best situated in Malaya itself, an alternative being North Borneo, which in any case will provide an admirable training area. A major need in this theatre today is an adequate transport force to replace the ageing batch of aircraft still in service; the phasing in of Beverleys this year is certainly not before time.

Equipment Requirements

We have seen that these reserves must be able to travel in most available transport aircraft and then operate on limited scales of transport and equipment for considerable periods. Furthermore, the dominance of the infantry role calls for the best available weapons at company level and below. The scale and type of equipment will be largely influenced by these considerations.

Airportability is probably the most important single factor. The poor performance of the Beverley with high payloads, the Hastings' inability to carry anything larger than light vehicles, and the restricted cargo compartment of the AW 660 demand that in the initial stages of an operation the ¼-ton truck and ½-ton trailer will be virtually all that units will be able to take. One-tonners could sometimes be carried, but only at the expense of several other valuable items. Surely this range of vehicles can be cut out of the unit establishment, thus leaving only the ¼-ton and 3-ton classes? Where really necessary, the long wheelbase Land Rover is likely to be a more satisfactory vehicle. The 3-ton truck will not often be transported by air, but will either stay behind or follow up by sea, depending on the scope of the task in hand.

Armoured units will also find it difficult to take the Saracen and Saladin when aircraft space is at a premium. However it is unlikely that anything larger than scout cars will be needed early on, and these present no particular airportability problems.

There is also a case for the issue of ultra-light vehicles to "teeth" arms—something far smaller than a Land Rover but with comparable load-carrying and cross-country ability. Examples in existence are the Harrier, a four-man personnel carrier powered by a motor cycle engine, and which folds into a box measuring 8 × 2 × 2 ft in size; and the American "Mechanical Mule", similar in principle but more robust and easier to maintain. Though this latter machine does not fold up, large quantities could be carried in a Beverley in comparision with current types of light vehicles.

Trolleys have been a favourite subject for recent mobility trials, and on tasks other than pure internal security in built-up areas, they confer considerable extra mobility on the infantry battalion. Light, folding, and therefore easily airportable in quantity, they obviate the need for many vehicles and ensure a more efficient use of given airlift in terms of useful payload carried. The 4.2-in mortar, for example, can be easily carried by trolley loads.

There are many other equipment problems, but the majority are army-wide and not peculiar to strategic reserves. Where infantry firepower is concerned, all ranks and units should be given the FN rifle or Sterling SMG. How many officers feel really confident of hitting a fleeting target at 20 yds with a .38 in or 9 mm pistol? With a Sterling they at least have a reasonable chance.

Wireless sets are terribly unsatisfactory at battalion level and below; in anti-terrorist operations in difficult country efficient, good-range sets down to individual sections may make all the difference between eventual success and failure. One hopes the new range of wireless equipment will fill this gap, and that strategic reserves will be among the first to receive them. There are also deficiencies in personal equipment; light sleeping bags, easily carried on the man, light igloo-type tents and a hard wearing combat suit are among urgent requirements. Finally, combat equipment; in 1958 many strategic reserve units were still wearing 1937 pattern webbing instead of the more efficient 1944 issue, and the new 1958 equipment should in turn be given to these formations as soon as it becomes available.

Lastly, the provision of packing and crating containers is poor. Panniers, largely due to expense, are on the way out, but there is nothing satisfactory to replace them and far too much space and weight is at present taken up in the average air move by thick heavy packing cases. A light easily portable wooden or aluminium box, preferably made on a folding or "no-nail" principal and available in several standard sizes, is an important requirement, and the new wooden Granby box may prove a step in the right direction.

Training

The training of "fire-brigade" forces is rather simpler than that of standard formations with heavy armoured and artillery support. Primarily everyone, not only infantry, must be well versed in the rudiments of internal security, and practised in operating in difficult terrain with the minimum of transport and logistic resources. Small arms training merits very special attention; the standard of shooting at sudden, moving targets must be continually improved by imaginative field firing exercises using Figure 11 targets. Airportability demands considerable training and practise in the physical aspect of loading and lashing equipment into aircraft—an army responsibility—and in the actual sequence and procedure of an air move. Army/air and army/police co-operation, signals training, and desert, jungle and mountain warfare will all require emphasis at different times throughout the unit as a whole; individually, such things as physical fitness, hygiene, map-reading and the development of initiative and responsibility at the junior NCO level for purposes of patrolling and similar tasks will need especial effort.

In this respect there is nothing like an actual move to put one's training into practice. Short-notice air moves, followed by "operations" in unfamiliar terrain, should be a regular feature of training and will act as a tonic to morale; both local and inter-continental moves should be practised.

Operational Readiness

The main reason for having such reserves is to ensure speed of action when required. How can this be best achieved when set against demands for training, leave and other diversions?

Taking a brigade group as our example, it is apparent that at least a portion must be ready to move with little or no warning; in fact it is quite likely that only the "combat" elements of units will move in the initial stages by air. Thus in each formation a certain percentage must be kept at extremely short notice. This could well be a battalion group, itself divided into "first lift" and "follow up" echelons. Exact proportions will differ according to particular tasks, and it may be necessary to keep staff tables for several different scales of men and equipment.

In a brigade group, therefore, when there is no particular crisis at hand, one battalion group may be placed at, say, twenty-four hours' notice, one at five days, and the third at fourteen days' notice. The first group must remain at base, and only local training will be possible, the second may strike farther afield, while the third will be able to indulge in larger exercises over longer distances. Leave and courses should fit in with this pattern—the group at near-immediate notice cannot afford to have many people away at once. The degree of notice can then be rotated between the battalion groups every four months or so, thus completing the full training cycle over the year, providing all is quiet within the theatre.

At present the training of reserves such as this is continually interrupted by frequent changes in units and faces. This is unsettling, though to some extent inevitable. However, the rundown of conscription and simultaneous increase in long-term regulars will soon bring a marked improvement; and surely these formations provide a strong case for the provision of all-regular units as soon as possible. A suitable tour period in a theatre reserve would be three years; infantry and armoured units rotating as a whole, the remainder probably on a personnel basis only. With an overall system on these lines, a high general state of operational efficiency should not be unduly difficult to maintain.

Conclusion

We are already some way towards establishing a mobile, airportable strategic reserve that can act in a wide variety of conventional present-day roles. In the next few years the importance of these forces, both as a deterrent and as a "fire-brigade", can hardly fail to grow. By the provision of a number of infantry brigade groups, suitably modified to meet the particular requirements of the Cold War, on a theatre basis, and by gearing their strength and disposition to the growing availability of air transport, we can contribute a great deal to world peace and stability.

Formations on the lines of those discussed above deserve a priority as high as nuclear ground forces in the matter of training and the allocation of new and better equipment, and reserves of this nature are bound to be included in the order of battle of the Regular Army for many years. The numbers suggested here may well prove inadequate—only time will show. If the outbreaks these reserves are called upon to suppress do eventually develop, despite all precautions, into limited or even global war, that is a different story.

Memoirs

MAJOR-GENERAL BASIL CHARLES DAVEY, CB, CBE

BASIL DAVEY was born on 21 November 1897, the son of Charles Edwin Davey, MA, BSc, of Jersey. He was educated at Blundell's School and the RMA Woolwich.

He was commissioned into the Corps on 26 August 1916 and after a short time at Chatham and the RE Training Depot, Aldershot, he was posted to 1 Field Squadron RE in France.

In September 1919 he went to India and joined the 2nd QVO (Madras) Sappers and Miners at Bangalore where he commanded 2 Field Troop.

He returned to England in 1922 and completed a Supplementary Course at the SME and at Jesus College, Cambridge, where he represented the University at Polo and was awarded a Half-Blue. After a short tour with 55 Field Company RE at Catterick he returned once more to 1 Field Squadron at Aldershot in 1925 and, while with the Squadron, he attended a Long Equitation Course at Weedon. After a three-year tour with mounted troops he was posted to Catterick as ACRE Northumberland Area; he stayed in this Works appointment for two years.

In 1930 he became an Instructor at the Royal Military College, Kingston, Canada, where he was immensely popular. Whilst in Canada, he qualified as a First-Class Interpreter in both French and Italian.

In September 1934 he was posted to command HQ Wing, 1 Training Battalion, RE and, as was inevitable, he became Master of the RE Draghounds for the season 1934/35.

Towards the end of 1935 he was sent to Rome as Assistant Military Attaché. His two-year tour of duty there coincided with the Italian conquest of Abyssinia, the summit of Mussolini's fortunes and the establishment of the Rome–Berlin Axis.

On returning to England he was posted once again to Catterick as OC 55 Field Squadron RE. Almost immediately after war was declared in September 1939 he was sent, as a Lieut-Colonel, to command 3 Training Battalion RE. He stayed in this appointment for a year and then became CRE 6 Armoured Division and served with the Division during the First Army operations in Algeria and Tunisia. He was an outstanding CRE of an Armoured Division and it was perhaps typical of him that quite unofficially, and contrary to the then Dress Regulations, 6 Armoured Divisional Engineers clandestinely took with them to North Africa black berets with silver RE cap badges which were immediately produced and worn on landing at Algiers. In those days armour and the black beret were synonymous and exclusive.

In April 1943 he was promoted Brigadier and, as Brigadier E 18 Army Group, he was engaged on planning for the invasion of Sicily. He took part in these operations as Chief Engineer XXX Corps, then part of the Eighth Army. He went with XXX Corps when it returned home to become part of the Second Army and, as Chief Engineer of the Corps, he was present in the Normandy Landings in May 1944, at the crossing of the Seine and during the extensive bridging operations carried out by XXX Corps over the River Maas, the Maas-Waal Canal, the River Waal and the Neder Rjin in connexion with the Arnhem battle in September of that year. For his services he was awarded the CBE.

Major-General BC Davey CB CBE

He returned to England in November 1944 to command 140 OCTU but early in 1945 he was posted once more to Italy where he took over as Chief Engineer Eighth Army and, after the German surrender, he became the Chief Engineer of the British Force that advanced into Austria and he remained as Chief Engineer BTA until the end of 1946. During his time there he had the chance once again to enjoy riding and he was able to study the haute ecole training system practised at the Spanish Riding School, Vienna.

At the beginning of 1947 he was posted to the War Office as Colonel E (Ops) and stayed in that appointment until becoming Commandant SME in September 1948. The SME had only recently returned from its war-time location at Ripon to its traditional home at Chatham. The newly transplanted school could not have been placed in more capable hands; under his guidance the SME took root, flourished and blossomed to its former self.

In 1951 he was promoted Major-General on becoming Commandant the Military College of Science, Shrivenham. He brought with him all the enthusiasm and drive he had shown at the SME and it is typical that during his tenure as Commandant the College became in 1953 the Royal Military College of Science. As Commandant of the newly-styled Royal College he was awarded the CB.

He retired after thirty-eight years' honoured and distinguished service in the Corps in September 1954 and returned to live in the Channel Islands. In 1955 he became a Jurat of the Royal Court of Jersey. He was taken suddenly seriously ill last November and died in London on 20 November 1959.

He married Enid, second daughter of the late Brigadier-General E. T. Tudor and Mrs. Tudor of Camberley on 23 June 1926. They had two sons and two daughters. Our most sincere sympathies are extended to the family in their sad loss.

NACR writes:

It was a joy to visit his Headquarters or any unit he commanded. One sensed at once the happy atmosphere. The spirit of enthusiasm that prevailed was infectious. Basil was an outstanding leader and a true friend to all those fortunate enough to serve with him.

ECB from Shrivenham writes:

General Davey was appointed Commandant of the Royal Military College of Science in 1951 at a time when the College was in the process of expansion. It had already embarked on a Guided Weapons Course; a Nuclear Science and Technology Course was soon to follow. General Davey was fully aware of the importance of studying not only conventional weapons but the weapons of the future and he used all his influence to build up in the College a team of military and academic staff to do so.

He had great breadth of vision and appreciated that the Royal Military College of Science had much to offer the regimental soldier. He did all in his power to encourage officers of all arms to come to Shrivenham to read for degrees because he thought such an education would greatly benefit not only the officer employed in the technical field but also officers on the General Staff and in Command. It was during his time that the General Staff Science Course was started. Its purpose was to give officers who were about to go to the Staff College, or had recently graduated there, a short science course to show how the scientist can help the soldier.

During this expansion period General Davey found time to build up the recreational facilities at Shrivenham so that every officer could have an opportunity of taking part in some sport or other. It was due to his efforts that the golf course and tennis and squash courts were built. He also started the Saddle Club.

He felt that young officers required an immediate Commanding Officer to whom they could go and who would take a personal interest in them. He therefore introduced Hall Commanders, one for each of the four Halls.

He was very much respected and admired by all and will be remembered, not only for his influence on the present educational structure of the College, but also for his personal charm and the many amenities which he built up at Shrivenham.

It might be appropriate to add that the late General Davey's son, Captain Anthony Davey, is at present a student at the Royal Military College of Science on a post graduate course.

Memorial Service

A Memorial Service to Major-General Davey was held on Saturday, 12 December 1959 in the Garrison Church, Chatham. The service was conducted by the Reverend H. L. O. Davies, QHC, ACG, Eastern Command, and attended by Mrs. Davey (widow) and members of the family. The Chief Royal Engineer, the Engineer-in-Chief, and many RE officers were present; the Institution of Royal Engineers, the Royal Engineers' Association and the Royal Military College of Science were represented.

The Reverend Andrew Bradley, Warden of Church House, Bagshot, gave the address in which he said that he had been the Chaplain at Chatham when General Davey, then Brigadier, was the Commandant SME. During those years he had grown to know and appreciate his direct qualities. His sense of duty, friendliness and out-spoken loyalty were an inspiration to countless folk who had come in contact with him.

Those attending the Memorial Service would have many memories of Basil Davey but it would be a sad day if it were memories only. Deo Gracias Basil Davey had left behind a great inheritance. He had carried on and enriched the great and famous inheritance of his Corps. Many who could not be present at the Service would bear witness to the help and inspiration that General Davey had been in their lives. He had no time for idleness. He could rebuke with some vigour, but he could help and encourage quietly with equal vigour. He had the uncanny knack of making you feel that your own personal problem was the only one in his mind.

On his first day at Chatham he had seen on the door of a small hut a notice saying: "Once a Sapper always a Sapper". It was only later that he appreciated how much the Corps meant to its members. He had a good tutor in Basil Davey. Young Officers and Officer Cadets who passed through Chatham when he was Commandant will be deeply grateful for the official and unofficial help and guidance he gave them; many will recall certain bruises from equitation exercises but with a grudging admiration of the example set.

In all this Basil Davey was not alone. His happy home life was an inspiration in an age when home life was not at a premium. Our thoughts today will be with his family in their sorrow, but this is not a sad occasion but a Service of quiet thanksgiving for the full life and work of Basil Davey. No one will ever know how many lives he influenced and transformed.

Many times at commissioning services held in this Garrison Church newly-commissioned Sapper Officers had been told that they were not merely curators of a traditional museum; the Corps must be enriched by their service. In his life Basil Davey certainly enriched to no small extent an already illustrious Corps. May God grant him a place of refreshment, light and peace. We salute a great Christian Gentleman.

L.

BRIGADIER DAVID FORSTER, CB, CMG, DSO

DAVID FORSTER was born at Woolwich on 23 January 1878, the son of Lieut-Colonel W. D. Forster, a Gunner. From St Paul's School, David passed second into the "Shop," where he gained one place and, with it, the Pollock Medal. On 23 December 1896 he was commissioned 2nd Lieut in the Royal Engineers, just before his nineteenth birthday.

From the SME, Chatham, Forster joined 11 Field Company early in '99, and just before the turn of the century he sailed for South Africa with 2nd Infantry Division. During the South African War he took part in the battles of Belmont, Graspan, Modder River and Magersfontein. But in July 1900 he had to be invalided home, having been dangerously ill with enteric fever.

After a short period again at the SME, he was posted to India in March 1901. From then until 1912 he "soldiered" in India and Burma, mostly with the Madras and Burma Sappers and Miners. He returned home to attend the coveted course at the Staff College, Camberley, in 1912-13, where he was a friend and fellow-student of William Dobbie of Malta fame.

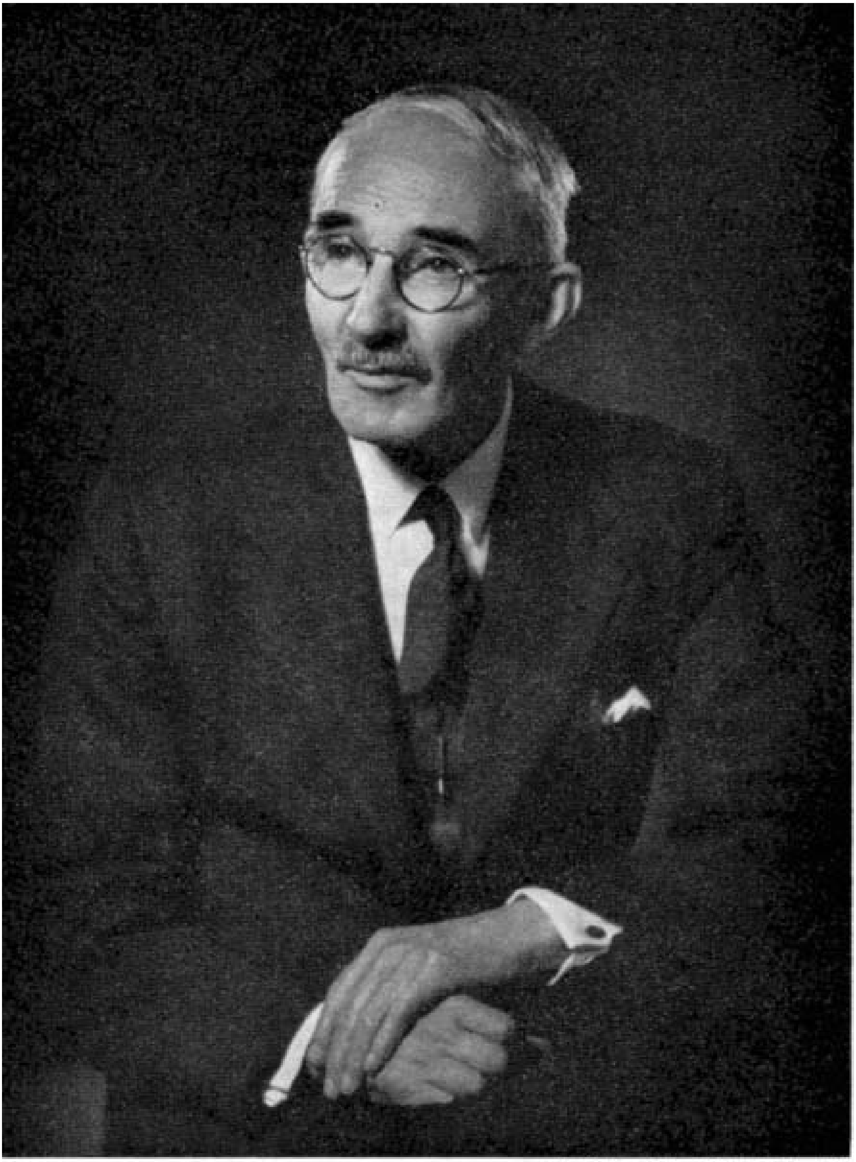
He returned to India, only to be ordered direct to France in September 1914. His wife and three young children were in Switzerland on holiday, *en route* to join him in India. They turned back as soon as travelling was possible and passed through Paris within earshot of gunfire from the Marne.

He remained almost three years in France, serving on the Staffs of 35th, 50th and 33rd Divisions, and taking part in the battles of Loos, the Somme, Arras and 3rd Ypres. Whilst GSOI of a Division in France, he had as his GSO 2 a young officer—also an Old Pauline—named Bernard Montgomery. Their GSO 3, named Hughes, subsequently took Holy Orders, became General Montgomery's Senior Chaplain in Eighth Army, and eventually Chaplain-General. Forster was four times Mentioned in Dispatches, awarded the DSO in 1916, and promoted Brevet Lieut-Colonel in 1917. He was twice wounded, both times in the right leg, and his wounds left him lame, and frequently in pain, until his death forty-three years later.

In 1918 he joined the Military Operations Directorate in the War Office, where he was concerned with Commonwealth strategic problems—though the name Commonwealth had not then been invented. In 1919 he was awarded the CMG. In 1921 he was a member of the British Delegation at the Washington Peace Conference, whence he made a tour of Canada.

On promotion to substantive Lieut-Colonel in 1922, he went to Dublin as CRE, his stay in Dublin being a turbulent one at the height of the Sinn Fein troubles. The following year he attended the Naval War Course at the Royal Naval College, Greenwich, subsequently visiting USA again in HMS *Hood*.

He was next posted to the Far East, being CRE Singapore and Malaya. He



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Brigadier D Forester CB CMG DSO.

made the early reconnaissances for the Cameron Highlands' Hill Station, leaving "Forster's Hill" as a memorial in that area. While on leave in the Far East, he visited Australia and New Zealand, and a report on this trip which he subsequently submitted earned for him the entire expenses of the venture. An officer serving under him in the Far East, Captain Nevil Brownjohn (later to become Quartermaster-General) complained many years after that Lieut-Colonel Forster used to bestir his officers very early in the morning and, despite his own game leg, would walk them off their legs on reconnaissances and exercises. But they dared not complain, as their CRE was lame!

In 1926 he was promoted Colonel, and early in 1927 was posted back to the War Office as Deputy Military Secretary. Not long after, the Military Secretary died suddenly, leaving Colonel Forster acting MS until a new General could be appointed.

Promoted Brigadier, from January 1931, until his retirement in December 1934, he commanded 13 Infantry Brigade at Catterick, living in Hipswell Lodge. It was rare during this period—and hence an honour for the Corps—for a Sapper to command an Infantry Brigade. During his last year as Brigade Commander, his Brigade Major was John Harding. Many years later, Field-Marshal Sir John Harding, when CIGS, told the writers of this Memoir that he had learned much of his soldiering from David Forster, who, he said, was one of the finest trainers of men he had ever served. On retirement Brigadier Forster was awarded the CB.

World War II saw him at once volunteering for service again, and from 1940 to 1942 he was Welfare Officer successively in Chatham and Home Counties Areas and in South-Eastern Command, now commanded by his old GSO 2, Lieut-General Montgomery. Later he became an Air Raid Warden and was wounded in the face during a raid on Wimbledon, his own flat being badly damaged, all the glass broken, the furniture thrown about, and his wife mercifully uninjured in a bed which was covered in glass-splinters, hundreds of which had penetrated the eiderdown.

In 1903 he married Isabel Frances, daughter of Lieut-General H. A. Brownlow, a Sapper. They celebrated their Golden Wedding in Wimbledon in 1953. The ceremony was attended by their three children, their three "children-in-law", and all eight grandchildren. His wife died two years later, leaving one son and two daughters. Their elder daughter married Lieut R. W. Ewbank, RE—now Major-General R. W. Ewbank, CB, CBE, DSO, BA, Chief of Staff, Northern Army Group—himself the son of a Sapper.

Aged 78, Brigadier Forster set off alone round the world. In Singapore he met Miss Reda Poynder, who was working in the Sandys Soldiers' Home, and they were married in September 1958. They set off for Australia and New Guinea, where he was taken ill. He died in England on 20 November 1959, aged 81. His widow is now returning to her work among the soldiers and their families in Singapore.

David Forster had had a distinguished military career. He always set the highest standard both for himself and for those under his command. The guiding law throughout his life was "God first—others second—self last." A retired Gunner Brigadier, who had known him for many years, writing soon after his death, described him as one of the finest Christian gentlemen he had ever been privileged to meet. Could one wish a finer testimony or a more lasting memorial?

R.W.E. and I.J.E.

BRIGADIER L. I. JACQUES, CB, CBE, MC

LESLIE INNES JACQUES who died on 28 December last was born on 11 December 1897 the son of H. I. Jacques, Esq of Bristol. He was educated at Clifton and the Shop. He was commissioned into the Corps at the age of 18 and after a short course at Chatham was posted to the Expeditionary Force in France serving with 280 Army Troops Company and 233 Field Company, gaining the MC in 1918.

Before returning to England in 1921 for his Supplementary Courses at Cambridge and Chatham, he served in Egypt with 16 Field Company of the 2nd QVO Madras Sappers and Miners, the Corps to which he was to return again for so much of his service.

After his Supplementary Courses, a year with 17 Field Company at Bulford was followed by a tour as Territorial Adjutant of the 50 Northumberland Royal Engineers (TA).

Thence to India in 1930 for ten years continuous service with the Madras Sappers and Miners. In the war years also he was still in touch with the Corps through its Field units in the 10 Indian Division and the 21 and 15 Indian Corps of which he was CRE and CE respectively, seeing service in Iraq and Burma.

After the war he reverted to his substantive rank of Colonel to become Chief Engineer Northumberland District and in 1948 he was appointed Chief Engineer West Africa Command.

He was awarded the CBE in 1945 and the CB in 1953 after some three years as Commander of the Engineer Services Liaison Staff BAOR, in Antwerp.

"Jacko" was not endowed by nature with a strong physique or athletic or equestrian ability, the gifts so valuable to a regimental officer. This handicap he overcame by his physical and moral courage, by perseverance and by enthusiasm. Those of his friends who saw him when he nearly lost an eye at Cambridge or when he lost a finger in the block of a Weldon trestle tackle at the bridging camp at Nanjangud, were astonished at his fortitude in physical pain. His ready wit and quiet sense of humour made him always an entertaining companion.

After retirement he lived quietly with his sister at Pinner, but in later years did not enjoy good health.

J.F.D.S.

A. C. HARTLEY, Esq, CBE, BSc(Eng), MICE, MIMechE, FCGI

ARTHUR CLIFFORD HARTLEY died on 28 January 1960 at St Thomas's Hospital, London, aged 71 years.

He started his civil engineering profession with the North Eastern Railways' docks at Hull, Hartlepool and Middlesbrough and later obtained mechanical engineering and management experience with Rose, Downs and Thompson of Hull, and the Limmer and Trinidad Asphalt Company respectively.

During the 1914–18 war he served in the Royal Flying Corps. He was responsible for the development of the Constantinesco synchronizing gear which enabled machine guns to fire between the blades of aircraft propellers.

After the war he became a partner in a consulting engineering firm specializing in the design and construction of cement works. In 1924 he became Assistant Manager in the engineering department of the Anglo-Persian Oil Company, later known as the Anglo-Iranian Oil Company. He became Chief Engineer of the Company in 1934 which post he held until his retirement in 1951.

During the 1939-45 war he was lent by his company for the development of a stabilized automatic bomb-sight. In 1932 he was appointed Technical Director of the Petroleum Warfare Department. He was largely responsible for the development of PLUTO, the oil pipeline which subsequently ran under the English Channel and delivered a million gallons of fuel a day from the UK base to our land and air forces on the Continent. He was also responsible for the development of the "FIDO" airfield fog clearance system and for "flame" weapons.

He was elected an Associate Member of the Institution of Civil Engineers in 1916 and a Member of the Institution in 1928. He served for many years on the Council and in 1955 he was elected Vice-President. On 5 November of last year he became the President of the Institution of Civil Engineers, the greatest honour in his profession.

Mr. Hartley was a foundation member of the Royal Engineer Advisory Board.

Book Reviews

AUSTRALIA IN THE WAR OF 1939–1945

Vol. V. South-West Pacific Area—First Year

By Dudley McCarthy

(Published by the Griffin Press, Adelaide, 1959. Price 30s)

Although Japan's entrance into the war had the signal result of ranging the USA on the side of Great Britain, it caught the Commonwealth order of battle decidedly off balance in the Far East and the Antipodes. Australia and New Zealand had sent their best troops and much of their latest equipment to the Middle East and the Mediterranean. Suddenly they had to form front north-east and face the possibility of Japanese invasion. Manifestly the defence of Australia was a maritime problem, yet the Royal Australian Navy was diminutive and the Royal Navy was so heavily committed elsewhere, that it could contribute only a tithe of the forces required for tackling the power of Japan at sea. Thus the USA, with their great fleets in the Pacific, inevitably took charge of the Japanese War.

The maritime potential of the USA indeed soon proved to be far greater than that of Japan. It seems fair to say that, if the Japanese surprise attack at Pearl Harbour had not thrown the US Navy into initial disarray, the fierce fighting in Papua, to which most of this book is devoted, would never have taken place. The Japanese would not have been able to force landings there. Even as it fell out, they had prodigious difficulties at Gona and Milne Bay, caused by Allied sea and air attacks. Their landing at Milne Bay was liquidated in fourteen days chiefly because the Australians had superior forces close at hand. At Gona, where they were opposed at first only by militia men and local troops, the Japanese invaders had a much longer run. They got as far as penetrating 90 miles deep into the Owen Stanley mountains but after three months desperate jungle fighting were compelled to fall back to the sea where some starved, some died in battle and a few escaped. Seemingly the Japanese hoped to avoid the effects of dwindling sea power by the prodigal sacrifice of their surfeit of troops. Fortunately maritime power does not work like that.

General MacArthur, Commander of the SW Pacific Area, loomed large in the defence of Australia. His rough methods did not altogether please many of the extremely capable Australian soldiers who worked under him. He paid little heed to tactics or training or indeed terrain and logistics. What he did have in full measure was a proper sense of urgency coupled with a will to prevail which stuck at nothing. He did not hesitate to order General Blamey to Port Moresby to "energize" in person the Allied advance through the jungle. Having unjustly blackguarded the fighting efficiency of the Australian troops in Papua, he sent in some untrained US battalions, who proved to be immeasurably worse. Whereupon he ordered the US Corps Commander with his Chief of Staff to the front line, promising them great rewards for success and ignominy for failure.

Dudley McCarthy's "ball by ball" account of the tangled fighting on the road to Burma and Wau, admirably photographed, reveals the appalling difficulties of every sort, which confronted the Australian and American soldiers. The vivid tactical details are a timely reminder of the importance of close range combat, which, in spite of the new techniques of nuclear destruction, will continue to be a basic feature of the violence of war. The air support of the Allied columns in the jungle was at first just as backward as it had been in North Africa and Burma. Aircraft, parachutes for supplies and airstrips were all insufficient. Yet a daily lift of 50 tons would practically have solved the supply problem.

Like the authors of the other Australian histories, Dudley McCarthy writes without bitterness of the raw deals, which during the crisis of the war, Australia often endured from the British Government. He remarks, nevertheless, that the emergence of America as the mistress of the Pacific, has given Australia a new orientation to thoughts on the future security of her great island continent. Perhaps this does not matter very much, for we are all companions in prosperity together and each must do what he can to preserve it. B.T.W.

THE SINAI CAMPAIGN 1956

By Edgar O'Ballance

(Published by Faber & Faber, 24 Russell Square, London. Price 21s)

The Author of *The Sinai Campaign 1956* has written a book which, in its direct approach to its subject, its straightforward form of narrative and its almost conversational military style ("he was able to contact column commanders personally by jeep and aircraft" *page* 192) remind one of the war diaries written hurriedly by adjutants with the mud and blood of battle about them. Indeed this is your reviewer's main criticism of this book: it is written from too close to its subject; there are plenty of facts but only rather superficial reflections. The author says in his Preface that he has for the most part avoided politics; but the entire scene of that time was dominated by political complications and any account that eschews them cuts itself adrift from what were then the guiding facts of life. This is a pity.

Beginning with a factual account of "The Uneasy Truce" from 1948 to 1956, the author embarks upon a good description of the Sinai Peninsula and the opposing forces. He then gives a day-to-day account of the fighting with a chapter of "Comments on the Campaign" followed by some speculation about what is likely to happen next. If one accepts that the author really knows his subject (including the local politics)—as one feels he does—this looking into the future is perhaps the most valuable part of the book.

The secret of successful military historical writing is to let the reader into the minds of the actors; so that he knows their doubts, fears, uncertainties and convictions (right and wrong); that is what distinguishes a story of human conflict from an account of a game of chess. One wonders what made the Israeli Chief of Staff take the risks he did. Did he know the Syrians would not march against him from the north? Did he know that an Anglo-French expedition was about to land in Port Said? Did he have any trouble with his own government? A hundred other questions occur to the reader; and innumerable uncertainties must have troubled General Dayan's mind. The skill with which he and his government resolved their doubts helped to give the Israeli Army the sinister touch that made it master of the Egyptians. In short, if you want to know what 7 Armoured Brigade—there is a homely British ring about all the formation nomenclatures—was doing on D + 4 this book will tell you accurately and in detail. But if you wonder why they were not digging air raid shelters in Jerusalem against Russian bombers—as some people in London thought *they* should be doing—you must look elsewhere.

A good book in its way, but not (according to your reviewer) in a big enough way.

M.C.A.H.

EXAMPLES OF THE DESIGN OF REINFORCED CONCRETE BUILDINGS IN ACCORDANCE WITH THE BRITISH STANDARD CODES

By CHAS. E. REYNOLDS, BSc(ENG), MICE

Published by Concrete Publications Ltd. 2nd Edition 1959. (Price 12s 6d)

The original edition of this book was an excellent reference where innumerable examples of problems in reinforced concrete design were worked out. Revision of Code of Practice 114 in 1957 not only introduced new values of concrete and steel stresses but also introduced the Load Factor Method of design which meant that the first edition was obsolete.

The second edition is not a revised first edition but an enlarged and more comprehensive one. Resistance to Bending, Bond and Load Factor Design each have chapters devoted to them, and Load Factor Design is mentioned, where appropriate, in other chapters. Many of the charts are identical to those in the first edition but in some cases they have been enlarged and are more pleasing to the eye and easier to use. In addition there are new charts, particularly in the Load Factor Design chapter, which are very ingenious.

Part II of the book is devoted to reinforced concrete drawings. All the details are given and calculation sheets are included to correspond with the drawings. The calculation sheets are referenced back to chapters on the subject in the book and provide a useful aid to neat and logical calculation.

This is a very welcome addition to the Reinforced Concrete Designers library, but as with all books of "DS Solutions" must be applied sensibly. Dependence on a work of this sort without proper understanding of the principles involved can only lead to disaster. W.C.

CURVE SURVEYING

By R. B. M. JENKINS, M.A., A.MIMechE, MILocoE

Published by the Cleaver-Hulme Press, Ltd, 31 Wright's Lane, London, W7 (Price 35s)

The problems of designing and setting-out circular and transition curves for roads and railways are covered, in varying detail, in a number of standard reference books that often deal with other aspects of survey as well. This little book of about 180 pages (of which a fair number are tables) covers the subject simply and concisely but in sufficient detail to be of use to the comparatively inexperienced engineer. The only current military equivalent is *ME*, Vol VIII—Transportation, Part IIA Railway

Survey (formerly Notes on Military Engineering—Part I (Survey) 1940 and hereafter referred to as *NOME*) Extracts from this publication slightly modified for roads, are reproduced in *ME* Vol 5, Part 1—Roads and Airfields 1957. It is interesting to compare both these with the book under review.

The main part of the book deals with circular curves, the super-elevation needed thereon for any particular speed and curvature. Also the length and best form of transition curve needed to introduce the super-elevation from the straight or to allow for a change thereof in compound curves. All these aspects are largely inter-dependent and one of the main attributes of the book is that it tackles the problem in logical sequence.

The first two chapters deal with the location and setting-out of circular curves, with and without instruments, and include the methods in *NOME* and Vol 5, but in rather greater detail.

The third chapter covers the calculation, from first principles, of equilibrium super-elevation at various speeds and radii and, also, recommends safe maximum speeds in excess of equilibrium. The chapter goes on to include methods of determining the minimum length of transition needed on both roads and railways. This part is particularly useful to the military engineer as the rather over-simplified methods in *NOME* have distinct disadvantages in railway work. Likewise it may often help with road problems beyond the scope of *NOME* or Vol 5.

The next three chapters deal with the design and setting-out of the three common forms of transition curve—the cubic parabola, the clothoid, and the lemniscate. The mathematics and theory are covered very well. The pros and cons of each are discussed and lead up to recommendations as to the best to be used depending on the sharpness of the circular curve; namely, the cubic parabola for the flat curves generally found only in railways and one of the other two for the sharper curves in roads. Most of the tables appear in this part and considerably ease calculations. Here again, these methods are more flexible than those in *NOME* or Vol 5, The latter are based on a form of cubic parabola, with a simplified form of setting-out, that rather limits their use on railways and may not produce good transition for roads.

The last chapter deals with an associated but rather different subject—The Realignment of Railway Curves by the Hallade Method. As the author says in his preface—"Although the Hallade Method of re-aligning railway curves is now used all over the world, it does not seem to have found its way into standard textbooks on surveying." The chapter covers the technique of "stringlining" the curve, the theory behind the calculations and the way these are carried out in tabular form. These are all well explained and easy to follow. However, as the author states, this is only an introduction and it is possible that the novice would find the method difficult and tedious on anything but the simplest curve correction scheme. A little more on the practical aspects of adjusting values and closing the computations might have avoided this. This is really a railway maintenance technique so is not mentioned in *NOME* nor, quite naturally, in Vol. 5. However the platelayer's method of "halving", a simpler, less satisfactory and more restricted method of effecting minor corrections, is given in *ME*, Vol VIII, Part II—Railway Construction (formerly *NOME*, Part II). It is not fair to compare this with the Hallade, or any other engineer's method, as the latter set out to take a very much wider view of the problem. There is no direct application for road work although the "correction" of roughly pegged alignments to introduce proper curves has been tried successfully using a modified Hallade method.

The text is readable and supported throughout with worked examples. There is a good index. Two minor criticisms; firstly, many of the tables are "buried" in the text and could well have been extracted into an appendix; secondly, a pocket size binding, rather than the existing quarto, is a possibility for a work of this length and would have enhanced its value for field work.

The book is recommended to anyone needing sound guidance on road or railway survey problems outside the scope of the current military publications.

T.W.M.E.

Technical Notes

CIVIL ENGINEERING

Notes from *Civil Engineering and Public Works Review*, October 1959

"A Rooftop Highway Town": A dramatic departure from the traditional concepts of Town Planning, based on a realistic appraisal of the requirements for modern and future traffic conditions, has been studied by the Glass Age Development Committee. This article describes a town to house 30,000 people, called Motopia, in which the traffic flows above the buildings, and vehicles and pedestrians are kept at a safe distance apart. Continuous vertical lifts and moving pavements provide access from the parking areas (which include provision for helicopter traffic) and the result could achieve safety, combined with spacious living conditions, without interfering with the flow of traffic through the "built-up" (in several senses!) area. The estimated cost is compared with anticipated rentals, and considered to show a profit. When this is set against the incalculable losses due to road accidents the scheme deserves real consideration.

"Soil Conservation Technique": Further details are given of the method, described in November 1958 for applying a mixture of straw, asphalt, seed and fertilizer to exposed embankments. The result aims at soil conservation and stability of the embankment by prevention of erosion by wind and rain, and may also have an application for concealment.

"Engineering Developments in the USSR": Reference has already been made to results shown by Russian Engineers employing a new technique for driving piles in which opposed eccentrically mounted weights are used to drive piles by vibration. The article now published gives considerably more detail and several drawings of typical rotary vibrators.

"Some Aspects of the Strength of Concrete": This is a statistical approach. In addition to the normal reasons for lack of strength—as in omitting some of the cement, or adding too much water—there are factors at work undreamt of by the field engineer. Reduced to simple terms, these might be described as "the statistical chances of a crack appearing". In fact, the broader the flange of a beam in tension the more chance it has of incorporating a weakness. The normal field engineer would hardly believe this mattered compared with the added strength the extra thickness provided. None the less, this statistical analysis is of great importance to a laboratory technician concerned with the design and conduct of experimental research.

"The Construction of the Chiswick Flyover:" While controversy rages over this subject, there are points to note in this article concerning the design of a large precast prestressed structure. The beams were made in three sections—the two ends being 38 ft long and the heavier centre sections 48 ft long and weighing 33 tons. The sections were precast in a factory 60 miles away and transported daily to the site, where they were lifted into position by a 45-ton mobile Lima crane. They were erected directly on the permanent bearings on piers and abutments, and on temporary rollers supported on steel trestles on either side of the transverse joints between the sections. These joints are nominally 3 in wide and continuity of the ducts across the joints was maintained by means of short lengths of rubber tube clipped to the ends of steel tubes projecting from the beams. (This is assumed to imply that the rod is passed through the end section, from the abutment end, until it projects well into the ducts in the centre section.) The rubber tube is fitted like a collar, and covers the rod where the joint occurs and extends beyond the jointed area into the ducts in the concrete. One end of the rubber tube is clamped to the rod, the other end being left free. When the grout has partially set in the joint, the exertion of pressure on the axial rod will stretch the rubber tube, thus breaking the grip of the setting grout. A skew bridge, incorporated with the flyover, was designed with rubber bearings. These bearings will permit expansion and contraction movements in both axial as well as longitudinal directions.

"Tests on a Flexible Runway Pavement": The article describes how the US Army Corps of Engineers have physically tested out their design method (CBR) for flexible runway pavements. Having carefully designed and tested the subgrade and the materials to be used, both a rigid and a flexible pavement were laid adjacent to each other, and trafficked heavily by a test roller deemed to be equivalent to a B-52 aircraft. The results proved successful. Slight settlement and cracking could be noted on the flexible pavement after 5,000 coverages, while less settlement, but slightly severer cracking, occurred in the rigid pavement. Both methods of design are now therefore equally accepted, and the US Corps of Engineers are now permitted to accept construction to either specification.

"Composite Action in Steel-framed Buildings": The authors analyse the evidence of strain gauges inserted in certain beams and stanchions during the erection of steel-framed buildings. These gauges recorded the complete case history of the loads imposed on their members from the time when they were first joined up to the frame to the time they began carrying live loads. In this way it can be seen how members get stressed at all stages of construction: as concrete floors are poured; as they set and take up part of the strain; as the shuttering is removed. In fact one useful point immediately made clear is that concrete floors can, by composite action, reduce dead load stresses in stanchions and beams if they can be left shuttered and propped until they reach their full working strength.

"The Plastic Bending of Beams Loaded in Non-Principal Planes": When a structural member is loaded in a Non-Principal Plane beyond its yield point a plastic condition will appear at the edges farthest from the neutral axis, and the neutral axis will shift both in position and in inclination. The article shows how, by simplifying geometry, and other practical approximations, an estimate can be made of the load for first yield and for the final limiting resistance when the section has yielded fully. An experiment with an angle section loaded to final yield corroborated the calculated result for this section.

Notes from *Civil Engineering and Public Works Review*, November 1959

"Overburden Blasting in Opencast Coal Mining": The article describes the use of commercial high explosives as a means of speeding the clearance of overburden for opencast coal mining. This first article of a series covers the different types of commercial explosive most commonly used, electric detonators, electrically operated short delay detonators and Cordtex detonating relays.

"The Internal Vibration of Concrete": The author was faced with the problem of comparing the relative efficiencies of different types and makes of internal vibrator. The tests devised demonstrated that the physical results cannot be accurately measured in terms of amplitude, frequency and maximum acceleration, and that therefore the relative performance cannot be determined simply by measurement of these criteria. The tests were carried out under controlled conditions. The mix proportions were kept uniform and the workability maintained within narrow limits by means of the Compaction Factor Test which was found on trial to be more sensitive and simple to use than the VEBE automatically recording consistometer.

The compaction achieved was measured by several methods, namely the change in velocity of an ultrasonic pulse, cube crushing strength, density and percentage rebound of the Schmidt Rebound Hammer. The first method proved better than the others. Care was taken to vibrate the samples for an identical period in every case, and to remove the vibrator slowly so as to avoid trapping air by a sudden movement.

The results cannot be termed conclusive. If nothing else they prove that the behaviour of the vibrator does not follow a simple pattern based on amplitude and frequency. There is a tendency for the vibrators with heads larger than 1 in diameter and frequencies of more than 6,000 rpm to give a considerably better performance than the smaller size and lower frequency vibrators.

"Features of Prestressed Concrete Runways": The many factors which govern the design of runways and the cost of different methods are discussed in this paper. Prestressed concrete pavements possess many advantages in this age of heavy jet airliners. They are thinner than plain concrete runways and, being more flexible, make better use of the ground resistance with multi-wheeled undercarriages. Their main advantage is that they can be laid in continuous lengths over a layer of sand which reduces ground friction. Plain concrete runways suffer from cracking at joints, or temperature cracks which allow the base to soften. The useful life of plain concrete is a function of the traffic using it, subjecting the concrete to slow, but progressive, deterioration. Prestressed concrete, on the other hand, possesses a great reserve of strength which is less likely to reduce with time. Cracks, should overloading occur, will seal themselves as the load moves off again. A new development is described whereby the pavement is stressed by jacks operated within a transverse, underground, subway. One useful point in this method is that the jacks can be recovered for re-use, and that, if a suitable prestressing system is used, adjustments can be made at a later date and repairs carried out even to the extent of replacing whole sections of the concrete apron. T.W.T.

Notes from *Civil Engineering and Public Works Review*, December 1959.

"Cardboard Forms Used on Radar Project." In order to produce a concrete floor of "waffle" grid construction, special cardboard formers were used instead of more costly timber or metal core boxes. The cardboard cores were made of cardboard egg-crate-type sections, rapidly assembled, taped up, and waxed. Each pad, 24 × 24 × 14 ins deep, takes three minutes to assemble and costs less than 2*s*. They are strong enough to walk on, and to support a 3-inch concrete floor cast above them. The 14-inch troughs between the cores serve as formwork for reinforced concrete ribs spanning in both directions. The photographs included make the use of this novel type of construction easy to appreciate. T.W.T.

ENGINEERING JOURNAL OF CANADA

Notes from *The Engineering Journal of Canada*, October 1959.

The October issue is devoted to the general subject of "Power", and it contains nine technical papers. Of these the first, "Power in Canada", is a statistical summary of the main features of power production in individual provinces and territories. At the end of 1958 the total installed capacity of hydro-electric plants was very nearly 22½ million hp, and that of thermal generating plants exceeded 3½ million hp. The first seven months of 1959 showed a net increase of 6.3 per cent, and it is estimated that the total output in 1959 will be about 102 million MWh.

There are five papers dealing with electrical and mechanical aspects, the titles being:—

"Some considerations in steam power plant design."

"The interconnected power systems of Nova Scotia and New Brunswick."

"The first cyclone fired boilers in Canada."

"138 kV undersea cable across Georgia Strait."

"The design of a Daniels-Boyd nuclear steam generator."

Of interest primarily to mathematicians is a paper entitled "A method of determining the power potential of rivers with many reservoirs and power plants".

The remaining two papers are of more general interest, and are briefly described below:—

"WHITEDOG FALLS AND CARIBOU FALLS GENERATING STATIONS": Hydro-electric installations at Whitedog Falls on the Winipeg River and at Caribou Falls on the English River were constructed as a combined operation. Similar turbine units are used in the two generating stations, which have a common tailwater in Tetu Lake at the confluence of the two rivers. Whitedog Falls has a rated head of 50 ft, with a rated capacity of 81,000 bhp: the rated head at Caribou Falls is 58 ft, and the rated capacity 102,000 bhp.

This paper provides some very solid reading, but it includes comprehensive details of the technical aspects of the subject. For the general reader it would have been improved by better arrangement and paragraphing, and by the inclusion of site plans.

"SILVER FALLS GENERATING STATION": This paper describes the driving of a hydraulic tunnel connecting the intake structure to the generating station. The tunnel is 2 miles long, and was driven to a diameter of 17 ft 6 in, giving a final diameter of 14 ft 6 in when lined with concrete.

The teaming of plant and general organization are interesting, and the importance of bit and steel maintenance is clearly demonstrated. The method of driving the 300 ft intake shaft and 200 ft surge shaft was unusual, and the comparative advantages and disadvantages of using (*a*) a 9-in churn drill, and (*b*) a 4-in diamond drill, and of different methods of mucking out, are worth noting.

Notes from *The Engineering Journal of Canada*, November 1959.

"FRAZIL ICE": In still water a surface sheet of ice is rapidly formed when heat loss results in supercooling of the surface. In flowing or turbulent water, however, surface water is interchanged with that from below until a layer of definite depth, depending on the degree of turbulence, is cooled to 0°C without ice formation. Further supercooling of the surface then leads to the formation of frazil ice particles, in the form of thin discs which later grow needle-like fragments from their edges. This frazil ice may cause serious clogging of intakes and canals, and can even form a navigational hazard or cause extensive ice jams. This review of its properties describes the theory of formation and the factors inducing it, methods of predicting the rate of cooling and of forecasting ice development, and summarizes design considerations and remedial action. Sponsored by the National Research Council of Canada, this paper is based on an imposing international bibliography.

"PRECAST CONCRETE FOR WINTER BUILDING": Canada suffers from serious seasonal unemployment during the winter, and an interesting paper on "Winter construction" was published in *The Engineering Journal* for February 1958 (see *R.E. Journal*, June 1958). The present paper examines in more detail the use of precast concrete, which can ensure high quality and halve construction time. The main practical difficulty is in making connexions between precast members. Several solutions are suggested, but the need for further study is acknowledged.

"BUSINESS TRAINING FOR PROFESSIONAL ENGINEERS": The December, 1958, issue of *The Engineering Journal of Canada* carried two papers on the training of engineers (see *RE Journal*, June 1959). These dealt primarily with technical training in this age of rapid scientific and technical development, but the present paper shows that this is not the only problem.

It includes some rather startling statistics, which seem to confirm the view that the practice of management is, at least eventually, a vital part of the engineer's profession. For example, an occupational survey covering over 75,000 engineering graduates showed that nearly 28 per cent were employed on "human relations", including supervision, sales, and personnel administration. In the United States, nearly half the graduates from the Massachusetts Institute of Technology are employed in business roles, and in Germany 36 per cent of those listed in the directory of directors hold engineering degrees.

Various methods of broadening the education of professional engineers are discussed. No particular solution is recommended, but it is recognized in many engineering schools that the civilian, no less than the military, engineer has need of much more than technical knowledge. R.P.A.D.L.

THE MILITARY ENGINEER

Journal of the Society of American Military Engineers

NOVEMBER–DECEMBER 1959

"From Atlanta to the Sea" by Lieut-Colonel Robert R. Ellis, Inspector General. This is the first part of an account of the operations conducted by General Sherman in 1864 in the American Civil War with special reference to the part played by an Engineer officer, Orlando Metcalfe Poe and the influence of the Engineer arm on the strategy of the campaign.

"The Big Dish" by Rear Admiral Eugene J. Paltier, Civil Engineer Corps, U.S. Navy. The Big Dish is the world's largest radio telescope which is being constructed under the direction of the Bureau of Yards and Docks, US Navy, on a site in Virginia. The bowl shaped antenna will be 600 ft in diameter and 94 ft deep at the centre. The height above ground of the structure will be 665 ft and the weight over 20,000 tons. This article, which is illustrated, gives a description of the design of the structure and of the administrative aspects of finance and organization. Work on the foundations is well advanced and design and contract action on the off-site construction of the component parts is proceeding.

"Repair of Fire Damaged Structural Steel" by Ernest M. Newman. A short, well illustrated, account of how two hangars, of which the frames were made entirely of structural steel and which were badly damaged by fire, were repaired with a minimum of dismantling and provision of new parts by the application of heat in selected patterns by means of an oxyacetylene torch. The method is described in sufficient detail and with enough illustration to make the general principles clear. The method saved much time and money.

"Nuclear Radiation. The Effect on the Individual" by Lieut-Commander John C. Le Doux, Civil Engineer Corps, US Navy. A short account, illustrated with diagrams and graphs, of the various kinds of radiation to which the body can be subjected and their effects.

"Modern Construction on the Last Frontier" by Commander W. J. McFarland, Jnr. Civil Engineer Corps, US Navy. The Last Frontier is the Island of Kodiak in the Gulf of Alaska and is the base of the US Navy Alaska Sea Frontier and the 17th Naval District. This article is a short illustrated account of the engineer construction work being carried out there partly by military units and partly by contract. The special conditions imposed by climate, a temperature range from minus 60°F to plus 65°F, winds of 150 miles an hour, and the complicated geology of the area in combination with the length of communications with the sources of supply make the task exacting but at the same time rewarding. The technical information is in insufficient detail to be of great value but the emphasis on accurate planning and programmed supply of stores is instructive.

"High Roads of Afghanistan" by Lieut-Colonel H. A. Swanson, Corps of Engineers Reserve. An illustrated account of Afghanistan today and of the work being carried out to improve the road system including bringing the Kabul-Khyber road up to modern standards. The Afghanistan Ministry of Public Works is being assisted by the International Co-operation Administration and American Engineers with heavy plant are being employed.

"Earthquake Damage Repair in Montana." A brief note with illustrations of the emergency work carried out to deal with the effects of the severe earthquake which occurred on 17 August 1959 in Montana. The note includes an interesting account of the cutting of a spillway to relieve the pressure on an earthquake made dam across the Madison River.

"Military Missiles and Rockets" by M. K. Lutz. This completes the series started in the September–October 1959 number of the *Military Engineer* and is, in effect, an illustrated catalogue of the surface to air, surface to surface, air to air and air to surface missiles and rockets now available to, or under development for, the United States Navy.

"Hydraulics Through the Ages" by Captain C. J. Merdinger, Civil Engineer Corps, US Navy. This article consists of Parts III and IV of the paper begun in the last number. A history of the development of the means of using water power and the progress of design and construction of harbours from the earliest times until the present day is of considerable historical interest.

"Engineers in the Sayre Highway Operation Mindanao" by Kenneth J. Deacon. An account of a rapid advance across difficult country with numerous destroyed bridges. A good example of the indispensability of engineers with a *Get on* mentality.

"Terrain Intelligence for the Pentomic Army" by Clifton A. Blackburn Jnr. A note on the problem of providing the necessary topographical information for emergency airborne forces in advance of the need arising, and the part to be played by the engineers in the task.

"Professional Men in the Field Army" by Lieut-Colonel Joseph I. Gurfein, Corps of Engineers. An eloquent plea for a recognition of the importance of professional men, by which is meant men with good technical qualifications of all kinds, engineers, doctors, lawyers, etc in the army in modern war and a recommendation that the educational policy of the country should take account of this fact.

"Mont Blanc Tunnel" by F. C. Livingstone. A condensed account, with illustrations, of the design, method of drilling, etc and administration of the cutting of this tunnel, expected to be completed in 1961, which will not only make a big reduction in the road distance between France and Italy but will remain open throughout the year.

"Surveys and Maps" (Current Surveying and Mapping News). This contains an interesting note on the problem of differentiating between nuclear underground explosions and natural earthquakes by the existing means of seismic detection.

"News and Comment". There are interesting notes on a new cross country vehicle, "*The Goer*" and on a method of cutting any thickness of reinforced concrete by means of a tool called a "*Lance*". A special mixture of iron and aluminium powder is burned in a stream of high purity oxygen creating an intensely hot reaction that melts both ferrous and non-ferrous material in its path.

E.R.D.L. notes contain a reference to a new chemical compound that is twice as effective as any other extinguishing agent against liquid fuel and electric fires. Mixed with helium or nitrogen it creates a combustion free atmosphere in which dangerous tasks can be done with safety.

J.S.W.S.

Correspondence

British Joint Services Mission,
Washington, D.C.
21 December, 1959

The Editor,
RE Journal.

Dear Sir,

Captain Knowles' article on "Loading and Unloading", and Colonel Shepherd's follow-up letter, are undoubtedly true in so far as they make the (not surprising) point that basic sapper training plus port experience make a useful stevedoring unit.

What is not mentioned, and thus may be overlooked, is the less obvious point that untrained (but fit) men of any arm can be used as stevedores to alleviate the usual shortage of trained port operating personnel.

This is done by diluting the port operating troops' hatch gangs by untrained men, so that a diluted gang is based on a hatchwayman, two winchmen, and at least two men in the hold, who are all trained stevedores. These are supplemented by untrained holdsmen, the number depending on the nature of the cargo and the need for dilution. Obviously the more trained stevedores who can be allotted to a hold the better, but the minimum requirement of trained men per gang is thus five. One port operating squadron so diluted can take on the work of two.

Therefore, assuming that all the trained stevedores are in fact up to their trade, dilution is a more economical way of expanding the capacity of a port operating unit than is the use of entire field sapper units which have been expensively trained to carry out other important technical tasks.

I am not suggesting that port operating units should be permanently organized to include untrained labour; the possible disadvantages of dilution are self-evident, and it is sometimes unwelcome on "political" grounds, but it is a useful card up one's sleeve which can be produced when necessary.

That dilution does work has been demonstrated from time to time; the best example I know is the Scottish TA Exercise "Winch" at Zeebrugge in 1954, in which two very diluted and under-strength port operating squadrons (one AER and one TA) discharged to craft seven ships containing some 7,000 tons of cargo and 150 vehicles during one week of their summer camp. In this case TA infantry battalions provided the dilutees.

The main transportation lesson confirmed by this exercise was that port operating units must be so well trained in peacetime that they can accept dilution at the outset of a war. Dilutees can usually learn on the job; the professionals must be trained already.

Yours faithfully,

R. J. Wade, Lieut-Colonel, RE.

Oriel College,
Oxford.
10 December 1959

The Editor,
RE Journal.

Dear Sir,

The Employment of Sapper Officers in Movements

Who can explain why the Royal Engineers became embroiled in Movements? Let me try. In the South African War there was a movements muddle which so upset the Royal Engineer Railway troops that a Directorate of Railway Traffic was formed largely from railway trained Sapper officers, to sort it out. In the First World War there was also a movements muddle and a special Directorate again had to be formed, headed by a senior civilian railway man and including several regular Sapper officers. The Sappers came into World War Two a little earlier, in fact as far back as the sending of two battalions to the Saar Plebiscite in 1935, when the Movements Branch of the War Office said that, although they knew all about long sea trooping, they knew nothing about ferrying two units across the Channel and through France; a rash staff captain in the Transportation Directorate said that he knew all about it; he did not, but he set up a small organization of Sapper officers who worked it out somehow or other. From that moment onwards the connexion between the Corps and Movements grew stronger, and many of the senior staff officers in Movements during the war were of course Sappers, both Regulars and Supplementary Reservists.

So much for the historical reasons, but there are other good reasons also. The Sapper officer is by training something of a hybrid and, therefore, used to wearing several hats at the same time, which as Lieut-Colonel Thackeray observed, is one of the features of Movements. Furthermore, the best engineers are those who can arrange for men and materials to be at the right place at the right time.

Yours faithfully,
R. E. BAGNALL-WILD, Brigadier (retd).

Major-General B. K. Young, CBE, MC
2 Mount Pleasant,
Guildford, Surrey.
29 December 1959.

The Editor,
RE Journal.

Dear Sir,

I was delighted to see the Historical Note about the 101 (London) Fd Engr Regt (TA) by its Hon Colonel in the *RE Journal* for December 1959.

As Colonel Mais rightly states, the 60th Division was formed in 1915 as the second line TA unit to the 47thDivision; I am sorry to see, though, that he dismisses the 60th Division's war service as "overseas in Palestine and the Middle East". I should not like to see such a mis-statement go down to posterity as an historical fact.

From March 1916 to April 1918 I was Adjutant to the 60th Divisional Engineers. The Division went over to France in June 1916, to the Vimy Ridge, and from there it moved into the Somme Battle; of this it saw but little since it was suddenly withdrawn from the front and sent off to Salonica in November 1916. I think we were all glad to leave the latter theatre of war and welcomed the move, in June 1917, to Egypt and thence to Palestine where the Division took a notable part in Allenby's victorious campaign which knocked the Turks out of the war.

As a result of the German offensive in France in March 1918 the 60th Division was mulcted of several complete units which were sent to France, their place being taken by Indian units. Whether one or any of the Field Coys were whisked away in this manner I cannot say since I had already left, but their war diaries should be able to clear up that point. The 60th Division ceased to exist some time in 1919 and has never been reformed.

It may be of interest to add that in France we were on the normal War Establishment with Wheeled Transport, but that the establishments for Salonica and Palestine were both considerably different though both involved pack transport—mules for Salonica and camels for Palestine.

Finally I must add how very real and valuable was the *esprit de corps* displayed by the 60th Divisional Engineers, first as Londoners and then as Territorials. The 101 (London) Fd Engr Regt can well be proud of those men who with the 47th Divisional Engineers and the Reserve Unit at Esher are indeed their ancestors.

Yours truly,
B. K. YOUNG.

Ten Watchbell Street,
Rye,
Sussex.
15 January 1960.

The Editor,
RE Journal.

Dear Sir,

After reading the review of the book by Magnus on Kitchener in the June *Journal* I recalled a little incident that has stuck in my memory.

In the summer of 1896 three very junior YO's, while doing the musketry course at Gravesend, took the opportunity one day after an early "shoot" to go up to town for a spot of amusement. We were dining at the "Cri" and about halfway through dinner the wine waiter came to our table and said: "Excuse me, gentlemen, but do you come from the RE Mess at Chatham?" I suppose he had overheard our conversation. After we had told him that he guessed right he went on to tell us that he had been head waiter in the mess, and spoke of various officers who had been there. He then said "and would you believe it, the young officers who always came in to breakfast about 9.25 were Mr Kitchener and Mr Chard".*

Yours faithfully,
E. G. Wace,
Brigadier General (retd)

*Later Lieut-Colonel J. R. M. Chard, VC, of Rorke's Drift fame.

1843 Pendozi Street,
Kelowna,
British Columbia,
Canada.
23 November 1959.

The Editor,
RE Journal.

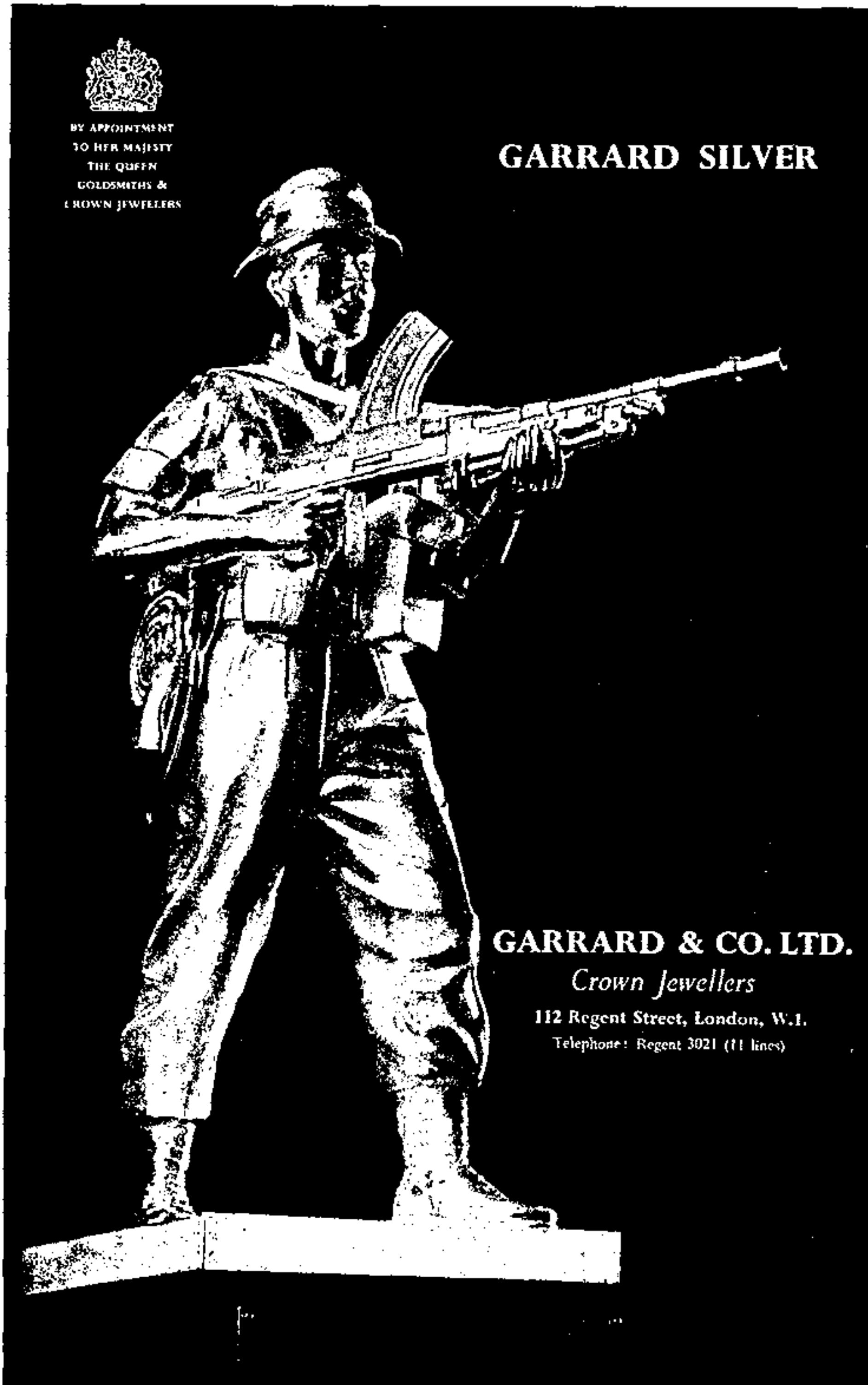
Dear Sir,

The interest of some of the older officers of the Corps will doubtless be stimulated by hearing that I had the extreme pleasure this past summer of being entertained in England by a number of that happy group who in the far-off days of 1910 to 1914 did so much to uphold the sporting traditions of the Corps in winning the Gibraltar Regimental and Subalterns Polo Tournament for three consecutive years and also the Royal Calpé Hunt Steeplechase for five consecutive years. The hospitality extended to me and my wife by Lieut-General Sir Philip Neame VC, Lieut-Colonel Sir Weston Cracroft-Amcotts, Major-General W. H. Oxley, Lieut-Colonels R. K. A. Macaulay and G. C. Campbell was beyond description and many hours were spent in recalling the pleasant days of long ago and also memories of Major-General Sir Richard Lee and Major-General Gerald Smythe who contributed so much to the RE successes during those years but who are unfortunately no longer with us.

If you think there is any value in the above you are welcome to put it in the *RE Journal* or the *Supplement*. I retired from the Corps in 1923 after serving for seventeen years, and have been living in Canada ever since. This was my first trip to England for over twenty-three years and I hadn't seen some of the above mentioned officers for about forty years. I think it is rather remarkable that so many of them are still in the land of the living after two wars and forty-five years.

Yours sincerely,
J. D. Gemmill, late Lieut-Colonel RE.

Note: Lieut-Colonel J. D. Gemmill, MC*, was first commissioned into the Corps 29 June 1906. He retired on 6 March 1923.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