THE ROYAL ENGINEERS JOURNAL—JUNE 1965 VOL LXXIX No 2

THE ROYAL ENGINEERS JOURNAL

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JUNE, 1965

Formation of the Royal Corps of Transport

On the 15th July the Royal Corps of Transport will be formed from an amalgamation of the Movement Control Service and the operating element of the Transportation Service of the Royal Engineers with the transport element of the Royal Army Service Corps.

The mechanical repair responsibility of the Transportation Service is to be transferred to the Royal Electrical and Mechanical Engineers whilst Port and Railway engineering remain with the Corps. Thus the long connexion of "Mov & Tn" with the Sappers comes to an end.

The Transportation Service first appeared officially in the British Army when the 8th Field Company RE was converted to a Railway Company in 1882 to take part in the first Sudan campaign, but the origins of Transportation go back long before that date. In the early part of the nineteenth century the 10th Pontoon Company operated in the role of the Army's first dockers, and in the Crimea both the 8th and the 10th Companies shared in the activities of the Land Transport Corps.

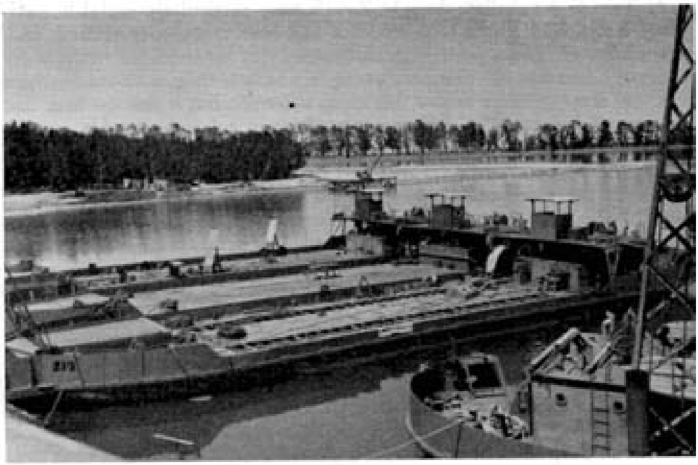
In World War I the railway and docks operating troops RE attained a strength of 2,800 officers and 66,000 men, and in World War II, with the addition of the Movement Control Service which was formed in 1938, these two branches of the Corps grew to a strength world-wide of 7,000 officers and 179,000 soldiers.

92 Regular officers, 107 Commissioned Short Service Officers and 1,100 soldiers will change their cap badges on 15th July 1965. We are sad to see them go but proud to know that they will be playing a vital part in the setting up of the new Corps. It has been the privilege of the Royal Engineers to develop and foster new ideas and activities arising from the natural growth of the Services, many of which have developed to the extent of calling for entirely separate organizations. Transportation and Movements are the latest to leave us, but we will have the satisfaction of knowing that their new Corps will be in many ways perpetuating our traditions.

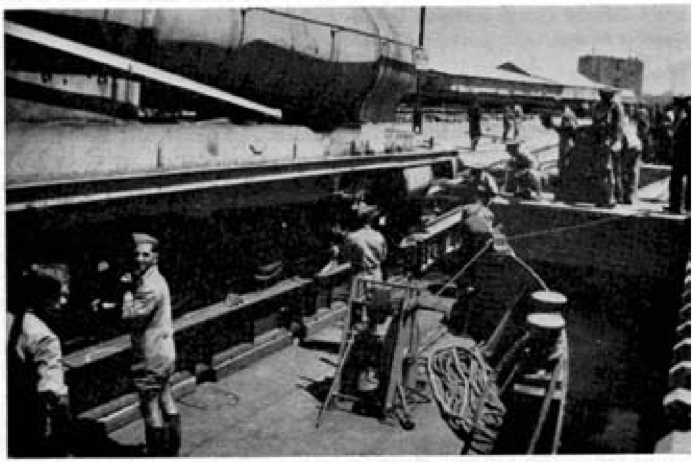
We wish those who are transferring every good fortune, and we shall look forward to a happy and close relationship between the Royal Engineers and the Royal Corps of Transport in the years to come.

G. W. Duke, Major-General,
Engineer-in-Chief (A).

1 June 1965



Type A Z-craft being fitted out at Ismalia.



Disembarking a 90-ton loco at Tripoli, Lebanon, 1942.

Z-Craft

Z-Craft

By Major-General Sir Eustace F. Tickell, KBE, CB, MC,
Col Comdt RE (rtd)

Origin

In July 1939, when General Wavell was appointed Commander-in-Chief, Middle East, one of the first tasks of his then very small staff was to investigate the possibility of a British landing in the Balkans, supposing war were to break out in Europe. It was obvious that a major problem would be the maintenance of an adequate force until the free use of a large port could be assured. What was required was some means of landing stores and vehicles on a shelving beach from ships standing offshore. This was peace time, but there did seem to be a definite military requirement for some form of ramped, shallow-draught, powered lighter that was able to reach the site, perhaps under tow—not for an assault landing, but for the much longer task of subsequent maintenance. No such craft were in existence, and as far as was known they had not even been thought of. LCT were to appear much later. Admittedly there was still at Malta one of the very large pontoons built for the projected operation against Ostend in 1917, but these had been designed to land troops and vehicles on a steep sea-wall and not a sandy beach.

In September, war broke out with Germany, and all efforts were concentrated upon the making of plans for the reception of reinforcements and for the construction of a base in Egypt and Palestine. The main port, Alexandria, was on the wrong side of the Delta, and the base would thus be dependent upon Suez, Port Said and Haifa. All were then of low capacity, especially the very small pilgrim port of Suez, which would become of great importance supposing that the Mediterranean were closed. The original plan was to moor ships at easily-constructed berths along the side of the Suez Canal, but this was vetoed by the Company Authorities through fear of the effects of bombing. They were, however, eventually persuaded to allow mooring at Firdan, where the Canal is wider, and this became the main landing-place for food-stuffs. It was now clear that the base would have to depend very largely upon lighterage from ships moored off shore at the ports and in the Bitter Lakes, and it seemed that this might be speeded up by the use of just the same craft as those required for a Balkan landing, which by then had been accepted as quite a possible long-term Middle East commitment.* A rash undertaking was, therefore, given to add a fleet of such craft to the then very slender stock of Transportation stores.

Thanks to the invaluable assistance of Lieut-Colonel L. W. Cole, a temporary RE officer with great experience of Egyptian waterways, a preliminary design and specification for a boat with the required characteristics was prepared, and arrangements made to build forty-four. These were to be called "Z-craft". The design was sent to India, where excellent detailed plans were made by Mr Eden Smith, the naval architect of the Hooghly Docking

* At the time, we had just started to build, while the going was good and with Turkish permission, a tee-headed pier and other facilities on the east side of the Gallipoli Peninsula. But we well knew, from experience at Mudros in 1915 and elsewhere, that the capacity of even several such piers might prove to be very disappointing. They provide inadequate stacking space—a shortcoming to be experienced years later with even the large Whale piers in Mulberry Harbour. The ship always beats the shore, and we were certain to want lighters.

Company. The components of the craft were to be fabricated in India and shipped to Egypt for assembly. Meanwhile, a large shipyard was constructed on Chevalier Island, near Ismailia, in the private garden of Baron de Bénoist, Agent Supérieur of the Suez Canal Company. The layout permitted fifteen to be assembled simultaneously and winched in succession to a central launching cradle. For some time the "Special Workshop, RE", formed for the work, was ill-equipped and desparately short of skilled manpower but, thanks to the enthusiasm of its Commanding Officer, Lieut-Colonel J. H. D. Bennett, now Brigadier J. H. D. Bennett, CBE, the first batch of forty-four Z-craft was successfully completed. This work was described by him in the *RE Journal* of March 1954. It involved *inter alia* the closing of more than two million $\frac{3}{4}$-in rivets.

Description

The first Z-craft (Type A) were 135 ft long (excluding the ramp), with a 30-ft beam, and had a draught of two feet forward and four feet aft, with a two-foot freeboard. The bottom slope was 1 in 50. The flat deck, the size of a tennis court, had 18-in coamings, but these could be hinged down or removed to facilitate cargo-handling over the side. There was accommodation below the poop-deck for a native crew of eight. The twin 98-hp diesel engines, which could be directly controlled from the wheel-house, drove 18-in propellors giving a speed of 8 knots. The craft were not intended for assault purposes, but the coamings and wheel-house were bullet-proof. There was also provision for a platform for mounting two guns, but this was always omitted (there were no guns). A 10 kW generating-set provided power for the pumps, lighting and degaussing. On the deck the craft could carry either 180 tons of stores, six Valentine tanks, ten lorries or 450 men, or below deck 150 tons of water (or bulk petrol, after special preparation). They would tow at 14 knots in calm water, but in a sea-way the steering gave trouble. This was very disappointing, but in practice the defect turned out to be not very serious, for we found that they could carry out quite long voyages under their own power in moderate seas. For this we had to thank the skill and courage of their excellent Indian crews (Hooghly watermen), who took enormous pride in their strange looking ships, and kept them beautifully.

Because of the special conditions under which we envisaged that a Z-craft would be used, it was possible to give her landing characteristics on either steep or shelving beaches that I believe have never been equalled in any other craft of her size. The inexorable geometry of flat-beach working often compels a boat drawing six feet aft to discharge down a very steep ramp into five feet of water, 200 yds from the shore, and this water-gap may be increased considerably by a quite small and invisible sand-bank. Such a performance did not meet our requirements, and, in spite of some raised eyebrows, the draught was reduced, but of course at the expense of hull-stiffness, propeller immersion, resistance to beam winds and general sea-going qualities.

The LCT (1), the first British landing craft, other than the very small LCA and LCM, was being designed at home at the same time. She drew 3 ft 6 in forward and more than 6 ft aft, with a bottom slope of 1 in 30 but, with her high sides, she was of course more sea-worthy. British shipbuilding was more speedy than the combined efforts of India and Ismailia, with the result that the first twenty-three were sent to Egypt so as to be operational some months before the launching of Z1. They were in time for Greece and

Crete, where the majority were unfortunately lost. The next to arrive were the LCT (2). They were slightly bigger and were destined to perform great service in spite of their rather unsatisfactory engines. Those that followed drew nearly four feet forward and more than seven aft.

The Type A Z-craft were found to be so useful that a second batch of forty-four was ordered to a modified design, but there was considerable delay in the arrival of the components. These Type B craft were of the same dimensions, but had a more easily assembled hull, more powerful engines giving 10 knots, a shorter ramp to carry the new and heavier tanks, accommodation for a European crew of ten, and other improvements.

The Egyptian Ports

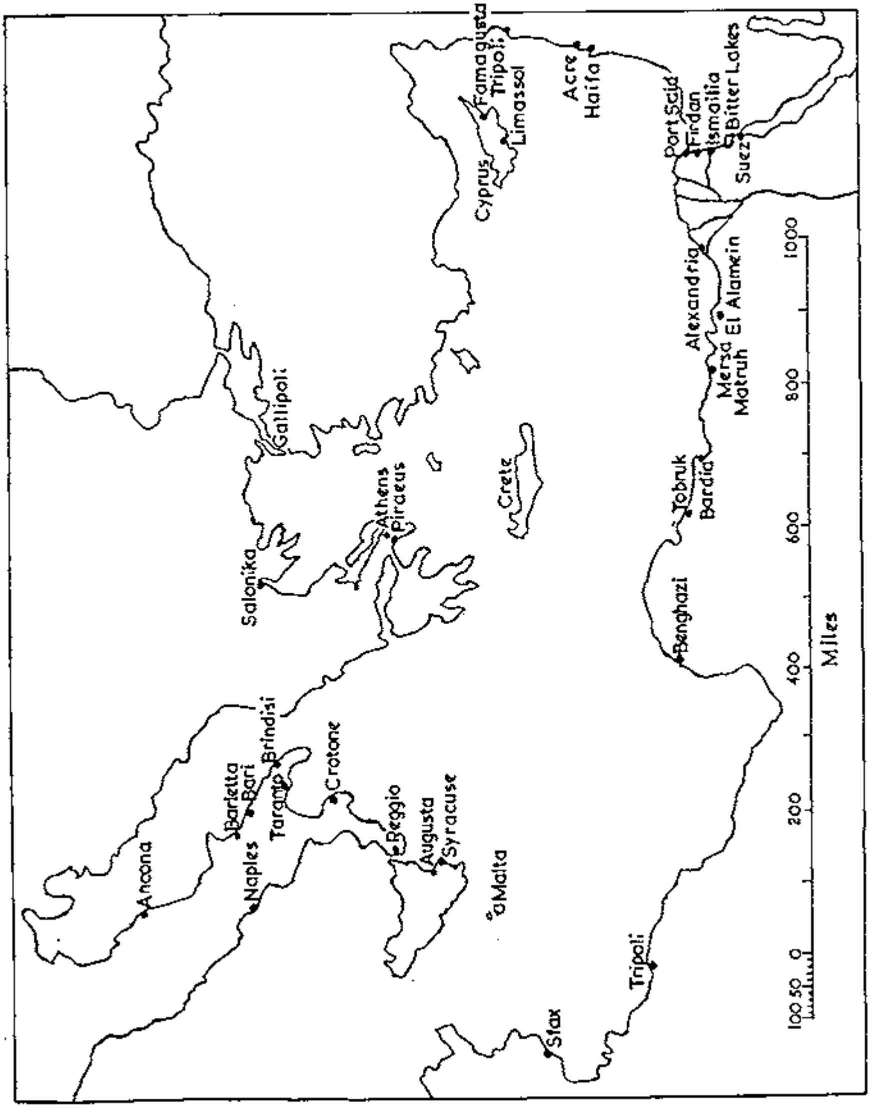
Both during and after the war, Z-craft were used extensively in the Canal Zone, particularly for the discharge of personnel, tanks and vehicles, but they were found to be very suitable for every type of cargo, including awkward loads. Their unencumbered decks were very simple to plumb with ships' derricks, and they were quick and easy to discharge. Their landing sites required little or no work, and were very different from the berths with at least eight feet of water, more than 3 miles of which had eventually to be constructed for other types of lighter. By the end of the war Z-craft had been responsible for landing half-a-million tons, and had achieved some remarkable daily figures.

They were also used for many unusual tasks, such as laying torpedo-nets in the Bitter Lakes and for lifting mines from the Canal. They helped to erect the huge removable net that was spread each night over a particularly vulnerable twelve-mile length of the Canal to indicate where magnetic mines had been dropped. Owing to a slight misunderstanding with the net operators, one Z-craft had to spend the night inside, well and truly snarled up. Z-craft on occasion had the honour of watering the *Queen Mary* and *Queen Elizabeth* in Suez Bay, and since the war have landed royalty at Port Said.

A Z-craft, fitted with rails laid on heavy girders, landed eighteen 90-ton locomotives at Tripoli (Lebanon) to operate the rail-link then under construction between there and Haifa. They were lowered from a ship equipped with powerful derricks, and were discharged via a 32-ft ramp hinged to a special railway spur. Although the ship was anchored a mile from shore, each round trip took less than an hour and half. The operation was to be repeated later at Benghazi for the opening of the Benghazi-Soluk railway, and again in Italy.

The Western Desert

During the siege of Tobruk a few Z-craft were sailed to Mersa Matruh for discharge of water, stores and vehicles, and after the relief two were moved up to Tobruk itself, but were unfortunately sunk by gun-fire while trying to escape when the port was later captured by Rommel. During the advance of the Eighth Army from El Alamein they were used on a larger scale to supplement the naval LCT. They made the long winter passages under their own steam, and even after the 450-mile voyage from Benghazi to Tripoli in rough weather were spick and span and at work within a few hours. In early January 1943, during the serious storm which carried away most of the mole at Benghazi, the thirteen Z-craft in the harbour came to no harm. This was a great credit to their crews, for all the large ships, eight of the seventeen LCT



Ancona
Naples
Barletta
Bari
Taranto
Brindisi
Crotone
Reggio
Augusta
Syracuse
Malta
Sfax
Tripoli
Salonika
Gallipoli
Athens
Piraeus
Crete
Benghazi
Tobruk
Bardia
Mersa Matruh
Alexandria
El Alamein
Cyprus
Famagusta
Limassol
Tripoli
Acre
Haifa
Port Said
Firdan
Ismailia
Bitter Lakes
Suez
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and all the LCM were severely damaged, three of the ships and some of the naval craft being a total loss. There is an Eighth Army story that one of these Z-craft had sailed gaily into Bardia before the town was fully in our hands.

At Tripoli the shallow-draught Z-craft were particularly useful in navigating the blocked entrance before this had been completely cleared, and, even when ships could get in, they discharged very big tonnages on the badly damaged quays. On one occasion, owing to a broken sling, a 40-ton Sherman tank was dropped some twelve feet on to a Z-craft, but it was the tank that went to workshops. The deck was plated up in a few hours. On another occasion, in the then very congested harbour a cargo ship loaded with RAF bombs and drummed aviation spirit became immobilized by a serious fire in her engine-room. When flames began to appear above deck she was given a widish berth, but a Z-craft promptly came alongside, and using her own pumps and tanks, put out the fire unaided. Her action was cited in Eighth Army Orders and recorded in her crews' papers.

At the end of the campaign there were six Z-craft working at Benghazi (landing mainly petrol and materials for the strategic airfields), fourteen at Tripoli and four at Sfax, 1,400 miles from Port Said. One had been lost through bombing while unloading petrol at Tobruk, and another while on the same task at Benghazi.

In a Combined Services report upon sea-maintenance during the campaign, it is stated that they "had without question proved to be the most efficient all-purpose craft used in the captured ports". After explaining their advantages compared with the LCT for this special purpose, the report asserts that "without their use the tonnages achieved would have been impossible". This view is shared by General the Lord Robertson of Oakbridge, GCB, GBE, KCMG, KCVO, DSO, MC, Col Comdt RE (retd), who was then responsible for the maintenance of the Eighth Army. The Official History of "Movements" during the war records that in the Desert ports "they saved the situation repeatedly", and I think that there can be no doubt that the Z-craft crews at Tripoli were doing their share when the Prime Minister cabled "You are unloading history".

Sicily and Italy

For the Sicily invasion the Western Desert Z-craft crossed the Mediterranean under their own power, carrying guns and lorries, including RAF "Queen Mary" transporters. Two had Bofors guns bolted to the deck and manned. They discharged their cargoes, and worked for a time on the beaches, but as soon as Syracuse, and later Augusta, were in our hands, they were used in the harbours for many purposes including the landing of awkward loads and water, and for the evacuation of wounded. For the invasion of Italy they ferried men and vehicles across the Straits to Reggio, were used at Crolone and then for the landing of the New Zealand Division at Taranto. On the capture of Naples they were found invaluable in the extremely badly damaged port, and eight remained there for several months at the urgent request of the American Engineers when they took over responsibility for the western seaboard. The other Z-craft worked on the Adriatic side at Brindizi, Bari, Barletta and finally at Ancona. One had been lost through bombing at Naples and another had been blown ashore in a sudden squall off Taranto.

Thus ended their war service against the Germans, but they had shown that under Mediterranean conditions their unconventional design had fulfilled its purpose, and, contrary to the expectations of many, they had always "got there". We had, however, made one big mistake—our initial order had been far too small. In mitigation it might be pleaded that at the time a Z-craft merely consisted of some blue-prints of what looked like a sea-going tea-tray, and some pages of figures that indicated that she would float, perhaps even (as we hoped) with her nose up and tail down. (Incidentally, her reasons for so doing are not obvious at first sight.) There had also been the question of engines, almost certain to involve a dollar commitment then strictly forbidden.

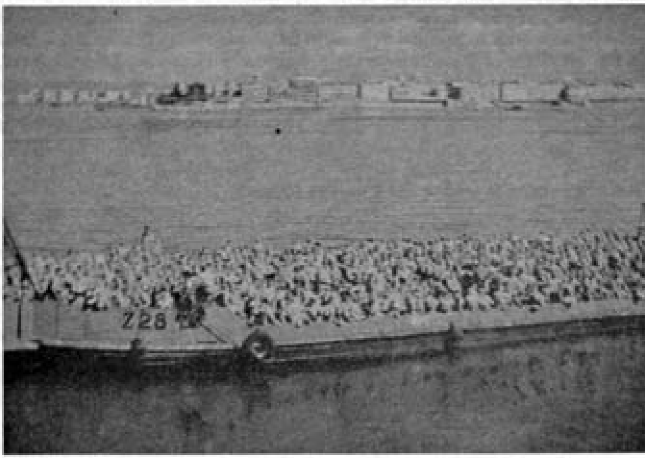
The Far East

After the Sicily landings work in the Egyptian ports declined, and as many Z-craft as possible were transferred to India for use in the Burma campaign. Fourteen were specially strengthened at Ismailia for towage in pairs, one on each quarter of an ocean-going ship, and they reached Calcutta without serious difficulty. They did not of course meet demands, and a further fifty-four were fabricated at Ismailia from virgin steelplate and sections complete with strengthening gear, and shipped to India for assembly. Arrangements for this were made at Fort Gloster (south of Calcutta), Blaunagar (north of Bombay) and at Karachi, but before the programme could be fully completed hostilities came to an end.

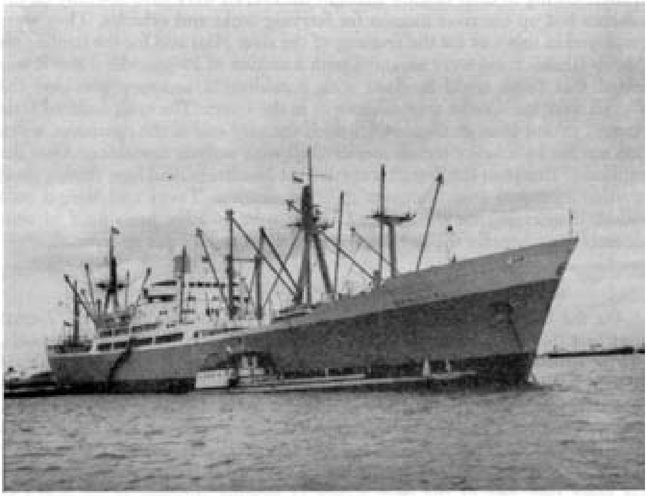
The first few of these craft to become available were used during the autumn of 1944 at Chittagong for the discharge of troops and vehicles. The number soon rose to ten which were included in the strange collection of boats forming No 4 IWT Group, employed with naval LCT for the sea-maintenance of the troops taking part in the reconquest of the Arakan that winter. Owing to their shallow draught the Z-craft were used not only on the beaches but up the river mouths for ferrying tanks and vehicles. They were employed in this way for the crossing of the river Naaf and for the landing on Akyab Island. Some were mounted with a section of 25-pounders, and it was found that these could be fired with considerable accuracy provided the Z-craft were anchored either offshore or in the rivers. The craft suffered little damage except from small-arms fire until the very end of the operation, when one was hit by a heavy trench mortar-shell with serious casualties. After the capture of Rangoon the Z-craft were used at Moulmein, and later during good weather operated from Rangoon to as far south as Tavoy and Mergui (600 miles), discharging on the beaches. They were to have been used in considerable numbers for the re-conquest of Malaya, but VJ day intervened.

Post-war in the Middle East

On the German withdrawal from Greece in the autumn of 1944, Z-craft were sent there to help in the maintenance, through very badly damaged ports, of the British force under General Scobie, now Lieut-General Sir Ronald Scobie, KBE, CB, MC, Col Comdt RE (rtd). It was a Z-craft that landed the first Red Cross supplies of grain at Piraeus for the half-starved Athenians. She was met on the quay by the complete Greek Cabinet, the British Ambassador and the GOC. Z-craft worked intermittently during the civil war that was soon to break out, and when peace was at last restored, they were for some time one of the only means of landing supplies as far north as Salonica, owing to the widespread sabotage carried out by the rebels.



New Zealand Division landing at Taranto, 1943.



Unloading ammunition, Singapore, 1960.

Z-Craft 3,4

The Middle East Z-craft, who now had British crews often commanded by quite junior NCOs, continued to work in the Canal Zone, with detachments at Limasol, Famagusta, Haifa, Tobruk and Benghazi, and were used extensively at Port Said during the troubles in 1951. When we withdrew from Egypt in 1955 they were based on Tobruk, where a repair slip-way was built. By 1956 their numbers had been reduced to thirty, mostly by sale to civilian firms. Of these there still remain, but re-numbered, three in Cyprus, two each at Tobruk, Aden and Bahrein, and one (*Zara*) used for training purposes at Marchwood. The voyages down the Red Sea and across the Bay of Biscay were not devoid of incident. There are also still two at Singapore, referred to below.

During the twenty years since the war Z-craft have had many adventures, but there is no space to mention more than a few. During the last two years of the British Palestine mandate that ended in 1948 it was necessary to limit the number of Jews who were pouring into the country, and the ships carrying "illegal immigrants" were intercepted at sea by the Navy and escorted to Cyprus. It was then the very sad and unenviable task of the Famagusta Z-craft to meet these ships and to land their woebegone and often truculent passengers, there to await vacancies in the quota. During the Arab-Israeli war that quickly followed the ending of the mandate, some 20,000 Arab refugees who had fled into Haifa were shipped by Z-craft to safety in Acre.

Owing to the lack of good harbours in Cyprus, the maintenance of our troops has always largely depended upon lighterage, and the Z-craft have had continually to work ships anchored three miles off shore in all weathers. They have landed VIPs, have carried bulk aviation spirit, have been found ideal for bathing parties, and two are even now engaged upon the construction of the mole for a small emergency harbour. On one occasion, while a Z-craft was taking on water in the very small harbour of Famagusta, a naval mine-sweeper was being towed out. Her tow-rope parted and she began to bear down on the boats moored at the quayside. The Z-craft commander (Staff-Sergeant Sinclair) promptly cast off, steamed into the rapidly closing gap and nosed off the mine-sweeper. He was awarded the BEM on the recommendation of her commander.

The Z-craft used at Port Said during the "Suez operation" in 1956 were to receive a special mention in the Task Force Commander's dispatch. Four were sent from Cyprus and four from Tobruk, the latter being tow-assisted by the Navy in order to reduce the time of passage. Two of these were damaged in the heavy seas, and had to be cast off, but repairs were carried out under very difficult conditions and they completed the voyage under their own power. There is no doubt that without Z-craft, working very long hours, the build-up would have been extremely difficult, because blockships in the fairway prevented LST etc from reaching the quays, and personnel, vehicles and stores had to be ferried from the outer harbour. Her shallow draught enabled one Z-craft to carry a party of troops along the canal west of the port for the rescue of some prisoners being held captive in a school building. On the British withdrawal, two Z-craft under a subaltern were left behind to assist in the clearance of the Canal. Their crews wore plain clothes under the United Nation's flag. One of these flags is now at Longmoor. All eight Z-craft eventually reached Cyprus. But once again they met very rough winter weather.

During the 1958 rebellion in the Lebanon a Z-craft was hired to the

Z-craft "Zara" at Marchwood.

Z-craft building their own harbour at Neptune Haven, Cyprus, 1965.

Z-Craft 5 , 6

Lebanese navy, and was used for the rescue of government troops and vehicles cut off by the rebels. She was then fitted with a Bofors gun forward and a Sherman tank aft, both welded to the deck, and had great fun sailing up and down the coast shelling rebel positions.

The Z-craft at Aden have been in continuous use for the maintenance of our small garrisons along the thousand miles of South Arabian coast, whose coral reefs keep shipping two miles off shore.

Post-War in the Far East

The fate of the sixty-eight Z-craft sent from Egypt to India in 1944 is now impossible to trace. Some were used by the Army for some time at Penang and Singapore and the others were apparently sold as war surplus. A few are still at work in the Hooghly, and two were used for many years as ferries between Penang Island and mainland. In 1956 there was one, red with rust, moored in the Great Lake in Cambodia, 150 miles up the Mekong River, but how or why she got there remains a mystery. In 1946 quantities of dangerous Japanese ammunition were towed out to sea in lighters, which were then sunk. When there were no more lighters the ammunition was dumped from the decks of Z-craft, one of which was unfortunately blown up with heavy casualties.

In 1955 the need was again felt for Z-craft at Singapore, and four, of which two still remain, were towed from the Mediterranean. It was lucky that they had been heavily strengthened and were unmanned, for they had a very rough passage indeed. They have since been in constant use on normal and extra-mural duties. They have salvaged sunken boats and aircraft, lifted large rocks and been hired to civilian firms for dredging operations and for the movement of heavy plant, including that used for the construction of the Shell oil refinery. They have also been hired for recreational training and to youth clubs etc for week-end visits to the off-shore islands. For this purpose they usually had a large marquee erected over the deck—unseamanlike, but very gay. Even gayer, however, was the Z-craft moored in the middle of the Straits as the platform for the stupendous firework display to celebrate the coronation of the Sultan of Johore in 1960.

Envoi

In their time, Z-craft have earned the wildest of epithets, ranging from—"One of the outstanding successes of the war" down to "The damned thing. She'll fall in two", but in fact they have done just (sometimes only just) what they were meant to do—a rather dull, but useful job. They were well-built well-engined and even more important have always been well manned. Some have had their moments and some have chugged along for nearly a quarter of a century. It is rather sad that the blue ensign, with its Sapper thunderbolt, is to be hauled down, for they have been very Sapper ships. Long may they sail under their new colours.

Presentation to M.E.X.E.

DURING a visit to the Research and Development Establishment (Engineers) at Dighi, Poona, on 29 September, 1964, the Director, MEXE (Brigadier H. A. T. Jarrett-Kerr) was presented with a silver centre-piece for the Officers' Mess, MEXE, by Brigadier M. N. Patel, the Director of the R & DE (Engrs).

The piece is a model of a semi-cylindrical hut developed for high altitudes, consisting of telescopic tubular frames, covered with fabric, and lined with insulating material. This hut was the first development project to be completed after the formation of the Establishment.

Presentation to MEXE

"Eighty Minutes to Spare"

By MAJOR M. D. KING, RE, AMI PLANT E

INTRODUCTION

IN 1962 a permanent MRT airstrip was planned by the Air Ministry Works Department to provide a greater degree of flexibility of communications between the two Sovereign Base Areas in Cyprus. The strip was planned to be 3,000 ft long in the first instance, but with the capability of being extended to 6,000 ft at a later date. The cost of the complete airstrip, which was to be placed out to civilian contract, was in the order of £125,000. In 1963, owing to the expense, the Air Ministry decided to shelve the project.

With the onset of the new Cyprus emergency early in 1964, however, flexibility of communications between the Bases became increasingly more important, particularly as it appeared possible that service families in the Famagusta and Larnaca dormitory towns might have to be evacuated in a hurry. The feasibility of building an emergency Beverley airstrip quickly, using resources within Cyprus, was therefore examined and an outline plan was drawn up by the Royal Engineers, Cyprus based on the minimum criteria for Beverleys provided by HQ Near East Air Force. Because of the urgency of the project, no allowances of time were made for unforeseen contingencies, and the estimate of twenty-one days to complete gave no leeway at all.

Eighty Minutes to Spare

Planning

The time scale for planning and execution of the work was as follows:—

(*a*) Requirement stated to the CRE at HQ NEAF at 1130 hrs on 2 March 1964.

(*b*) Preliminary recce carried out on the site of the original MRT strip the same afternoon.

(*c*) Detailed recce carried out by OC Cyprus Park Sqn RE on 3 March.

(*d*) Plan submitted to the CRE at 0930 hrs 5 March and discussed with HQ NEAF and MPBW the same day.

(*e*) Requisitioning of land started on 9 March, but was not completed until 24 March.

(*f*) Work began on site at 1200 hrs 24 March.

(*g*) Work completed, and first Beverley landed, at 1200 hrs 14 April 1964.

The requirement was given to the CRE by Group Capt (Ops) at Episkopi after one of the regular conferences at HQ British Forces Cyprus. The question was, simply, could an emergency Beverley airstrip be built at Dhekelia quickly enough, or indeed at all. The same afternoon a preliminary recce took place on the site of the originally planned permanent airstrip. The ground here (photo 1) was partly of growing barley, but largely of outcropping limestone with shallow pockets of coarse topsoil, sufficient only to sustain thorns and weeds. Difficulty was likely to be found in any excavation necessary because of the hardness of the rock skin, and this would probably mean considerably more fill than in the original plan.

The previous year tests had been carried out, using heavy rooters, to try and break up the caprock which protected the softer limestone underneath. These tests had been abortive; the rooter's tines failed to dig into the rock skin and obtain a purchase. Even with added weights on the rooter no worthwhile results had been obtained. Since these tests, however, we had received in Cyprus a D8H, and it seemed possible that the added weight and power of this machine might succeed where the rooters had failed. A test soon showed that this was true, although it would be a difficult job as the cap was almost as hard as concrete. Nevertheless the decision was taken to go ahead and plan.

The AMWD scheme had visualized equal areas of cut and fill, with a continuous fall of 1 in 125 from West to East. The maximum permissable gradient (Appendix A) was 1 in 50 and allowed undulation provided the rate of gradient did not exceed 0.25 per cent. The profile of the chosen alignment (which was in fact the only suitable site in the Sovereign Base Area) showed one hump at the Western end and another at the half-way mark with a dip between the two, and a bigger dip still near the eastern end. Allowing only for minor excavation of the highest outcrops, the fill needed would vary from a 15 in minimum to over 5 ft at the big dip, but the resultant surface, although within the required limits, would rise and fall like the back of a Chinese dragon and we would need at least 40,000 cu yds of fill.

The material to be used for the fill was "havara". This is a soft, limestone rock, heavy in gravel content, which is generally easily quarried with standard field equipment. Its most miraculous property is its ability to settle quickly without compaction, and with the addition of water and surface rolling only, to set like concrete. Such a material would need no surfacing for an airstrip only required to be in operational use for thirty days. Several quarries existed in the area, mostly of inferior quality, but one of excellent havara had been found a few weeks earlier less than two miles away, and should hold sufficient for our needs. The limiting factors were likely to be the availability of quarrying plant, space in the quarry for both these and the tippers in the first instance, and then the number of tippers available for the task in the later stages when the quarry had been properly opened up. Shortages of other plant were not likely to worry us provided that we did not have too many breakdowns. In the event this proved to be a poor assumption, as stoppages became so frequent that too much time was wasted through machines being off the road. As a result almost all the available machines had to be used, and there were few, if any, reserves left by the time the job was done. A further factor, not appreciated at this time, was the lack of robustness of most types of tipper used, and the consequent heavy repair bill incurred by them.

Specification

The specification (Appendix A) for a thirty-day emergency MRT strip for Beverleys calls for a 3,000 ft long and 75 ft wide runway with 300 ft over-runs at each end. Turning circles 75 ft radius are required at both ends, together with an entrance road and aircraft parking space. Each side of the runway needs to be clear for 90 ft and must not fall at more than 1:10 (later changed to 1:50). The longitudinal gradient must not be greater than 1:50 and the soil strength not less than a California Bearing Ratio of 10.

We wanted, if at all possible, to improve on the minimum and give better results than those asked for. The main improvements we wished to make were in the width of the runway (120 ft), a larger turning circle (85 ft), and considerably flatter longitudinal gradients. This would mean an increase in fill, however, to over 60,000 cu yds, a not inconsiderable task.

Plan

Our plan was essentially a simple one. It involved removing caprock and topsoil over an area of 3,600 by 300 ft. Havara had to be quarried at a rate of some 3,000 cu yds per day, carried an average of 1¾ miles, and dumped. It then needed spreading, grading, watering and compacting to 6 in below the finished surface. The final layer would then be added, graded, watered and rolled. As a sideline to the main task, three pipelines had to be laid across the strip, two of which were needed to carry irrigation water, and one for telephone lines. In order to complete the task as soon as possible, we intended working a 12 hr day and a seven day week, and expected to finish in twenty-one days. The urgency of the situation allowed us none of the usual Sapper reserve—the little bit of time up our sleeves for emergencies—and we firmly committed ourselves to the twenty-one day limit, albeit with some trepidation.

Engineer Equipment

The available equipment was as follows:—

(*a*) Cyprus Park Squadron	Tractors (crawler)	Size I	2
		Size II	4 (*a*)
		Size IV	2
	Scrapers	8 cu yds	2
	Graders	12 ft	3 (*b*)

	Excavators	19RB	3
		BK 50	1 (*b*)
	Road Rollers	8/10 ton	5
	Dumpers	$4\frac{1}{2}$ cu yds	4
	Tippers	10 ton	5 (*c*)
		3 ton	2
	Cranes	as required	
	Compressors	as required	

Note: (*a*) 2 from Ordnance stockpile (*b*) 1 from stockpile (*c*) 3 from stockpile

(*b*) 33 Field Squadron	Tractors medium wheeled (Gainsborough)		2 (*d*)
	light wheeled (Michigan)		3 (*d*)
	Tippers	3 ton	2
	Water bowsers	100 gallons	1

Note (*d*) one fitted with excavator bucket

(*c*) MPBW and RAF/ACB	Tractor (crawler)	Size I	1
	Excavator	Smith & Rodley 520	1
	Road Roller	8 ton	1
	Tippers	10 ton	5
		7 ton	5
		3 ton	4
	Water bowsers	300 gallons	1

Of the tractors, a size II and size IV were still working in the Troodos Mountains (but on twenty-four hours notice to return), and other calls on the medium and light wheeled tractors of 33 Field Squadron reduced the initial availability of these to two machines, one of which was fitted with a blade and the other a bucket. The MPBW (ex RAF) D8 unfortunately did not arrive until Day 7, and only worked for a few hours before breaking down completely. The second size IV—a Drott—was on a major overhaul in Command Workshops REME and was not ready for us until after the first had finally given in.

Two of the RB 19 excavators were rigged as face shovels, and the third, a dragline, was held as a reserve. This machine was only required to work on one day, after which it was (temporarily) cannibilized to keep the other excavators going. The lorry mounted BK50 was a stockpile equipment, which we obtained at short notice on Day 11 to act as reserve when the ex RAF Smith & Rodley 520 excavator, which arrived on Day 10, had proved ineffective.

Thus of the twelve tractors theoretically available for dozing duties, we really had the use of only eight at the outset, and of the seven excavators on the list we were only able to use three together in the first instance in the quarry, though for some periods later on we kept four, and on one occasion five, loading points going. For each loading point, a dozer was needed to feed the excavators and keep them fully occupied with loading rather than excavating.

The initial distribution of plant was to be as follows:—

	Airstrip		*Quarry*
Size I	D8H	caprock clearance	RB 19 & Fowler
Size I	Vickers Vigor		RB 19 & Fowler
Size II	Fowler & Scraper	topsoil removal	Michigan (bucket) &
Size II	Fowler & Scraper		Gainsborough

Size IV	Drott	spreading havara RB 19 (dragline)—reserve

Load Carrying

Tippers	10 ton	10
	7 ton	5
	3 ton	8
Dumpers	4½ cu yds	4

RESPONSIBILITIES

The task was divided into areas of responsibility, each under an NCO, with the Park Squadron Commander and the Military Plant Foreman exercising overall control. These areas were:

Quarry—	excavation	Plant Sgt
	control of tipper loading	MT Sgt
Airstrip—	site control	S/Sgt
	tipping havara	S/Sgt
	pipelines	Sgt
	servicing	Fitter Cpl
	refuelling machines	MT Cpl
	repairs in unit workshop	Fitter Cpl and Veh Mech Cpl

The squadron MTO was in control of all tippers, including liaison with Command Workshops for repairs when needed, and the phasing in of relief drivers during the morning and afternoon breaks, to keep the machines loading and tippers moving unceasingly. The other two officers in the Squadron, the 2 i/c and the OIC Stores continued with their normal work, since the unit had to carry on functioning in the stores, workshops and administrative fields, mainly in support of the peace-keeping force.

LAND REQUISITION

Although we were ready to start work on the project as early as 5 March, nothing could be done until requisition of the land had been completed. This was expected to take only a week, but eventually was not finished until the 24 March. The land, although belonging to the Republic of Cyprus, lay within the boundaries of the Dhekelia Sovereign Base Area, and so became liable to requisition for military use under the terms of the Treaty. The political situation at this time was very delicate, and since it was our wish not to antagonise unnecessarily the local villagers who were farming the land, the proceedings took much longer than we had expected. Due to the political implications, we were unable to do anything at all on the ground, and no preparatory work of any kind was possible.

CONSTRUCTION

So it was that at 1200 hrs on 24 March, with a flourish of local publicity, and a scene reminiscent of the Wild West and "Wagons roll!", the total of thirty-one of all types of vehicles and machines which had assembled at a distance, started to move onto the site. The operation was on.

The first act was to "prove" the centre line, to show the local villagers that the requisition was a fact, and that we intended to go right through their

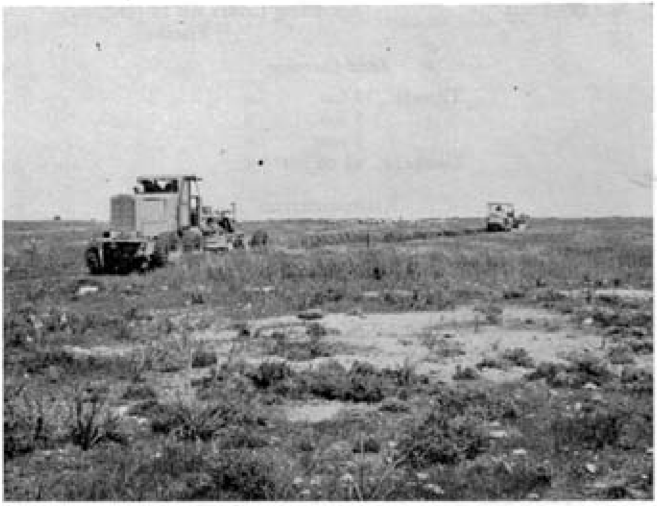


Photo 1. The D8H leads a grader through the barley to "prove" our right to build the airstrip. A small area of caprock can be seen in the foreground.

Photo 2. Early days in the quarry. The tippers are (from front) an ex-RAF 3 ton Bedford, an Army 10 ton AEC, and an ex-RAF 7 ton Bedford.

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barley (for which they were to get compensation) to the agreed limit. This was done by ceremoniously driving the D8H followed by a grader straight down the centre line and back again (photo 1). In the meantime three other tasks had begun. The first of these was marking out of the 240 yds long access road, which was to be 30 ft wide and 12 in deep. The first load of havara arrived at 1215 hrs and it is a measure of the speed with which the operation got under way that this road was completed in under 3 hrs! At the same time the Maintenance Area, with office, servicing trailer, POL point and flood-lighting was being set up, and the surveying of the centre and side lines had begun. By the end of the day topsoil had been cleared from the first barley field (500 ft) and work was in progress on the next 150 ft, across the width of the runway proper, and havara tipping had reached 80 ft along the strip at a depth of up to 2 ft. Our satisfaction at the way work had begun was rudely shattered next morning when torrential rain caused abandonment of work for the day shortly after 1000 hrs. Had the rain merely fallen steadily the work could have been carried on, but it was too heavy and would have bogged us down had we continued. Such bad weather at this time of year was completely unexpected and equally unwelcome. The loss of a day at this stage was a severe blow to our already tight schedule.

The next day was the first full day to be worked, and the pattern of the whole operation was set when one of the RB 19s fractured a fuel line, and two tippers went off with jammed hydraulics. Later in the day the second RB 19 broke a hoist rope and the Gainsborough developed fuel trouble. Several other tippers were off the road for short periods, though at this stage it was mainly due to the RASC drivers being unfamiliar with the ex-RAF vehicles. Nevertheless, progress was most satisfactory, havara tipping reaching 250 ft along the runway, and caprock and topsoil removal out to 1,400 ft.

The following day was Good Friday. By now everyone knew that the target was twenty-one days non-stop and none were keener than the young RASC drivers, many of whom on this and subsequent days appeared at the quarry up to 15 minutes before the official start time of 0630 hrs. By now, too, it was routine to announce the quantity of havara moved in the morning, afternoon, day, or best hour, and records (Appendix D) were set up and broken almost every day. There was no let-up; it was steady and continuous work that was producing results. Inevitably, considering the age of most of the plant and tippers, breakdowns began to occur more frequently. In particular the Fowler tractors were very old and began to shake to pieces, and all types of tipper except the ex-RAF 10 tonners sustained damage to the bodywork which soon resulted in jammed tailgates.

We now began to realize that the repair backing arranged was not going to cope with the influx of work for long, and that unless something drastic was done it would not be many days before construction came to a complete standstill. However, the support we received from Command Workshops REME to back up our own fitters and vehicle mechanics was magnificent. All paperwork was waived and a simple system took its place. A vehicle or machine was driven, carried or towed straight from the site to the repair shop concerned. With the highest priority (except for A vehicles), repairs were started at once and continued until completed. If the job was short the driver stayed, otherwise he was called back in time to take the vehicle straight from a modified "out" inspection and back on to the site. During the course of the operation it was a common occurrence to have six or more vehicles or

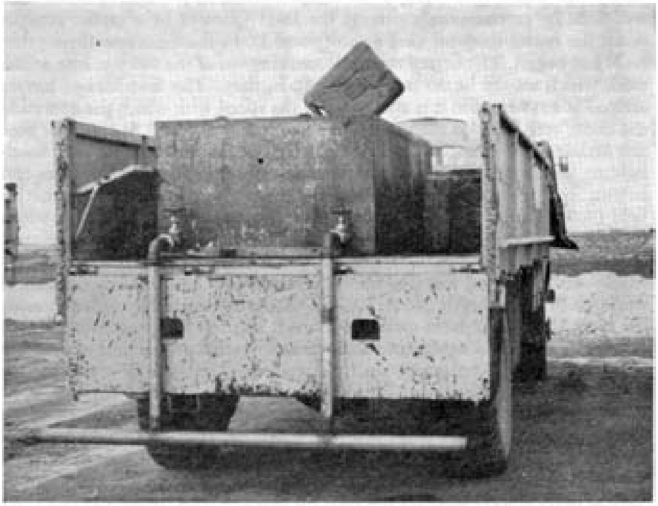

Photo 3. Improvized oil spraying bowser on a 3 ton vehicle.

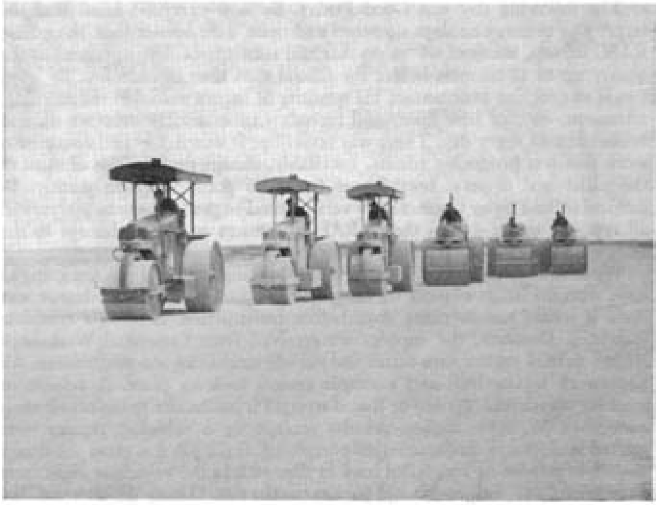

Photo 4. The rolling echelon.

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machines in Workshops at one time, and as many as twenty separate jobs listed in one day. Every tipper and dumper passed through at least twice before the end, mostly for body straightening and rehanging of tailgates, or for hydraulic faults.

Despite these troubles progress was good, and improved daily. By Easter Sunday we had reached 800 ft and by the Tuesday (Day 7) 1,600 ft, having put in exactly 4,000 cu yds the day before, and over 3,500 that day. By now we were through the first dip, and into the stretch of least fill. Here we streaked ahead—435, 465 and 460 ft on Days, 6, 7 and 8. As soon as we started getting into the really big dip, however, the distances covered dropped back sharply and the next three days showed 340, 200 and then 140 ft. We had planned for 5 ft of fill only, but because of the improvement to the gradients we were having to fill to over 7 ft at the Northern edge of the runway, and as the ground continued falling away, to a maximum of over 9 ft in the 90 ft cleared zone.

While the level of havara was pressing forward on the strip, the quarry was getting larger by the hour (Photo 2). On Day 8, the hourly record was up to 489 cu yds, and this was only to be broken on two further occasions (best hour 527½ on Day 16). The RB 19s had settled down to a healthy rhythm, only occasionally marred by a broken rope, and the operators, who had probably the toughest job of all, had lost the initial aches in their forearms and wrists. One of these operators had not so far had any time off at all, and indeed was the only man to go through the full twenty-one days without a break. His skill was such that he was able to load a 10 ton tipper in under 3 minutes. Nevertheless, it was essential to have dozers feeding the excavators continuously for two reasons—firstly the havara soon became hard enough to cause the excavators trouble in breaking it away, and this added strain caused many broken ropes and several other breakdowns, and secondly, the RB 19s are slow machines to move from one position to another and we could not afford to have them or the tippers waiting idle while the machines were moved. So the tractors became vital in the quarry, as well as on the strip and breakdowns among the old Fowlers meant that the load fell more heavily still on the D8H and Vickers. At times the havara was so hard that only the D8H could move it and later still it became necessary to blast the top surface, where the solid skin was up to four feet thick.

Even the one modern tractor we had—the D8H—was not immune to mechanical trouble, and a serious loss of power, together with the emission of thick black smoke when under load was soon diagnosed as being failure in the turbocharger. When dismantled it was found to be due to collapse of the bearing. The exhaust and intake manifolds were then modified to take a specially made pipe by-passing the turbocharger system, and allowing the machine to operate at about 70 per cent efficiency while we waited for a new assembly to be flown out from UK. This particular failure was so unusual that even the Cyprus Mines Corporation, which uses a number of these machines, did not keep a spare in stock. We were consequently even more perturbed when a few weeks later the replacement collapsed in the same way after less than 200 hours use. Nevertheless it was an immense relief to be able to continue using the D8H, because two of the four Fowlers had early on given up the struggle, and a third went out on Day 17. The two Gainsboroughs also gave trouble, one going off on Day 7 with a serious defect in the steering differential, and the second following it with the same complaint on Day 14.

All the while the work on the strip was steadily progressing under the careful eye of the Military Plant Foreman—Day 12, 3,652½ cu yds; Day 13 3,356½ and the end of the strip was reached on the lower level; Day 14 3,927, and Day 15 best of all with 4,022 cu yds. The second layer of about 6 in then went on very quickly, the major part of it taking only four days to lay, finishing on Day 19. In the meantime many other tasks had been completed—sieve analysis, moisture content and CBR tests (Appendix B) marking tests with dyes, paints and cement mix for centre and side lines, laying of water pipes, and that for telephone lines, the removal of the redundant overhead lines and telegraph posts, erection of windsock tower and tests for oil spraying against dust and surface erosion.

Dust was a menace throughout the operation. On many days the wind raised such thick clouds that all men working on the strip had to wear eye-shields as well as surgical masks obtained from the BMH, and there was a very real danger of tippers colliding on their way to and from the far end of the runway, or even of men being run down. It was the cause of several break-downs, and was going to be a hazard to aircraft landing. The RASC Petrol Depot had large quantities of used oil available and tests showed that sprayed on the surface at the rate of 1 gallon to 4 sq yds it not only controlled the dust, but also added considerably to the strength of the surface. Contrary to expectation the oil did not leave a greasy surface, and with an even spray could be rolled in without difficulty. This didn't help during the construction of course, but was to be of real assistance after completion of the extended strip. The oil bowsers, designed for the task (Photo 3), became most useful at the end of this stage in marking out the centre line with an oil stripe which showed up very clearly from the air and was not a danger to the aircraft tyres. The remaining marking was done by white painted PSP at 100 ft intervals down the sides (50 ft intervals round the turning areas) and by solid lines across the ends, spray painted with two coats of white paint. After completion of the extension and improvements to the strip the centre line was similarly marked with panels at 50 ft intervals.

The airstrip was now nearing completion, and while the final careful grading of the surface was being carried out on the far end, the 300 by 150 ft Aircraft Parking Area and the 300 yds long entrance road were started at the near end, and rolling of the finished surface of the runway was also begun. Consolidation had in the main been achieved by careful routing of the laden tippers, but even on sections which had little or none of this, the natural properties of the havara allowed it to slump into a completely firm base of very high CBR value. Added consolidation along the Eastern end, which had fewer tipper runs was given by the use of the 30 ton Scammell and semi-trailer, carrying one of the "dead" Fowlers. The width of the trailer, and the number of wheels, gave good coverage, a fair weight and the rolling could be done at a reasonable speed. The final surface rolling was done slowly of course, and with six rollers in echelon (Photo 4) the last stage was soon nearing its end, and the site could be cleared of all machines except the rollers and graders.

The Final Day

Day 21 started with one corner of the Parking Area unfinished, with a little grading needed and with the rolling of most of both Parking Area and entrance road still to be done. The 21 days were up at exactly 12 noon, and the opening ceremony had been planned to allow the touchdown of the first

Beverley at that time. A notice board had to be erected, a dais and chairs installed, and car parks taped off before then, and as the time went on, and rolling was still continuing, the officer in charge of the troop from 33 Field Squadron which came in to do this task was beginning to feel a bit uneasy. However, at last it was done, and the rollers, rolling the entrance road as they went, finally left the site only eighty minutes before the deadline! At 12 o'clock precisely the airstrip was formally opened by the Commander-in-Chief British Forces Cyprus, Air Chief Marshall Sir Denis Barnett, KCB, CBE, DFC, MA, and to the considerable relief of all those present, and in particular the CRE and those who built the strip, the first Beverley swung into line for a perfect landing.

Conclusions

The main conclusions reached after the operation concerned the equipment used. Some of the tractors were very old, and it was perhaps not too surprising that they did not stand up to 12 hours' continuous, but not unduly heavy, work on each of twenty-one days. However, we have a right to expect that modern machines, such as the Michigan and Gainsborough wheeled tractors, should be able to do so to a far greater extent than they did. The list of breakdowns given in Appendix C does not list all the faults by any means, and in fact only covers those where REME assistance was required. There were far too many cases of blocked fuel lines, hydraulic and steering faults on all five machines, which were in no way the fault of the operators nor of the unit fitters. It must be remembered that there were two servicing trailers in continuous use, and that all normal maintenance on the machines was meticulously carried out. Even the BK 50, which was a new machine, produced several hours of trouble apart from the major defect of broken teeth on the steering ring, and the replacement machine, also new, proved nearly as unreliable, and was relegated to our reserve.

The tippers used were of the following makes:—

10 ton AEC (Army)	7 ton Bedford (ex-RAF)
10 ton Leyland (ex-RAF)	3 ton Beford (ex-RAF)

3 ton Commer (Army)

Of these, the only type to really stand up to the task was the 10 ton Leyland. This was partly because it only tipped to the rear, but principally because the body was of sufficient strength to withstand the effect of being knocked by the arms of Michigans or Gainsboroughs, or being hit by a swinging bucket. None of the five Leylands required any body repairs at all—all the other eighteen tippers did, and in particular the five AECs required complete rebuilding of the tipping bodywork, quite apart from the number of times tailboards, tailgate posts and latches needed repair before the rebuild became necessary. For this type of work, a three way tip is quite unnecessary, does not give sufficient stability in the tipping operation, and carried the added risk of distortion from off centre loads. The 7 tonners were underpowered in their engines and hydraulics and with only a single ramp, the slightest slope meant a bend or fracture. Three out of the five in fact went in this way and these had to be fitted with slings and tipped by crane in order to avoid losing the tipping capacity. The 3 tonners, particularly the Bedfords, were underpowered in their engines for this type of task. Our conclusion was that the 10 ton Leyland was by far the best vehicle for airfield construction work, and that all the other types, and particularly the 10 ton AEC, were much too weak in the body.

Photo 5. The 10 ton Leyland tipper, which proved itself to be very robust in the heavy work involved.

Photo 6. Spreading, and forming the runway.

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Photo 7. Three BK 12 graders produced an excellent surface.

The final conclusion, which has been reached many, many times before, but is still worth repeating, is that a really hard job of work such as this is the best morale booster one can find.

Postscript January 1965

Shortly after the completion of the emergency airstrip we were asked to enlarge it to enable Argosys to make use of the runway. In a further three-week period, after a three week gap, the overruns were strengthened and incorporated into an extended runway of 4,050 ft overall. The cleared zones were filled in and the level raised to give a maximum gradient in these zones of 1:66 and the Parking Area was increased in size to 750 by 150 ft. This involved a period of nearly as intense activity, during which time a further 43,303 cu yds (overall total 109,204 cu yds) or 52,478 tons (overall total 132,356 tons) of havara was moved. On 20 June a full scale Argosy trial took place after which OC 114 Sqn, RAF Benson wrote:—

"The airstrip at Kingsfield, Dhekelia is entirely suitable for the daytime operation of Argosy aircraft using Tactical Operating Data Manual limits up to the normal maximum all-up-weight in temperatures up to 31°C (97,000 lbs for takeoff; 92,000 lbs for landing). Night operations using goose neck flares and a maximum AUW of 92,000 lbs should present no difficulties. The Royal Engineers have done an excellent job of work."

Since that report, training flights have been carried out almost weekly, and twice a complete Battalion Group has been lifted using four aircraft and amounting to some thirty sorties a day (Photo 8). So little damage resulted to the havara surface after such lifts that an average of four hours rolling per night was all that was required to prepare for the following day. The airfield is completely suitable for night flying, and has been used under all conditions. Very bad weather has occurred during the past few weeks, with more torrential rain than has been seen in Cyprus in ten years, but the surface drained well after each storm and was suitable for flying within a few hours. The RAF are still keen to have it surfaced to make it a permanent airfield, and discussions are going on now as to whether the money can be made available. If surfacing is not possible, however, it seems that havara is nevertheless capable of producing a good, reliable runway requiring little maintenance even under the worst weather conditions likely to be met.

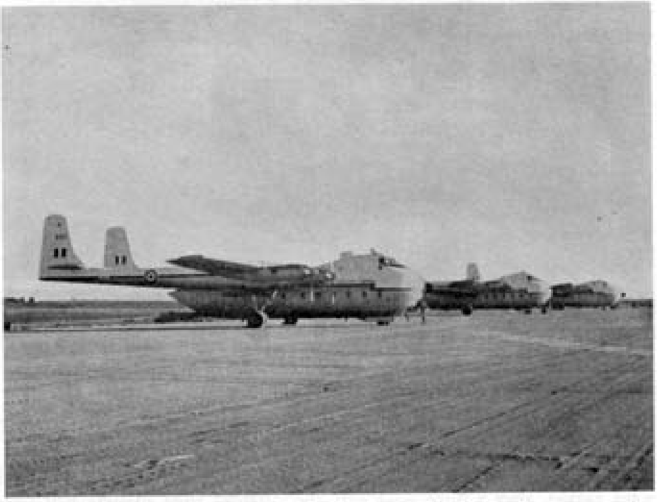


Photo 8. Three of the four Argosys on the Parking Area during the Battalion group exercise.

APPENDIX A

Minimum Criteria for a Beverley MRT Strip and Summary of Contruction Details

Item	*Minimum*	*Actually Produced*
Length	3,000 ft	3,000 ft
Width	75 ft	120 ft
Subgrade strength (30 days operation)	CBR 10	CBR 100
Cleared zone	90 ft	90 ft
Turning circle radius	75 ft	85 ft
Gradients		
Longitudinal	Centre third 1:50 up or down End thirds 1:50 down	First 1,300 ft 1:180 Next 500 ft 1:125 Remaining 1,200 ft 1:100
Transverse	1:80	1:80
Rate of change	0.25 per cent	0.25 per cent
Approach funnel	1:50 for 5,000 ft	1:50 for 5,000 ft
Overrun	Not essential in initial stages	300 ft each end
Parking Area		300 × 150 ft
Entrance road		30 × 900 ft

APPENDIX B

Moisture Content, Sieve Analysis and CBR Tests on Havara

Moisture Content

Sample A (Top of quarry)	*Test 1*	*Test 2*
Weight of container + wet sample	71.92	73.00
Weight of container + dry sample	70.00	71.10
Weight of water	1.92	1.90
Weight of container	27.14	28.10
Weight of dry soil	42.86	43.00
Moisture content	4.48 per cent	4.13 per cent

Sample B (Bottom of quarry)	*Test 3*	*Test 4*
Weight of container + wet sample	74.00	67.4
Weight of container + dry sample	72.00	65.0
Weight of water	2.00	2.4
Weight of container	27.13	26.09
Weight of dry soil	44.87	38.91
Moisture content	4.45 per cent	3.6 per cent

Average moisture content of havara in quarry = 4.16 per cent

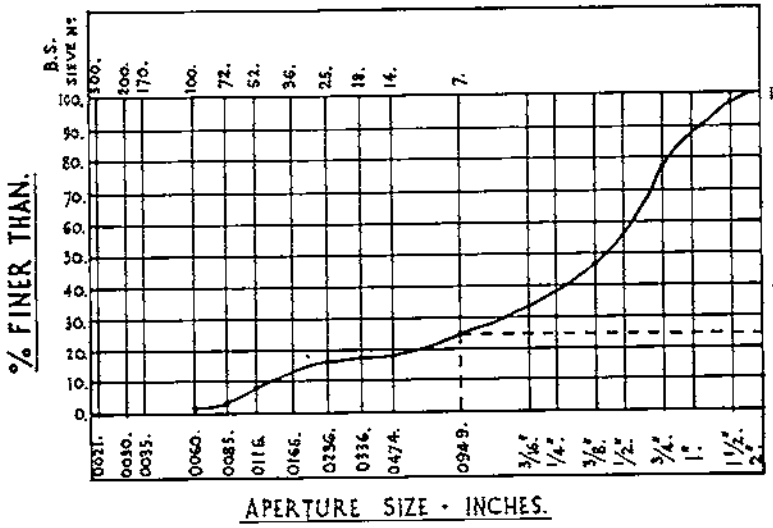
Sieve Analysis

Sample A (Top of Quarry)

B.S. Sieve	Wt retained (gms)	Percentage retained	Total percentage passing
1½ in	110	2.5	97.5
¾ in	873	20.9	76.6
⅜ in	1,320	31.5	45.1
3/16 in	535	12.8	32.3
7	337	8.0	24.3
14	234	5.5	18.8
25	75	1.8	17.0
52	406	9.8	7.2
100	222	5.4	1.8
200	28	0.8	1.0
passing 200	41	1.0	
TOTAL	4,181	100%	

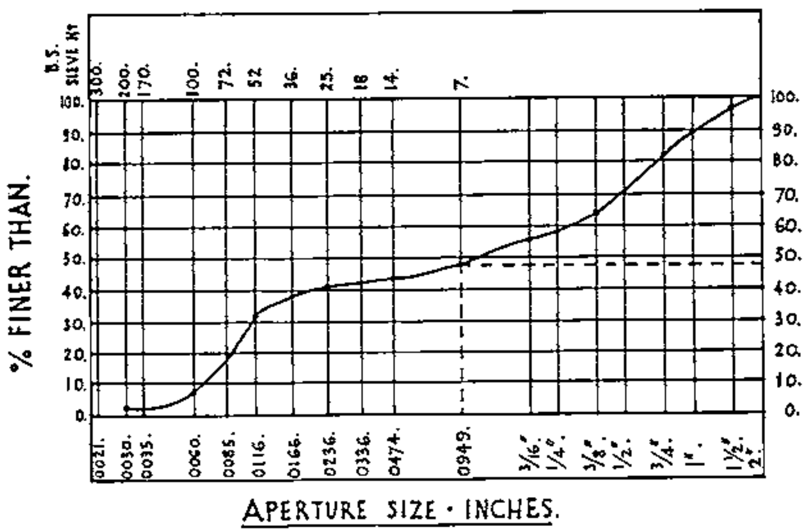
Sample B (Bottom of Quarry)

B.S. Sieve	Wt retained (gms)	Percentage retained	Total percentage passing
1½ in	216	4.0	96.0
¾ in	792	14.8	81.2
⅜ in	915	17.0	64.2
3/16 in	485	9.1	55.1
7	326	6.2	48.9
14	290	5.4	43.5
25	170	3.2	40.3
52	470	8.8	31.5
100	1,340	25.2	6.3
200	220	4.2	2.1
passing 200	110	2.1	
TOTAL	5,334	100%	



GRAVEL = 75·7 % – SAND = 23·3 % – FINES = 1%.

· FIG. 1 · GRADING CURVE FOR SAMPLE 'A' ·



GRAVEL = 51·1 % – SAND = 46·8 % – FINES = 2·1%.

· FIG. 2 · GRADING CURVE FOR SAMPLE 'B' ·

CBR Tests

Soil type	gravel havara
Proving ring	6,000 lbs PR 602
Location	15 ft in from edge of runway
Compaction	100 per cent water-rolling

Test 1 (surface test)		*Test* 2 (subsurface test—$1\frac{1}{2}$ in below surface)	
Pen × 10^{-3} in	Load (lbs)	Pen × 10^{-3} in	Load (lbs
25	1,200	75	500
50	1,800	100	900
54	6,000	Nil	6,000

In both cases the surface strength gives better than 3,000 lbs at 0.1 in penetration, and 4,500 lbs at 0.2 in penetration, and therefore shows a CBR value of greater than 100 per cent as compared with California crushed limestone. No sensible curve can be drawn for these tests.

APPENDIX C

REME Repairs Required to 'C' Vehicles and Plant

Tractors

International BTD 6	Broken hydraulic conduit, control valve pipe broken. Eventual engine failure due to piston liner wear and excess oil consumption.
Drott 4-in-1	Broken control valve lever. Engine failure due to excess wear caused by dust ingress and crankshaft bearing knock. Suspension members cracked, threads stripped, bolt holes elongated.
Fowler Challenger 3 Mk 2	Overhaul main clutch, weld r/h ram pivot pin case, seized r/h steering clutch. Followed by second main clutch failure coupled with engine failure, transmission faults, track link fracture and reduced power in hydraulics.
Fowler Challenger 3 Mk 2/1	Engine fuel system overhaul. Drawbar rear quadrant material failure with distortion at final drive reduction gear back plates. Hull sprung with oil leaks. Angle dozer U-frame fractured.
Fowler Challenger 3 Mk 2/1	Suspension cross roll-up shaft, r/h crank pin break up. Track frame roller failure. Injector pump tappet springs broken and atomisers faulty. Fracture of material at angle dozer U frame.
Vickers Vigor Mk 2	Weld r/h ram pivot pin. Replace sheared final drive sprocket bolts (twice). Sprocket assembly replaced. Main clutch centre driving plate failed. Steering servo mechanism refitted. Transmission began to break down with "high speed" out of action.
Caterpillar D8H Mk 2	Replace turbocharger, having modified exhaust and intake manifolds to allow operation on normal aspiration. Replace broken bolts at l/h ram pivot (cross beam), involving removal of sheared set bolts with heavy radial drill, and local manufacture of new bolts. Repair broken injector pipe by rerouting pipe and shortening, as special material was not available. Replace turbocharger for second time, failed after 200 hours running.
Michigan 75 DS (No. 1)	Replace crankshaft rear oil seal. Replace sheared front axle mounting bolts. Weld broken front axle mounting brackets.
Michigan 75 DS (No. 2)	Repair brake servo system. Renew sheared axle mounting bolts. Engine became excessively worn due to dust ingress at induction.
Michigan 75 DS (No. 3)	Repair cracked front axle mounting brackets and bolts.
Gainsborough Mk 2 (No. 1)	Steering hydraulic pipe repaired (twice). Bending of front attachment main frame arms noted. Transmission fault diagnosed as steering differential trouble, established as disintegration of "spider" after four days of dismantling effort.
Gainsborough Mk 2 (No. 2)	Transmission fault as for No. 1, new assembly fitted. Bending of front attachment main frame arms noted. Differential assembly broken up for second time, after only thirty-nine hours work in quarry.

Excavator

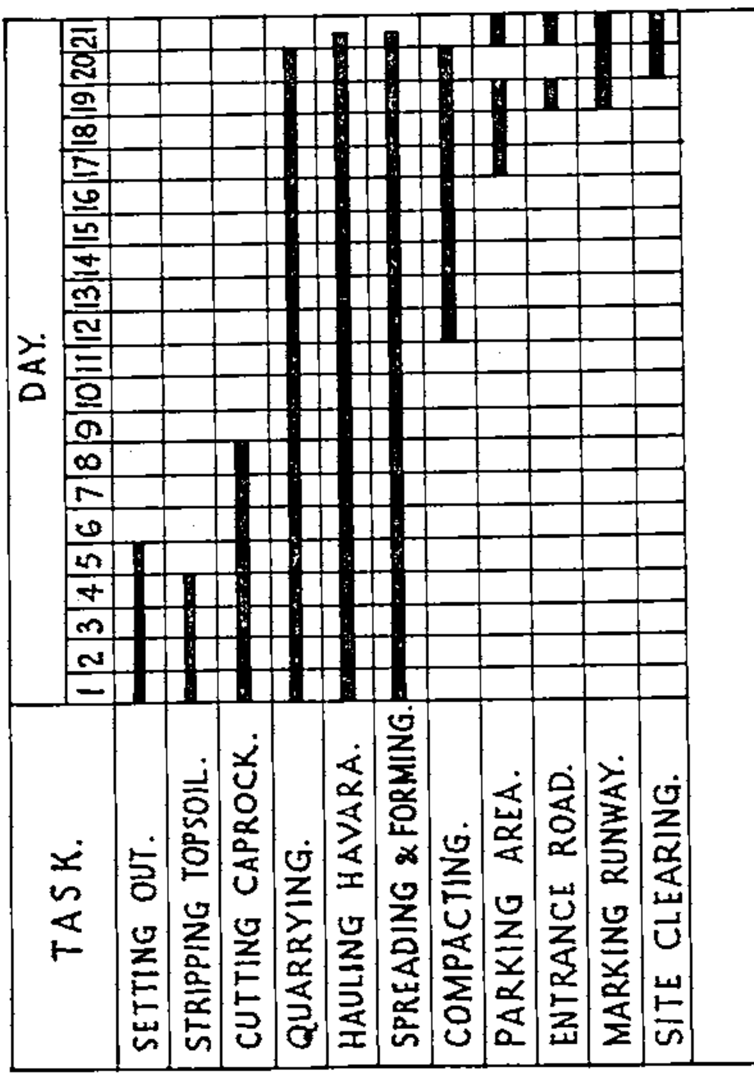
Blaw Knox Mk 50 Mk 3	Renewal of slewing ring when four teeth broke away after sixty hours running.

Grader

Blaw Knox 12 ft MB (No. 1)	Broken transmission lever repaired.
Blaw Knox 12 ft MB (No. 2)	Steering box adjusted and centralized, linkage overhauled.
Blaw Knox 12 ft MB (No. 3)	Fan belts renewed.

APPENDIX D

Work Table and Statistics



· FIG. 3 · WORK TABLE ·

STATISTICS

Day	Cu yds moved daily	Total cu yds	Best hour cu yds	Footage daily		Total footage	
1	1,154	1,154	—	80		80	
2	767½	1,921½	285	30		110	
3	2,790½	4,712	364	140		250	
4	3,149½	7,861½	394	130		380	
5	2,885½	10,747	417½	200		580	
6	3,300	14,047	412½	220		800	
7	4,000	18,047	454½	335		1,135	
8	3,514	21,561	403	465		1,600	
9	3,615	25,176	489	460		2,060	
10	3,302	28,478	388½	340		2,400	
11	3,292	31,770	369	200		2,600	
12	2,534	34,304	416	140		2,740	
13	3,652½	37,956½	398½	160		2,900	
14	3,356½	41,313	422	100/150*		3,000/150*	
				Left	Right	Left	Right
15	3,927	45,240	471		630		780
16	4,022	49,262	444½		620		1,400
17	3,895½	53,157½	444½	600		600	
18	3,340	56,497½	527½	370		970	
19	3,166	59,663½	493	2,030	1,600	3,000	3,000
20	3,396½	63,060	363				
21	2,841	65,901	435				

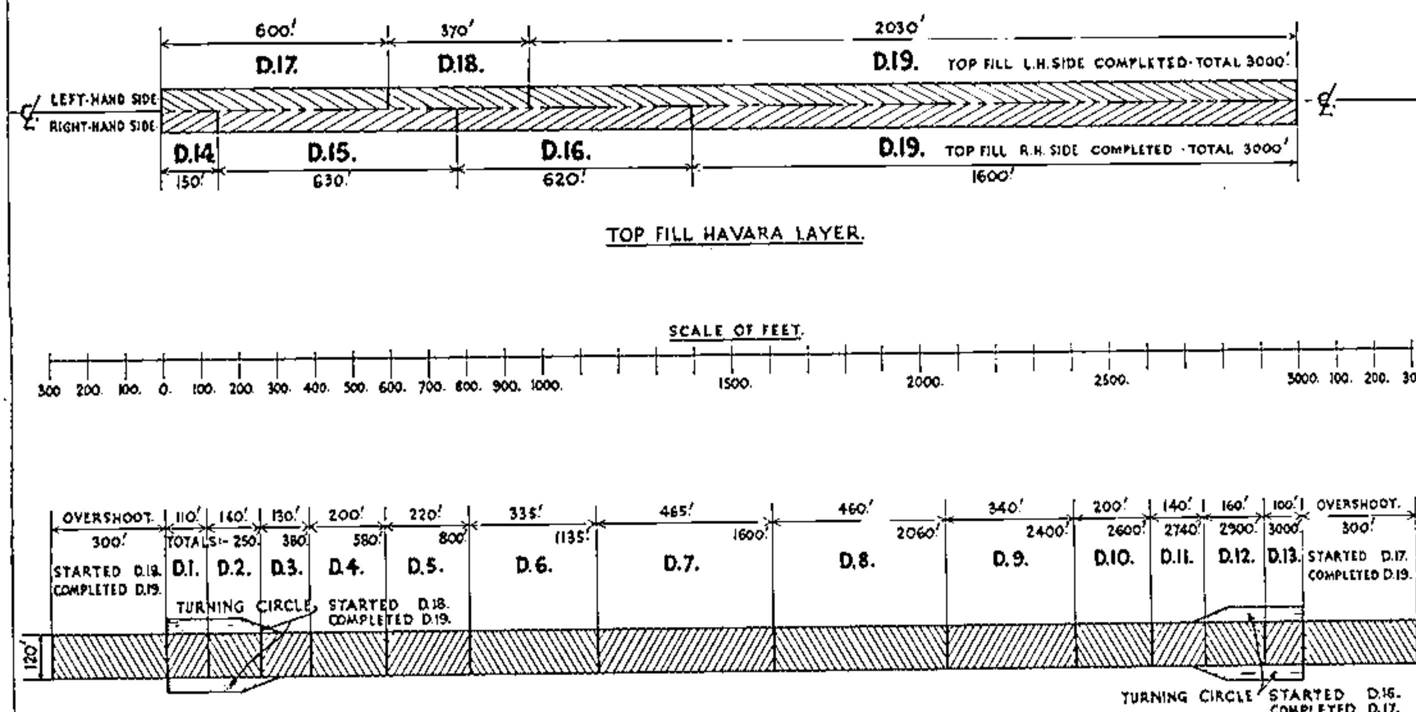
* Second layer on right half of runway

Havara moving

Area moved	65,901 cu yds
Weight	79,878 tons
Tipper journeys	9,347
Mileage covered (3½ miles return)	32,714 miles
Fuel used (petrol and diesel)	14,771 gallons (includes all plant)
Cost price of fuel	£560

Hours worked

Total hours worked	202 hours
Weekly average per man	68 hours
Average number of men daily	60 men
Total man hours worked	12,120 man hours



NOTES:- 1. ENTRANCE ROAD STARTED ON D.19. COMPLETED ON D.21. (NOT SHEWN ON CHART).
2. PARKING AREA STARTED ON D.17. COMPLETED ON D.21. (NOT SHEWN ON CHART).
3. GRADING OF SITE TOOK PLACE DURING D.18, 19 & 20. ROAD ROLLERS WERE USED ON D.19, 20 & 21 EXTENSIVELY.

INITIAL HAVARA LAYER.

· FIG. 4 · PROGRESS CHART. ·

The Gurkha Engineers in Borneo 1962 to 1964

By Major G. N. Ritchie and Major D. H. Bowen, MBE

Introduction

This article is confined to the employment of 68 and 69 Gurkha Independent Field Squadrons during the period October 1962 to July 1964. Throughout the period covered by this article, however, other units and individuals of the Royal Engineers, Royal Australian Engineers and Federation Engineers were deployed on operations in Borneo Territories.

Background

In October 1962 the first troop of Gurkha Independent Field Squadron (thereafter referred to as 69 Squadron), in support of the Queens Own Highlanders, arrived in Borneo to assist the police operating against pirates on the North Borneo Coast. By November 1962 the whole of 69 Squadron was located at Kota Belud, North of Jesselton, North Borneo, under command of Major R. J. Francis. They were engaged on the extension of the Brigade Training Area being constructed in North Borneo.

The Brunei Rebellion

On 8 December 1962 rebellion broke out in Brunei. Within forty-eight hours 99 Gurkha Infantry Brigade Group had deployed an *ad hoc* headquarters, three battalions of infantry and a Royal Marine Commando. The majority of its affiliated field squadron however was left, as the military presence, in North Borneo. One troop of 69 Squadron did, however, manage to get into Brunei, on 9 December, and assisted in the Commando assault on Limbang and subsequent maintenance of the force. The main engineer effort at this time came from 54 Corps Field Park Squadron. The remainder of 69 Squadron managed to get down to Brunei, in late December 1962/early January 1963.

This was a period of "ad-hocery" that was to persist in the Borneo Territories for many months to come. By the first week of January 1963, the engineer effort in Brunei was deployed as follows:

OCRE (Major D. G. N. Genet, RE)

- "ad-hoc" Stores and Plant Det 54 Sqn
- Det 10 Port Sqn
- Ad-hoc Works Section
- 69 Gurkha Indep Fd Sqn (without a Park element)

By Christmas 1962 the rebellion in Brunei had been crushed and the bulk of the rebels were in detention camps, some of whom were guarded by engineers! The hard core of the organizers escaped, it was presumed, into the surrounding state of Sarawak. It was feared that they might try to subvert some of the jungle tribes. It was necessary, therefore, to deploy infantry detachments while at the same time maintaining morale of the tribesmen. This set the framework of counter-insurgency operations.

On Good Friday Indonesians disguised as TNKU (Brunei Rebels) raided the Police Station at TEBEDU in West Sarawak. Subsequent operations and incidents disclosed the existence of a Clandestine Communist Organisation (CCO) in Sarawak, together with plans for an insurrection. HQ 3 Commando Brigade with two battalions and a Royal Marine Commando were deployed immediately in West Sarawak. The Commando Brigade had no organic engineer support and one troop of 11 Independent Field Squardon RE was sent to support them. Major Genet, the OCRE was withdrawn about this time and the new OC 69 Squadron (Major G. N. Ritchie) became responsible for all engineer troops in Borneo Territories; his command stretched from Kota Belud in North Borneo (now renamed Sabah) to Kuching in West Sarawak and involved support to two Brigade groups.

End of a Rebellion

In June 1963 an operation was mounted which saw the end of the Brunei Rebellion. The officers of 69 Squadron were discussing late one night, over a glass, the problem of operating boats in Borneo, when an urgent demand for two assault boats was received from the 7th Gurkhas. The Officers manned the boats and twelve hours later the operation had accounted for all the leading figures of the rebellion, except Azahari.

Confrontation

The tempo of operations decreased between June and August, but on declaration of the formation of Malaysia, Indonesia's confrontation attacks increased in intensity and frequency. This necessitated a change in deployment and tactics.

The front is some 1,000 miles long with ten battalions to cover this frontage. The answer was remarkably similar to the "Nuclear" posture, except that battalions held a Corps frontage, with eyes and ears forward, and company and platoon bases or forts in depth to cover the likely approaches. These camps were based on river junctions or, SRT airstrips. The aim was to define, contain and then destroy. Mobility was achieved by helicopters.

In October, 99 Gurkha Infantry Brigade returned to Singapore for rest and retraining. 69 Squadron, less one troop, returned to Kluang, Malaya. B Troop 69 Squadron remained in West Sarawak in support of 3 Commando Brigade. 68 Gurkha Independent Field Squadron (68 Squadron) was flown out from the Strategic Reserve as an operational reinforcement and deployed in Borneo by Christmas 1963. Their arrival brought the total number of field troops available in Borneo to seven, four of which were Federation Engineers, an increase of 700 per cent in two months. B Troop 69 Squadron could now return to Kluang for a well-earned rest. 2 Engineer Squadron Federation Engineers, with two field troops from 68 Squadron, were deployed in West Brigade, 68 Squadron less two troops in Central Brigade and one troop of the Federation Engineers in East Brigade. The Gurkha Enginners troop in West Brigade were deployed with one to the 2nd Division and one to the 3rd Division of Sarawak.

December 1963 also saw the arrival of a CRE Borneo (Lieut-Colonel H. W. Webb-Bowen) and two RE Stores Sections. The end of "ad-hocery" was in sight. The arrival of HQ 51 Infantry Brigade Group brought a further improvement in the command and control of troops in Borneo Territories.

Engineer Tasks

It is difficult to give a really clear and concise statement of what tasks were carried out and what work should have been carried out. The old cry of "Help the Army to live, to fight and to move" applied but requires some amplification. A clearer split may be:—

Tasks to make life a little more comfortable for everyone (to live),
Immediate assistance to communications (to fight), and
Long term assistance to communication (to move).

The areas that field troops were operating in each had their own separate problems. Most of the 2 Division of Sarawak could be supported by road or river with some helicopter maintenance to remote troops. The 3rd Division is served by the River Rejang, navigable to mienswecpers up to 120 miles inland, and the Balch and Balui rivers navigable by long boat for most of the remainder. Distances, however, are so vast, that a supplementary helicopter service was essential. In the 4th and 5th Divisions Sarawak and the Interior Residency supply was by air, Beaver or Pioneer to the few airstrips, and forward by helicopter SRT airstrips were usually Twin Engine Pioneer, but in one or two difficult sites only Beaver or Single Engine Pioneer could be used.

Help Army to Live

The original inhabitants of our forward jungle bases occupied them in a hurry and built very temporary "bashas" with limited cooking facilities and no water supply other than the Millbank Bag and personal water sterilizing tablets. From the beginning bathing and washing was carried out in near-by rivers and streams until a high incidence of leptospirosis and encyphalitis made it necessary for all water to be sterilized. The field troops solved the problem in a variety of ways. In West Sarawak canvas "S" tanks were used and then normal alum sedimentation and sterilization with WSP was carried out. This was not completely successful as the canvas "S" tanks rotted within a matter of 8–10 weeks. Galvanized metal, 200 gallon, tanks have since been fabricated in Kuching and are being used in place of "S" tanks. Later supply points built in the Third Division utilized Braithwaite tanks in place of "S" for sedimentation and sterilization The heavy steamer traffic on the Rejang made it possible for heavy engineer loads to be carried relatively cheaply so this system was satisfactory. The Central Brigade posed a particular problem. Complete reliance on air transport precluded heavy loads such as Braithwaite sections; we had learnt the lesson of the "S" tanks and so had to look around for some other system. Forty-four-gallon drums were available at most sites and were the obvious solution to storage. The thought of alum sedimentation in 40-gallon lots, however, was horrifying. Our requirement was for a filter. Mutterings were heard of the Midget Meta Filter, Light Weight Filters, Stella Stirrup Pump Filters, etc but no matter how loud we shouted we never seemed to get any. 68 Squadron then produced the Murcott filter. This was basically a 4 ft casing of 4 in pipe into which was placed a "candle" composed of parachute silk wrapped around fine wire gauze on an angle iron frame. This produced almost the same effect as a Meta or Stella filter. 68 Squadron were now in business. Armed with the 2-in Alcon pump, 2-in plastic hoze and batteries of 40-gallon drums joined by 1 in plastic they fitted up all the forward camps with shower and ablution units.

Following a visit by DADAH we were faced with another problem, the provision of flyproof, ratproof kitchen/ration stores. Fairly easily solved by prefabricating a simple box construction in the park troop workshops and airdropping them with wire mesh, nails and bags of cement. The engineer troop in the Third Division, however, was able to produce some really magnificent cookhouses. Bricks, cement and sand were easily transported. Archaeologists of the future are going to be puzzled by some solid field ovens in the middle of the jungle. We made one elementary mistake. Our cookhouses were designed for, and built by, Gurkhas. No sooner were they finished than the Gurkhas moved out and British troops moved in. Field kitchens must be dual purpose.

Help Army to Fight

Water Communications. The coast of Brunei is a maze of tidal waterways, bordered by dense nipah palm groves. During the rebellion and counter CCO operations these had to be patrolled and searched; the only way to do this was by boat. Except for a few areas along the coasts and in the First and Second Division of Sarawak, where there are roads, the majority of movement in Borneo is by air or river. Many of the rivers are navigable up to, and in some cases in excess of, 100 miles for craft drawing up to 5 ft of water and the remainder are navigable to long boats for most of their length. These longboats, powered by Johnson, Gale and Evinrude outboard engines, are expertly handled. These same boats and engines provided the security forces with much of their mobility.

When 42 Commando arrived in Brunei in December 1962 they immediately impressed a large number of boats and outboard engines. These were eventually supplemented by Mk IV assault boats, storm boats and 50 hp (1945 pattern) Military Evinrude outboard engines. The unreliability of the Evinrudes was soon apparent. Initially the running of small boats was the responsibility of the Royal Navy but was later taken over by 69 Squadron. So great was the requirement for river transport that it became impossible for 69 Squadron to man all the boats and gradually the battalions became responsible for operating their own. Battalions used their own pioneer platoons and their redundant MT drivers. In particularly dangerous rivers local boatmen were enlisted as border scouts and employed as boat drivers.

The main lesson learnt by everyone in the Borneo Territories is that Johnson, Evinrude and Gale make outboard engines by the thousand for use by people in Borneo, not for pleasure but as an essential part of their daily lives. There is an excellent spares backing even in the remotest villages. In comparison the military specials are unreliable, have an uneconomic power/-weight ratio and do not have a separate fuel tank.

During the period of low activity between June and August 1963, HQ 99 Infantry Brigade Group decided to hold a number of Brigade Headquarter exercises. One of these entailed a river crossing of twenty Land Rovers and trailers. The only rafting equipment was some very tired Mark III assault boat raft superstructure and stormboat jeep ramps. The problem was solved by joining and stiffening the stormboat ramps with angle iron pickets to form a superstructure. This was then lashed to the carrying rails of three single assault boats.

During 69 Squadron's retraining period in Malaya this improvization was developed with the assistance of the Engineer Base Workshops Singapore.

The latest Mark is mounted on one double and two single assault boats. The raft has carried a full class six load over ten miles against a three knot current. We have named this the "Sherbahadur Raft", after the Queen's Gurkha Officer responsible for the original improvization.

Helicopter Landing Zones. The success of operations in Borneo depends on the speed at which troops can be deployed to cut off infiltrations and incursions. This can only be achieved by helicopters. Most longhouses have a small "padang" that can be used as helicopter Landing Zones and those that haven't build one as a prestige symbol. The main requirement was for a necklace of Landing Zones along the border covering known tracks and likely approaches. There is a requirement for a drill whereby Landing Zones can be constructed rapidly (hours not days), either by walk-in or rope-in parties, to allow rapid deployment of infantry. The need was, and is, greatest in Central Brigade where there has been one section almost continuously employed on this task, either on its own or in conjunction with infantry. The drill we evolved was:—

(*a*) Select, clear and construct the "touch down" point. In preference to clearing all trees and roots to ground level it was found quicker to build a pad 15 ft by 15 ft standing about 12 in to 15 in high.

(*b*) The approaches and cleared areas are then removed. The most effective method is to start on trees furthest away from the pad and work towards the centre. The trees are cut halfway through using lightweight mechanical or cross cut saws and left standing. This is to avoid forming a tangle early in the operation thereby hindering movement and slowing down work.

(*c*) A large tree near the pad is felled and made to fall outward. This starts a chain reaction which clears the area, including any trees which are leaning the wrong way.

(*d*) One or two trees may have to be cleared later but normally, once the main clearance is done, helicopters can land and take off.

The greatest waste of time is in getting the cutting party to the site. Much thought has been given to developing a technique for roping-in, either into the foliage of jungle giants followed by "abseiling" or a straight rope-in. Practice and experience was obtained in climbing down the trees but we never managed to "abseil".

Aerial Ropeways and Bridges. In a number of places jungle camps are separated from their supply dropping zones by large rivers. After much difficulty stores were obtained ex UK and a number of aerial ropeways and single cable suspensions bridges were made.

Help Army to Move

Roads. Very little work was carried out on roads. 69 Squadron reopened and maintained the 12-mile road from Limbang in Sarawak's Fifth Division to Bangar in East Brunei State while supporting 42 Commando in their follow up after the Limbang Assault. "A" troop of 68 Squadron were employed for a short time on the Padawan—Tebadu link road in West Sarawak. This was started by the Federation Engineers and handed back to them when the Squadron was withdrawn.

Airstrips. The major work in improving the Security Forces Mobility was in the construction of Short Range Transport (SRT) airstrips. Throughout Sarawak and Brunei there are many airstrips of varying size and quality. Many were built by Resident and District Officers and some by Missionaries, using local labour and tools, while others were built by PWD using modern methods and equipment. Despite the growth of the helicopter force the requirement for SRT airstrips has not decreased. The fixed wing aircraft is more economical and has a greater payload range. A number of new SRT airstrips were required to increase the mobility of the security force.

Under present circumstances it is not permissable to detail all the airstrips on which the Squadrons worked by name. The type of work carried out, however, is illustrated in the examples given below.

(*a*) High utilization, and in some cases overloading, caused two grass strips to break up. Emergency repairs were carried out to improve drainage, construct a hardstanding and improve approaches using local labour and lightweight plant. One of the strips again broke up and is being rebuilt to full Civil Airways standards.

(*b*) A further strip was built by PWD with Sapper supervision and assistance. It was supposed to be built to full Civil Airways Twin Engine Pioneer (TEP) standard. Unfortunately no civil airways representative was available at the initial reconnaissance so their requirements were unknown. The airstrip was built to Royal Air Force minimum standards. Unfortunately these are not acceptable to Civil Airways so further work is required on the approaches before this can be accepted by civil aircraft. The fill and surfacing of the airstrip gave the Sapper officer a great deal of worry. The material used was a clay-silt-gravel mixture which proved very difficult to compact. The PWD engineer, however, was certain that all would turn out well. His claims were fully justified as the finished product is usable in all weathers. The main lessons re-learnt were the necessity for having the right airmen available on the initial reconnaissance, and how much we must depend on local knowledge.

(*c*) An airstrip, initially designed to MRT—Beverley standards, provided another example of the necessity of having the airmen at the start of the project and of demanding exact criteria. The airstrip was downgraded to SRT after an experienced Beverley pilot visited the site. A Caterpillar D4 was airdropped in January 1963, followed by a Ferguson 203 complete with trailer and a Vibro Roller brought in as helicopter underslung loads. Finally a Wobbly Wheel Roller was airdropped, in April. The airstrip was surfaced with turf taken from an adjacent site. Experience gained at this site showed a need for a truely airportable grader. It is hoped that the Transatlas grader, fitted to a Fordson tractor will meet the requirement.

(*d*) Only one site could have come into the category of the "three day airstrip" beloved of planners. It did in fact take five weeks. It was a sand based airstrip on the Brunei Coast designed to take Beaver aircraft only. One Michigan Light Wheeled Tractor and an Aveling Austin Grader were available. The area was cleared of light undergrowth, side drains were dug, low lying areas were filled and grass seedlings, recommended by the Agricultural Department, were planted. We then waited for the rains, firstly to water the grass and secondly to enable us to compact the sand base. Unfortunately although this was the rainy season it did not rain and the majority of the grass died. We are still hoping that the remainder turf will spread.

(*e*) One Twin Pioneer strip was built by extending an old Missionary airstrip from 300 yds to 600 yds in length. Only one Size 4 Dozer (Caterpillar D4 of uncertain vintage), a Wobbly Wheel Roller and a Massey Ferguson 203 with bucket and back-actor were available. The dozer and roller were airdropped and the Ferguson stripped and sent in by helicopter. Clearance of site and approaches was by civil labour on contract from the local long-house. The Massey Ferguson dug the side drains and the dozer pushed two small hills in to fill up a small bog that existed in the middle of the proposed alignment. Grading was carried out by towing two large tree trunks, at an angle, behind the dozer. Grass seed was eventually obtained after Engineer Resources combed the Far East for a suitable seed.

(*f*) In one last example, 68 Squadron were required to find a project officer and plant foreman. In the event they had up to twenty men deployed at any one time on such tasks as culverting and removal of rock obstructions on the approaches. Three Size 2 Tractors (Caterpillar D6), two scrapers and one pneumatic roller, together with operators were provided by PWD. Fifty Indonesians provided the labour force. The final airstrip will be built to full Twin Engine Pioneer standards. It was in an extremely difficult position that involved the removal of two hills, one over 100 ft high, diverting two streams and filling in a very large bog. At one stage in construction the officer in charge was seen sitting on a hill morosely watching the locals fishing on his airstrip. The finished level is designed to be above known flood level. This airstrip will be gravel surfaced. The original reconnaissance was carried out by an officer from 69 Squadron. 68 Squadron completed the earth moving and levelling of the airstrip. Final surfacing and the approach road will be completed by 69 Squadron.

Conclusion

Experience over the past twenty months has shown that there is a wealth of major engineer work available in Borneo. Apart from the airstrips, troops have been involved in small expedient tasks. A criticism can be, and has been, levelled that engineer effort has been frittered away in small uneconomic units. The immediate and urgent requirement was water and hygiene in jungle camps, boat operation and maintenance and helicopter LZ's. These required small, self-contained parties. Air transport is so limited that a field troop cannot be deployed to complete a task and move on quickly to the next tasks. Two or three men may take longer but they can be moved easily. The large backlog of small tasks have now been completed. Some maintenance work is required but it is hoped that engineers can now start on some major tasks.

Officer Training

Five of the troop commanders deployed on operations in Borneo had just spent three years at Cambridge or Shrivenham, and had never held any command position. By the end of their spell on operations they were confident, experienced troop commanders capable of planning difficult engineer projects and operations. Troops operated at great distances from the squadron headquarters and troop commanders soon learnt to stand on their own feet, particularly in the difficult task of advising and supporting senior, strong-minded infantry officers.

Engineering with Nuclear Explosives

By Major D. R. Whitaker, RE, MA, MINucE

Introduction

It is not widely known that during the Suez crisis in 1956 it was suggested that, should the Canal become unuseable for any reason, an alternative, sea-level canal across Israel could be constructed with the help of nuclear explosives. The scheme was not implemented but it gave rise to a number of other ideas on the engineering uses to which nuclear explosives could be put and the United States Atomic Energy Commission (USAEC) has since then pursued these in the PLOWSHARE programme. During this programme hundred of chemical explosive devices and many nuclear devices of different sizes have been exploded at different depths and in different types of ground, and as a result reasonably accurate predictions on the characteristic performances of large explosions can now be made.

Characteristics of Nuclear Explosives

Nuclear explosive devices can now be tailor-made in a large variety of yields, physical sizes and costs, and with effects to suit users requirements. Cost is the factor which may most effect the peaceful uses of such devices and, in order to encourage American industry and potential overseas users at least to consider the economics of nuclear engineering schemes, the AEC issued in 1958 and has revised in 1964 estimates of the cost of a wide range of explosive yields. A charge of $350,000 will be made for a nuclear explosive with a 10 kiloton yield and $600,000 for a nuclear explosive of 2 megatons yield.[1] Interpolations may be made for other yields based on a straight line drawn between these two charges on semi-logarithmic paper as shown on Fig. 1. These charges cover nuclear materials, fabrication and assembly, and arming and firing services. Important services not covered by the charges are safety arrangements, site-preparation, including construction of holes, and transportation and emplacement of the devices. The charges are also based on a projection to a time when such explosives will be produced in quantity for routine commercial use.

For excavation explosives normally emplaced in a drilled hole, the diameter of the explosive container must be kept to a minimum. Typical diameters are 36 in for a 100 kiloton device and 48 in for 1 megaton, which for deeply buried applications could be reduced to one and two feet respectively. Information on size and cost of British devices has not been released, but it is reasonable to assume that, with the exchange of technical information with the USA, the characteristics of British devices will be similar.

The amounts and kinds of radioactivities produced by detonation of a nuclear explosive are dependent upon the specific design of the explosive. The two extremes of design are a pure fission device, which produces a very high quantity of fission products, and a pure thermonuclear device which would produce no fission products. The excess neutrons in both processes ultimately react with either the structural materials of the device or the surrounding matter and result in the production of other radioactive species. At the moment small yields are normally derived from fission effects while larger yields are thermonuclear devices triggered by a fission explosion. In a

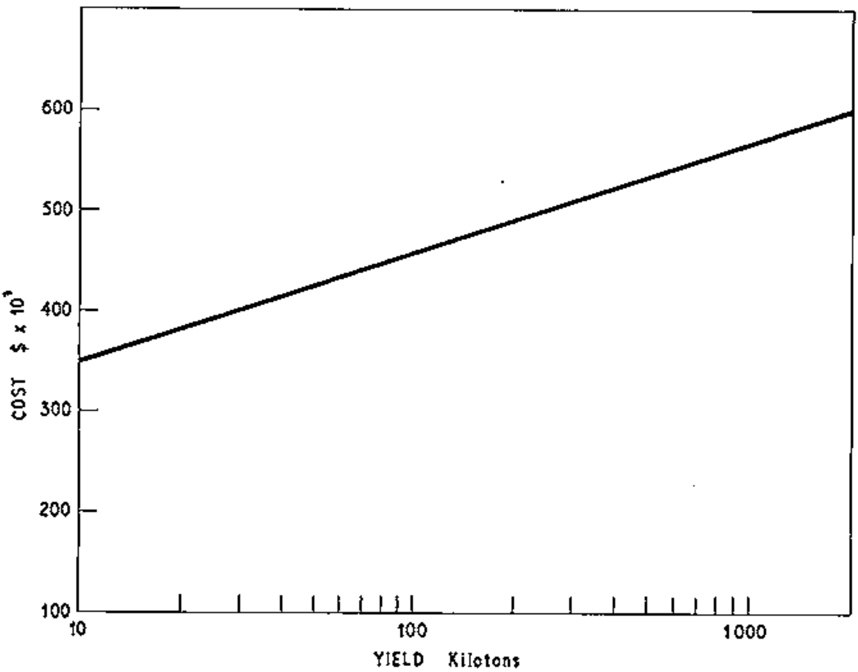


FIGURE 1. FUTURE CHARGES FOR THERMONUCLEAR EXPLOSIVES

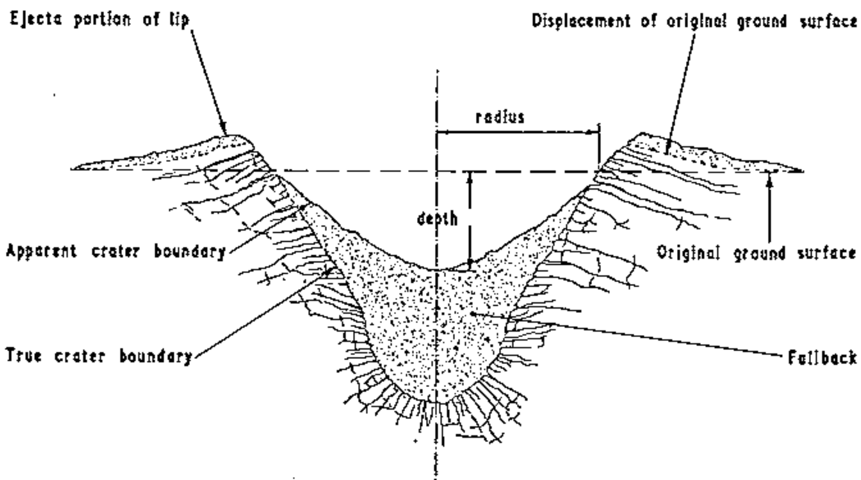


FIGURE 2. CROSS SECTION OF A TYPICAL CRATER IN ROCK

cratering explosion the fate of the various activities can be roughly predicted if the depth of burial and the nature of the sub-soil are known. Precautions necessary to counter these hazards are discussed in another paragraph, but the general rule is that thermonuclear devices must be used if radioactive contamination is to be minimized and economy achieved.

Cratering Effects

A crater must be clearly defined before cratering data can be fully understood, and Fig. 2 shows the cross section of a typical crater. For the purposes of excavation the prime interest lies in the apparent crater dimensions. Figs. 3 and 4 shows idealized curves relating the apparent crater radius and depth to the depth of burial of the charge.[2] The experimental points from which these were plotted show considerable scatter, especially for burial depths over 200 ft, and all points have been scaled to give results as if they had been exploded in desert alluvium. It can be seen that for surface burial a rather small crater is obtained. As the depth of burial is increased the crater dimensions increase until a maximum is reached at what is termed the optimum depth of burial. There is an optimum depth of burial for each particular crater dimension. As the depth increases still further the crater size drops off until the explosion is ultimately contained in the ground. The mechanisms by which subsidence craters and fully contained craters occur are illustrated in Figs. 5 and 6.

As a rule of thumb a 1 kiloton device buried 100 ft underground will produce a crater 300 ft in diameter and 80 ft deep. A 1 megaton device buried 1,000 ft underground will produce a crater 3,000 ft in diameter and 800 ft deep.

The use of a row of charges detonated simultaneously to excavate a ditch has so far been investigated only with chemical explosives, but the results will be applicable, using a scaling law, to larger nuclear charges. It has been found that charges spaced a single crater radius apart give a smooth-sided ditch with apparent dimensions 10 to 20 per cent larger than expected on the basis of single charge data. Charges spaced apart 1.25 times the radius of a single crater result in a ditch with dimensions approximately equal to those expected from single charge data. Charges spaced 1.5 times a single crater radius apart given an unsatisfactory result, the final cross section being irregular and the width of the ditch being actually less than the diameter that would be expected from single charge data. When a uniform ditch has been blasted, the lips on the sides of the crater are 50 to 100 per cent higher than would be expected from single crater lips, whereas the lip on the end of the ditch is virtually non-existent.

No precedents exist to enable engineers to predict the problems resulting from the instantaneous removal of huge quantities of material from deep craters. Because of the infinitely varied soil, rock and geological conditions which may be encountered in nature, predictions for the majority of cases are still difficult, but the PLOWSHARE programme has fully investigated the results of explosions in relatively homogenous desert alluvium and rock-like basalt.[3] The stability of crater slopes is probably the most important of these engineering problems, and, happily, nuclear explosions in rock and granular soils will generally provide slopes with long term stability, although of course geological discontinuities and water pressure must be allowed for

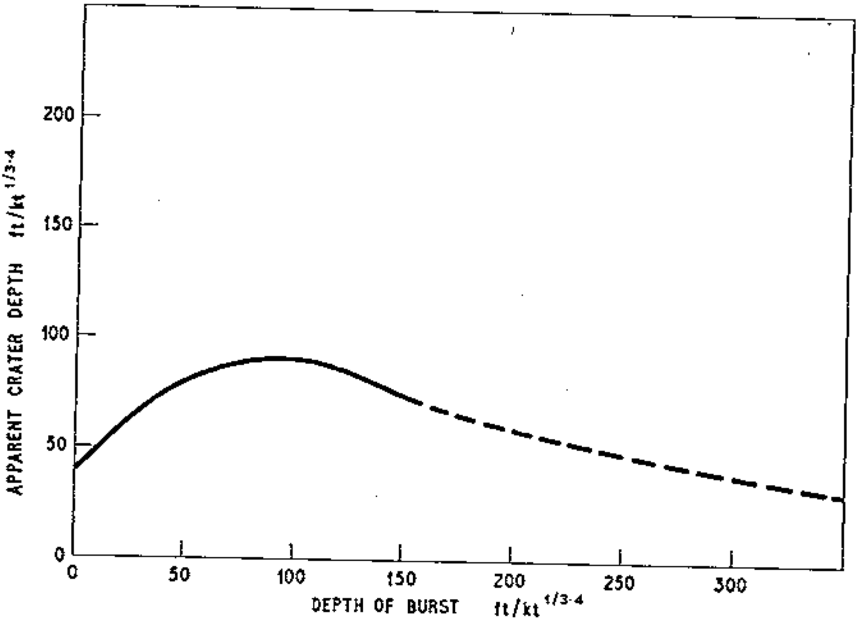


FIGURE 3.

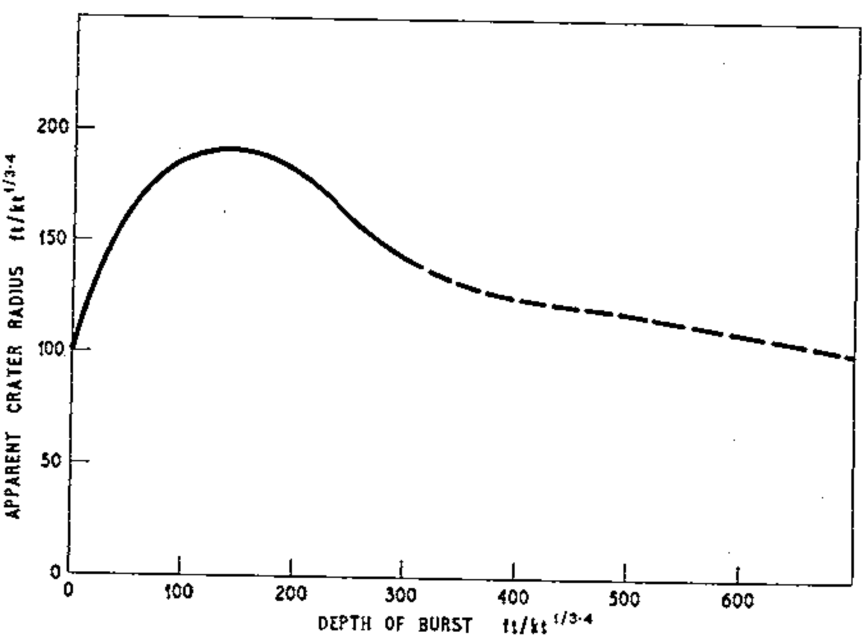


FIGURE 4.

in the final form of such excavations, just as they must be allowed for in conventional earth moving operations. The fallback materials in the bottom of such craters are also generally in a stable, dense condition because of the large drop height but being much finer are more liable to erosion. Long-term stability considerations in cohesive soils, including some shales, unfortunately require slopes which are much flatter than those which can be produced economically by nuclear means. The qualities of the lip of craters is also of importance since structures such as roads may well be built on them. While considerable grading may be required to level these lips, the evidence points to them as offering similar foundation conditions to the original surface strata, but with a layer of fine dust on top. The quality of ejecta from nuclear explosions has not yet been fully investigated, but the majority of it normally consists of the original sub-soil in almost unchanged density, with any rock broken down into aggregate which is either immediately usable, suitable for crushing or requiring secondary blasting.

Emplacement of Charges

Recent mine disasters have drawn attention to the accuracy and speed with which quite large holes can be drilled deep into the earth, and this is the very technique which is most often used in placing nuclear charges for earth excavation. There are three main drilling methods capable of boring holes of sufficient depth and diameter for device emplacement: auger drilling, core drilling and rotary drilling.[4] Auger drilling, using flight or bucket augers would provide a fast, low cost emplacement tool for low yield devices not more than 130 ft below the surface in moderately hard materials. Core drilling is a useful method for drilling through very hard rock up to 200 ft down, or where an auger drill has failed, while rotary drilling, the method now often used for oil well drilling has no real limitation as to depth or material conditions and has shown itself to be the most adaptable method for device emplacement. All three methods will require the hole to be cased if it goes below the water table, or if the sides are not strong enough to stand up by themselves. Of course, the narrower and shallower that the hole can be kept the faster will the drilling operation be completed. A lorry mounted flight auger can be positioned over a site, drill a 100 ft deep 36 in diameter hole in moderately hard material and move off in an 8 hr shift. A 66 in diameter hole, on the other hand, being drilled in hard material, may require many days for the transportation of the gear to the site and site-preparation and drilling may take place at under 1 ft per hour, with hole casing and dismantling of the gear perhaps doubling the total time.

The cost of emplacing a device will normally be more than the cost of the device itself. Costs per ft of completed hole can vary from $20 for a narrow, shallow hole in soft but dry material to over $500 for a wide hole in hard, wet ground. A series of similar holes dug in a row would of course be more economical than a single hole and if the diameter of the holes could be kept to about 48 in or less and the depth to under 130 ft then the drilling equipment could be lorry or trailer mounted with all the obvious benefits which that would bring. The cost of nuclear explosives is likely to continue to drop since the technology of making them is new, but the overall cost of using them for earth moving will not be reduced substantially until cheaper drilling methods are developed.

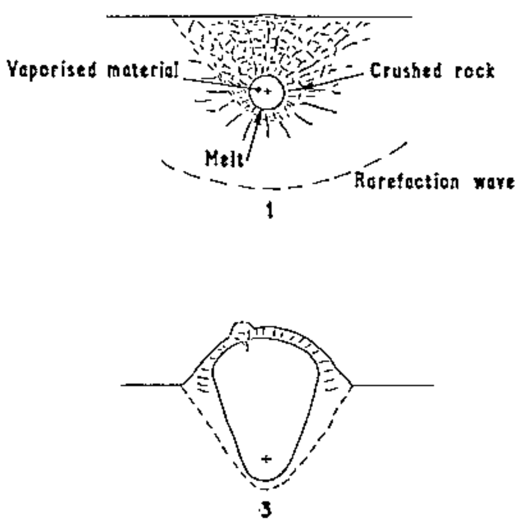


FIGURE 5. SEQUENCE OF CRATER GROWTH

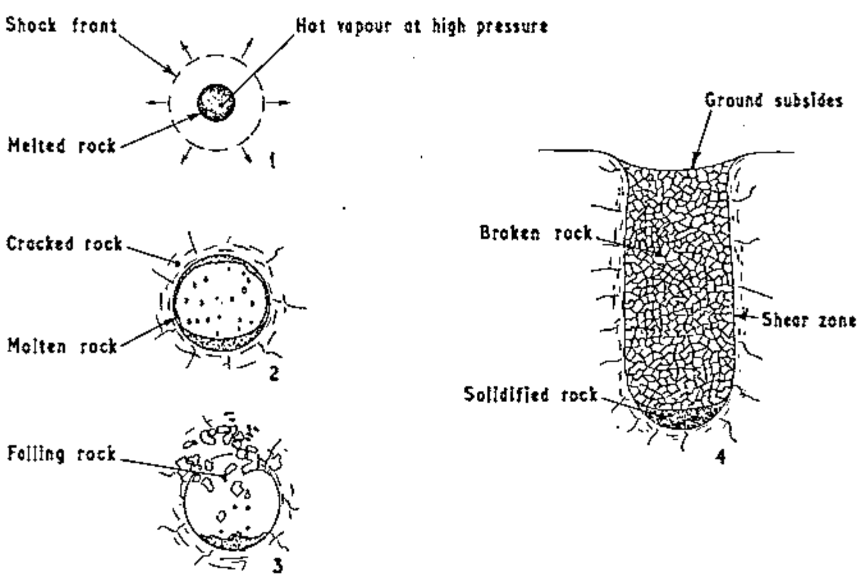


FIGURE 6. SUBSIDENCE CRATER GROWTH.

Hazards to Health and Property

It is no use pretending that it will ever be possible to create a second Serpentine in London with a nuclear explosive; the peaceful uses of such devices are possible only in remote, almost uninhabited areas or for schemes of sufficient importance to justify the evacuation, permanent or otherwise, of a population nearer than, say, 10 miles to the projected explosion. In general, this is not such a severe limitation as might be expected since it is nearly always in underdeveloped areas that fast, large scale earthmoving is required (new roads through mountain areas are a good example). However, accurate predictions must be made of the amounts, kinds and distribution of radioactivity which will be produced as well as the likely blast effects of any explosion. It has already been explained that the use of fusion weapons can minimize radiological dangers and Fig. 7 shows as an example the human

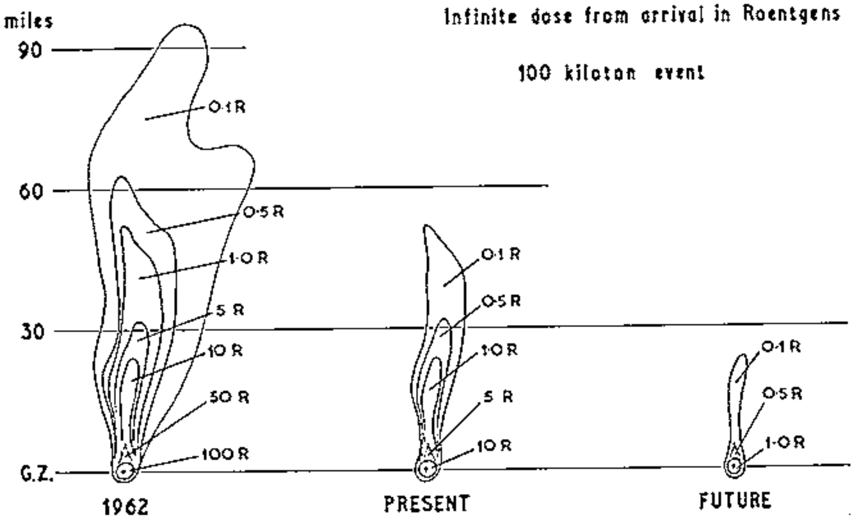


FIGURE 7. PRESENT AND FUTURE REDUCTION IN FALLOUT DUE TO IMPROVED TECHNOLOGY

lifetime dose pattern from a 100 kiloton event exploded in 1962, together with the reduction which may be expected due to improved explosive technology.[1] A delay of perhaps 24 hours will soon be all that is necessary before a crater can be entered for inspection after an explosion, while it should be possible to start normal work in a crater after about four days. Evacuation of the local population for radiological reasons will be necessary only for a matter of days while the area is accurately surveyed.

The blast effect along the ground from an underground explosion is only about 25 per cent of that from a surface or air burst shot.[5] However that part of the blast directed vertically upwards is very sensitive to atmospheric conditions and can cause damage at freak distances. Little work has so far been done on the blast effect of row charges for ditch digging, but there is some evidence to show that at certain points of the compass from such a charge the effects may have to be added directly together, and this could be the limiting factor to the number of large charges which can be exploded simultaneously for ditching. Again, a rough guide is all that is possible here. For one proposed scheme a row of ten devices with a total yield of approximately 1 megaton has been calculated to give a peak overpressure at the nearest town, 10 miles away, of up to 83 millibars, at which value only a few large shop windows will be broken (Project CARRYALL—see below). Some damage to property is inevitable in such schemes, but it must be estimated and added to the cost of the scheme. Thus it can be seen that, while the precautions necessary to safeguard life and property will necessitate a considerable effort and expense, provided that the nuclear engineering operation is in relatively undeveloped terrain the obstacles presented are by no means insurmountable.

Some Possible Uses

The uses to which nuclear explosions can be put fall into three broad categories, scientific research, industrial applications and engineering. The first will be of little interest to engineers and it is sufficient here to say that the research mainly utilizes the extremely high neutron flux available for a short time, the intense heat propagated, or the seismic effects. Industrial applications are slightly more applicable in an engineering article and it is worth mentioning that these include removal of earth to allow deep ores to be mined by open cast methods (and there are indications that the Russians used this method as long ago as 1956, although it has never been confirmed that the many kiloton yields used were in fact nuclear); the shattering of rock to release natural gas and to aid the recovery of oil from shale; the blowing of rubble chimneys to effect in-situ leaching of minerals; large scale underground chemistry to form, amongst other things, oil, from buried materials; and the production and storage of nuclear produced heat in contained craters.

The engineering uses to which it has been suggested nuclear explosions could be put are based on the cheapness with which they can excavate earth as compared to conventional methods. One estimate,[6] brought up to date by substituting the most recently announced costs for nuclear devices is

Yield of Device	Volume of Earth Moved	AEC (Bomb) Charges	Other Costs	Cost Per Cubic Yard
1 KT	230,000 cu yds	$250,000	$1,000,000	$5.45
10 KT	1,200,000	$350,000	$1,500,000	$1.54
100 KT	13,000,000	$450,000	$2,000,000	$ .188
1 MT	95,000,000	$600,000	$2,500,000	$ .033

Conventional methods in rock cost about $2 per cu yd. Another estimate is 2 cents per cu yd for a megaton explosion and $10 per cu yd for a kiloton explosion.[7] Of course a nuclear explosion will often remove unnecessary earth and any specific estimate would have to take this into account. Clearly, then, only the larger yields are economic at the moment, although if other costs (which include surveys, drilling, and all safety precautions) can be kept down, even the smaller yields would be. The obvious uses which cheap excavation methods suggest are the construction of canals, both for shipping

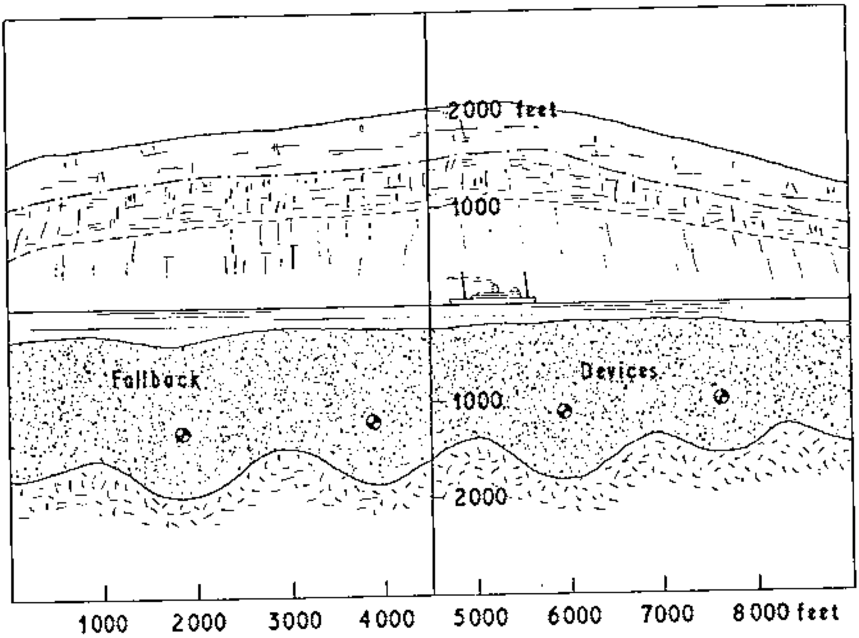


FIGURE 8. PROFILE THROUGH CONTINENTAL DIVIDE CUT

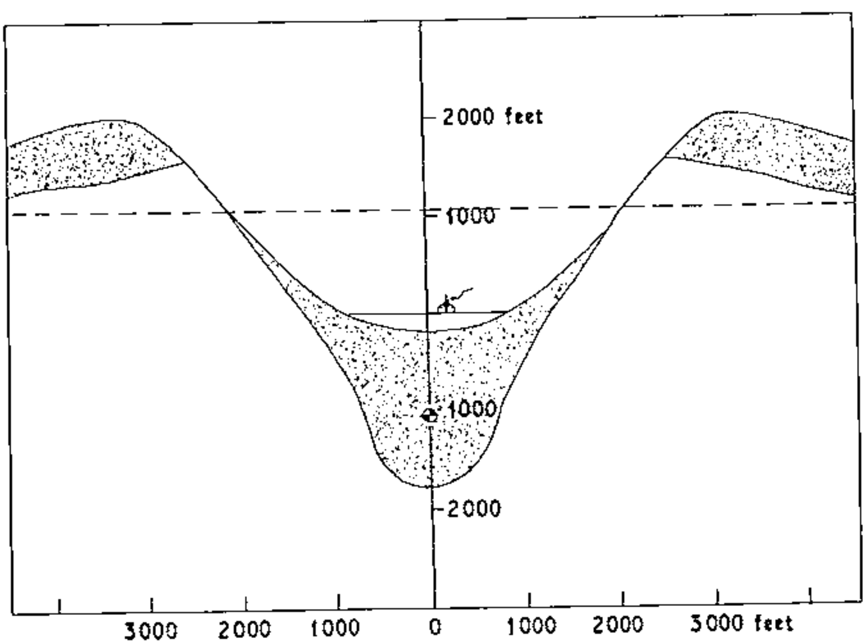


FIGURE 9. CROSS SECTION OF CONTINENTAL DIVIDE CUT

and for the movement of water, harbours and cuttings for roads and railways; the blasting of surface and underground reservoirs for water storage; the production of hardcore and the formation of dams.

The most widely publicized scheme for the peaceful use of nuclear explosives aims to build a new, sea-level Panama Canal. The present Canal has reached its capacity and in a few years will be quite inadequate. The estimate for widening and lowering to sea level the present Canal is in the region of two and a quarter billion dollars, while realistic estimates for the nuclear blasting of twenty-five alternative routes vary from about the same sum down to under one billion dollars.[8] As an example of the scale of operations which would be required details of one of the most favoured routes, known as Route 17, the Sasardi-Morti Route in Panama itself are here given. The cut would require 300 nuclear charges ranging in individual yield from 100 kilotons to 10 megatons, with a total yield for all charges of 170 megatons. The emplacement holes, all of which would require encasing, would have depths ranging from 550 to 1,230 ft. There would be fourteen detonations in each of which a row of charges would be fired simultaneously to blast a section of the canal. Between four and fifty charges, with a total average of 10 megatons, would be exploded in each detonation to dig sections of from 1 to 6 miles at a time. The most difficult section of this route would be through what is known as the Continental Divide, and Figs. 8 and 9 show how this cut is planned.

The nuclear engineering scheme which is in the most advanced state of planning is called Project CARRYALL.[9] The aim of this project is to reroute a railway and an important highway through the Bristol Mountains in California. A two mile cut with a maximum depth of 340 ft or a tunnel would be too expensive to accomplish by conventional means and the railway company and highway authority concerned are seeking to use nuclear explosives to make the cut. Twenty-two devices will be required, with individual yields of from 20 kiloton to 200 kilotons and a total yield of 1,730 kilotons. The resulting cut will carry eight traffic lanes and a railway. The total cost of the scheme will be about $15,000,000 as compared to $22,000,000 for the cheapest conventional solution, which would also mean a much longer route. If the best method could be done by conventional means it has been estimated that it would cost over $50,000,000.

Three nuclear engineering schemes have been proposed for Alaska;[10] a harbour at Katalla to give access to a vast coalfield, a canal through the Aleutian Chain to give an easier passage to shipping to western Alaska and a dam across the Yukon river to give hydroelectric power to the area (and incicentally, probably change its climate). In South East Asia a canal has been suggested across the narrowest part of Thailand to cut a thousand miles off the route to the Far East.

Australia has shown great interest in PLOWSHARE and has had a team studying it with the specific object of devizing schemes to help development of her vast rain-starved areas of desert. One simple application to this particular problem is to blow chimneys of crushed rock or reservoirs to hold the water from the very infrequent torrential rain which occurs. The Snowy Mountains scheme could perhaps have been more cheaply executed with the help of nuclear explosive.

Most of these schemes are outside the British sphere of influence so that the Royal Engineers would have little chance of participating in them and the

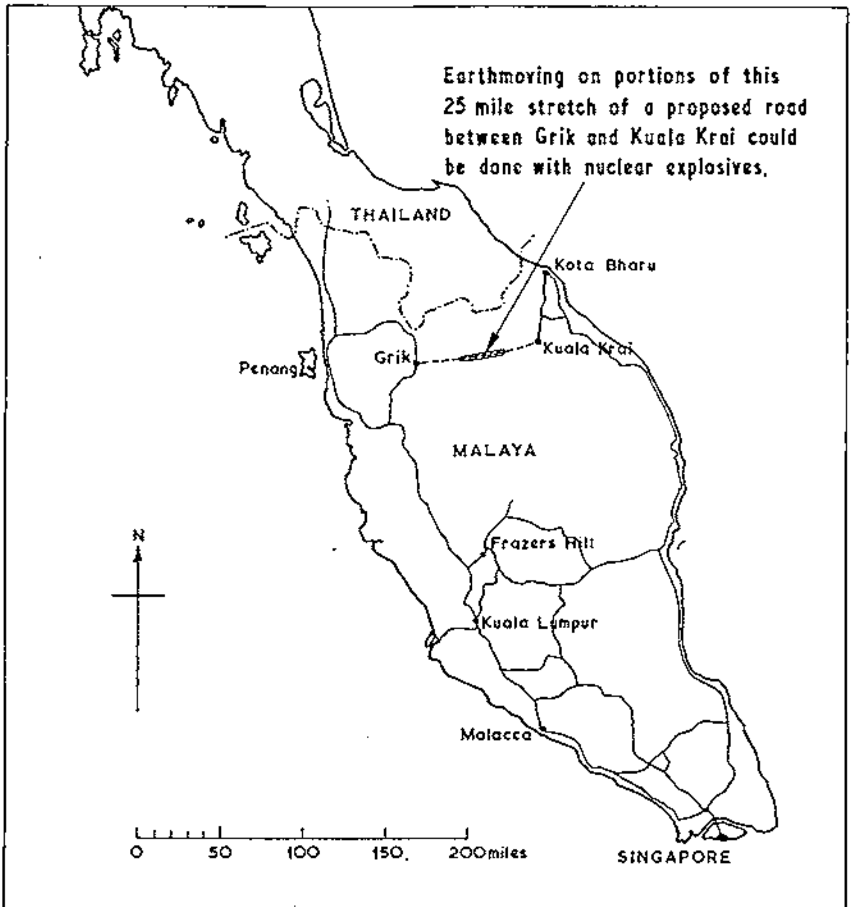


FIGURE 10. MALAYA

writer has heard of no proposals for schemes in which the Corps might take part. One possibility, however, would be the use of nuclear explosives to assist the construction of the road planned to link the East and West coast of Malaya in the North. At the moment a traveller wishing to go by road from the top left to the top right hand corners of the country has to go as far south as Frazer's Hill (see Fig. 10) making a total journey of over 450 miles. Grik, on the west and Kuala Krai on the east are only 75 miles apart but the intervening country is mostly mountainous jungle. The route was surveyed by a Troop of the Federation Engineers in 1959[11] and a project for the construction of the road prepared by the Canadian Government in 1962, but no work has yet started. The road would also have great strategic importance, running as it would close to the Thai border where there is still Communist terrorist activity. The USA has recently offered military and other aid to

Malaysia and it might, therefore, be possible to get experts from the PLOWSHARE programme to assist in the preparation of the scheme. Nuclear devices might also be provided by the AEC, were suitable British devices not available. The peaceful use of nuclear explosives in that part of the world might also have great propaganda value and a sobering effect on aggressive neighbouring states. Finally, the Royal Engineers could play a part in the execution of such a plan—which if carried out speedily, could be the first of its kind in the world.

Conclusion

Provided that some provisions of the current Test-ban Treaty can be relaxed nuclear explosives can now be regarded as an additional, powerful tool for the engineer. Although extensive research has gone into the method of their use, no one seems too anxious to be the first to undertake a project using them, partly for political reasons and partly because with no precedents it is not possible to be a hundred per cent certain of costs. If drilling costs can be substantially reduced so that excavation will be really cheap, all large earthmoving operations in the future which can use them may have to do so. Their use is possible only in relatively underdeveloped regions, although new techniques are constantly making them less of a hazard to health.

Nuclear engineering is now taught at the Royal School of Military Engineering but is mostly slanted towards reactors. Surely the Corps should gain more knowledge and experience in the engineering uses of nuclear explosions by taking more interest in the PLOWSHARE programme and studying possible projects such as the North Malayan Road. If then, in the future, a project arose which could be most efficiently accomplished by the use of nuclear explosives, the Corps would be in a position to undertake it and regain, perhaps, some of that reputation for pioneering new techniques for which Sappers used to be so well known.

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Assistance by the Royal Engineers to the Water Supply Industry in a Nuclear Emergency

By COLONEL S. K. GILBERT

FOLLOWING a nuclear emergency it is likely that the armed services would be deployed very largely in support of the civil power in one role or another. The most obvious uses for formed, disciplined and armed bodies of men are in the maintenance of public order. There are, however, bound to be a great many secondary roles for the armed services. For example, certain units of the Territorial Army are being trained in fire-fighting, and equipment is being provided for them to mobilize in this role. The fire-fighting stage should not however extend beyond the first few days following an attack.

At this period, a few days after the explosion of nuclear bombs, we might expect to be concerned with the most elementary aspects of existence—water, food and shelter. In fact one of the prime essentials at this period would be a supply of drinkable water. There are many reasons why our supplies of drinkable water at this period may be hard to come by and this article proposes to mention them, to describe the methods by which it is proposed to overcome them, the precautions already taken by the Ministry of Housing and Local Governments and the types of assistance which the Royal Engineers might give to assist in maintaining water supplies.

The principal problems are radio-active contamination of surface water sources by fallout, lack of electricity supplies, damage to water supply installations, and lack of personnel with the requisite technical training and in the numbers required at the vital moment.

About two-thirds of the population of the country are supplied with water from surface sources. This two-thirds includes practically the whole of Wales, the West Country, the Lake District, the great industrial districts on either side of the Pennine range, many large towns such as Manchester taking water from the Lake District, Liverpool and Birmingham taking water from Wales, Glasgow drawing water from Loch Catrine, London drawing water from the Thames, and many smaller towns, like York, Bedford, and Oxford dependent on supplies drawn from rivers. There are many gaps in our knowledge about the degree to which water would be contaminated by fallout. Not having exploded nuclear bombs on a large city we do not know the precise constitution of the fallout and in particular we do not know to what extent it would be soluble. It is, however, reasonably certain that where the fallout was heavy it could contaminate catchment areas, reservoirs and rivers to a degree which would make the water unsafe to drink. We cannot, of course, know in precisely what areas this contamination is likely to occur and we must, therefore, be prepared for it to happen anywhere. The rural areas which have been described as virtually wholly dependent on surface water sources—the Lake District, Wales and the West Country—are not heavily populated but it is always possible that a period of uncertainty before a nuclear war might lead many people to seek refuge in these westerly areas. We must, so far as we are able, prepare for many different eventualities.

Mention has been made of radio-active contamination of water to a degree which would render it unsafe to drink. This is not something which can be measured in water like its temperature, nor is the poison in this case one in which you can say a lethal dose is so much and a safe concentration would be so much. The effects of all types of radio-activity lead to a cumulative dose. In estimating the safe dose from water, account must be taken of the dosage received from the environment if the subject is in, or passes through, a fallout area and the dosage received from food. When estimating the safe dosage from water it is necessary to make some estimate of the length of time during which the subject will be consuming contaminated water. All these calculations or estimates have to be made against a background of the rapid rate of decay of many of the radio-nuclides contained in the fallout. One of the more difficult aspects in this respect is that some types of radio-active matter taken into the body in water (or in food) will remain in parts of the anatomy and continue their pernicious bombardment of it almost indefinitely. Radio-activity of 10^{-2} microcures per millilitre has been accepted as the maximum permissible for ingestion in water for planning purposes, but this level is at present being reconsidered.

Turning now to the difficulties which might be occasioned by lack of electricity supply we must realize that all underground water has to be pumped up, that all water from river sources must be pumped and that the only water supplies which will operate by gravity are those where there are reservoirs on high ground as, for instance, in the Pennine areas. Even in towns supplied from such reservoirs there are often small areas to which water has to be pumped owing to the height at which they are situated. A very large proportion of the population is, therefore, dependent on pumped water. Practically all water pumping is dependent on mains electricity supplies. Some pumping stations have other sources of power, for instance old steam plant not yet removed or diesel engines, sometimes specifically installed for standby purposes, but the proportion of the population served in this way is not large. Interruption of electricity supplies would, therefore, have a major effect on water supply.

There is of course a large number of electricity generating stations. Some might be destroyed by an attack but if after a nuclear catastrophe power were to be rationed and the water supply industry given a high degree of priority, it is likely that sufficient generating capacity to supply the water industry would be available. On the other hand electricity distribution arrangements are almost exclusively overhead power lines and sub-stations consisting of apparatus exposed to blast. The distribution arrangements might, therefore, be extensively disrupted. There is a saving element here in that the distribution network is an elaborate web which contains many alternative paths down which power might be channelled. Nevertheless we could reasonably expect widespread interruption of electric power supplies.

In all the circumstances before and after a nuclear attack there might well be deficiencies in the staff available.

We can now turn to what, in the immediate aftermath of the attack, would be the minor troubles which might beset the water industry. It may seem strange to place destruction of waterworks installations, disruption of mains and so on among the minor troubles. In the 1939/45 war these were in fact the major and almost the only difficulties. The difference arises from the differences in scale between one nuclear bomb and even a heavy attack by high explosive bombs. The heavy attack by high explosive bombs ruptured a number of water mains and possibly hit pumping stations. It left *in situ* the populations who were normally supplied through these pumping mains and installations. The explosion of a nuclear weapon would result in the total destruction of surface buildings over an area wider than that over which the underground water mains would be destroyed. Except, therefore, where a nuclear bomb destroys mains which go on to supply populations beyond the damaged area, the destruction of water mains is not likely to be a prime difficulty. Later, when the radio-active strength of the fallout had decayed, and when electricity supplies had been to some extent restored, these troubles would be the major ones during the reconstruction period.

As soon as possible after the attack it would be necessary to close valves on water mains running into areas of destruction. The areas of destruction for this purpose would, at first at any rate, extend to the areas in which buildings are only lightly damaged because the light damage may well include disruption of the plumbing fittings in a house, some of which are normally in the roof space, thus allowing escape of water until such time as the main stopcocks for the premises were turned off. In the early stages after a nuclear attack therefore a great number of valves on the water mains would have to be turned off and after this a large number of stop valves supplying damaged properties. It is not improbable that there would be a good deal of debris to clear before these stop valves could be reached.

Another difficulty that may face the water supply industry is that if there is a prolonged period of international tension there may be large movements of population into rural areas. The official dispersal scheme may or may not be put into operation but with some nine million motor vehicles available, unofficial dispersal could affect a massive proportion of the population. This would mean that certain rural localities might double or treble their population. There are few parts of the country which are not now provided with mains water supplies. Such supplies have normally been calculated on a basis of twenty-five or thirty or more gallons per head per day. If supplies can be maintained in these areas which we presume are well away from physical destruction by bombs, then by rationing and reduction in industrial demand there would be adequate water even if the population were more than trebled.

Water undertakings in common with everything else in the country would suffer from the general disruption of life and transport, the restriction of movement in fallout zones, the interruption to a greater or lesser extent of the telephone system and the overloading of all alternative means of communication. Many undertakings, however, have their own mobile radio networks and these should be of great assistance in transmitting information about damage and in organizing emergency measures after the attack.

It would perhaps be wise at this point to describe very briefly the way in which the water supply industry is organized, as it differs vastly from the other public utilities like electricity, gas and railways which have been nationalized. At the end of the last war there were 1,200 water undertakings in England and Wales and some 300 in Scotland. Today the number of undertakings in England is down to less than 300 and decreasing fairly rapidly. This has been done by combining numerous small rural and municipal undertakings into area boards. We still have in England many different types of water undertakings ranging from the Metropolitan Water Board which gives supplies to most of the Greater London area, down to small undertakings supplying two or three thousand people.

This great variety and multiplicity of undertakings, as they are all independent, must be led rather than driven on the way towards taking adequate civil defence precautions. During the 1939/45 war the industry was organized in "mutual aid" groups. It was not likely that more than one or two undertakings in a particular area would be badly hit and the intention was that the other undertakings in the group would help those which had been damaged to re-establish supplies.

This organization is being co-ordinated with the emergency chain of control. At each regional seat of government which would be the headquarters of a Regional Commissioner there would be a regional water co-ordinator. He is the Chief Engineer of one of the major water undertakings in the region. At the sub-regional headquarters there would be a sub-regional water co-ordinator and at lower levels in the chain of command, that is the countries and county boroughs, there would be liaison arrangements between the civil defence headquarters and the water undertakings.

From the government side the Ministry of Housing and Local Government has established a stockpile of mobile plant to assist water undertakings. This falls roughly into five parts: generators, deep well pumps, booster pumps, arrangements for carting water and arrangements for chlorination. There are mobile generators from 500 kW down to 7 kW. The larger and older generating sets are mounted on several trailers and are somewhat heavy and difficult to tow, but the recent purchases have been generators of 100 kW capacity which, mounted on their trailers as complete sets, weigh about 6 tons and are, therefore, reasonably mobile. The 100 kW generators are provided with Deutz air-cooled diesel engines.

In the smaller sizes we have generators down to 7 kW for the operation of 6 in submersible electric pumps and 1½ kW to provide emergency power for the fixed stations of water undertaking's mobile radio networks.

In addition to electric submersible pumps there are Morrison jet pumps. These are driven by diesel engines. The pump is in two parts. The high pressure section drives high pressure water down a pipe to an injector apparatus at the bottom. The injector produces a large flow of low pressure water up a second pipe in the borehole and this is suction-lifted and boosted at the top by the low pressure section of the pump. Self-contained pumps of this type can lift up to 7,500 gallons per hour from depths of 90 to 100 ft. They can, of course, only be installed in a large diameter borehole or in a well.

The numbers of such pumps stockpiled are not very large because the submersible pumps already installed at the bottom of wells or boreholes are most unlikely to suffer damage during a nuclear attack and in general it is anticipated that pumping stations of this type can be set in action as soon as either mains electricity supplies or some of the large number of mobile generators are available.

Where an area cannot obtain normal water supplies through the mains either due to contamination of a surface source or lack of electricity supplies for pumping, it may be necessary to supply a minimum of water to preserve life by carting. In this connexion it should be mentioned that it is not considered practicable to distribute water so that all premises receive a fair share through water mains if the quantity available is less than about 10 gallons per head per day. This is of course due partly to leakage from which all mains systems suffer (there are plenty of mains in this country which have been in the ground for one hundred years or more) and partly due to the fact that water will not reach the more distant and higher consumers if the nearer and intermediate consumers all make heavy demands.

This implies that either we have a fairly full mains supply in operation or we shall have to cart water, at any rate to part of the area. Our stockpile for carting water consists of tanks which can either be fixed on requisitioned lorries or set up on the ground. To operate a carted water system we should have to establish vehicle filling points (something not in any way new to Royal Engineers) and these we envisage as having something like the elephant trunk standard used to fill locomotive tenders. The tanks in the stockpile consist partly of rectangular galvanized steel tanks of 250 gallons capacity, mostly purchased during or immediately after the last war and 400 gallon plastic drums, some of fibre glass and some of polythene, which have been purchased more recently. In addition to the tanks fixed on vehicles and used for carting water it would probably be necessary to set up "water retailing stations". These would consist of some of the stockpiled tanks on the ground connected to tap ranges (which are also stockpiled) to enable large numbers of consumers to fill their buckets and jugs.

Such a carted water system would require a good deal of work in setting it up and could not come into operation quickly. To cover the interim period before emergency mobile generators can be brought to pumping stations, or a carted water system set in operation, the householder will be advised to store water in his house sufficient for about fourteen days. Even on a scale of a quart a day of drinking water some households might have difficulty in storing what they would require for such a period. There would be many other households where the precautions for one reason or another were never taken. There would be households were an influx of refugees had rendered the store insufficient. There would be households where, due to damage or accidents, the store would have vanished. For these and a great many other reasons we cannot possibly allow anything like fourteen days to elapse between the time of the attack and the time at which some improvised system of water distribution must become effective. We aim at having some sort of supply available even in the most difficult areas by, say, five or six days after the attack.

Part of the stockpile consist of 6 in plastic hosepipe and of 6 in rigid polythene pipe with quickly-made joints. It is intended to lay these types of pipe overground either to make connexions between mains systems where water is available and systems where it is not, to form a by-pass round an open service reservoir which has been contaminated by fallout, or to supply the vehicle filling stations described above. Large amounts of this material have been stockpiled by the Fire Service for fire-fighting purposes and, circumstances permitting, some of this would at a later stage be available for water supply.

The bacteriological purity of water is normally taken care of by careful selection and protection of sources, by filtration and by chlorination. Under the conditions following a nuclear attack we may be driven to use any source. It is unlikely that we should have filtration apparatus available and normal forms of chlorination being dependent on chlorine gas or chloros liquid would not outlast whatever stocks of these forms of chlorinating agents were held by the undertaking. It is not practicable to stockpile chlorine gas owing to the great cost and weight of the cylinders, nor to stockpile chloros liquid because this deteriorates seriously over the sort of period for which stockpiling would be required. We have, therefore, adopted bleach powder as our sterilizing agent, one which is certainly well known to all Sappers. The methods of chlorination would have to be improvised and might be somewhat crude, perhaps no more than a solution of bleach powder in a bucket with a hole in the bottom of the bucket from which the bleach dripped into the well or borehole or the pump suction. The bleach powder is stockpiled in hundredweight drums and is of tropical type with good keeping qualities. It has, when manufactured, 35 per cent available chlorine. After a nuclear attack we should probably aim at putting five parts per million of chlorine into the water from a doubtful source and two parts per million even from a good source.

Particulars of all known underground sources of water are being obtained and circulated to the principal civil defence headquarters and water undertakings. At these headquarters 1 in maps show the more important mains and all reservoirs, pumping stations, filter arrangements and so on.

After the fires, which would certainly follow nuclear explosions, have been put out or burnt themselves out, perhaps four or five days after the attack, it has been arranged that the Fire Service would come to the assistance of water undertakings. They would start the war with very large numbers of pumps suitable for drawing from surface sources, and for boosting, also a large quantity of 6 in diameter hose and portable piping. Circumstances permitting, much of this should be available to help in the restoration of water supplies. All pipe connexions on the Ministry stockpiled plant are of the same type as those used by the Fire Service on their hoses and 6 in pipes.

Structural precautions against damage from nuclear bombs can only be of marginal effect. Anything near the bomb-burst would be damaged beyond repair. There would, however, be zones of lighter damage surrounding those of total loss and these would be much greater in area than the former. Whilst it would not be economically possible to take precautions which would preserve the buildings in these zones, it may be possible to preserve the machinery. The essential parts of a pumping station which draws water from underground are the pumps, which are usually situated down the well or borehole and reasonably safe from damage, the pump motor which is often at the top of the well, but sometimes in modern installations built in one with the pump and submerged; motor starters, electrical control gear, instruments and valves on the surface are less essential items. In booster pumping stations the pump and pump motor is normally quite a small unit. It is, therefore, generally possible to protect the really essential parts of pumping stations by the erection, in a period of tension before an attack, of cribs or cages of steel and timber around these items. Collapse of the walls and roof would leave the essential parts of the station usable. Protection of all the electrical switch gear would be more difficult, but if the roof of the pumping station has been blown down, overhead electricity supply cables will be interrupted as well. If the pumps and pump-motors have survived and a mobile generator can be brought to the station, pumping can be re-started. Where the starter for the electric motor is damaged the mobile generator can be connected directly to the pump motor and then started, bringing the pump motor up to full revolutions as the generator speed increases.

Protection for personnel at water installations may be in the form of small shelters built of interlocking concrete blocks. The blocks would be stored in peacetime and put together as near as possible to the mains or valves which the personnel sheltered are to operate. Some of these personnel shelters would be built inside the pumping stations and so on. These cribs and shelters can for the most part only be installed during a period of tension before an attack.

Protection of water purification installations is, on account of their size, not reasonably possible. Where these are out of action we shall depend on emergency chlorination by the use of bleach powder.

After this somewhat discursive picture of the water industry, readers may reasonably ask what may be expected from the Royal Engineers.

(1) Before an attack it might in exceptional cases be possible to speed up the installation of protective cribs and fallout shelters, by assisting such work, although if the period of tension preceding an attack is short, Sapper units may not be organized and ready to operate in time.

(2) In the post-attack period, say from 3 to 15 days after the attack, help in organizing emergency supplies:

(*a*) installing our stockpiled pumps and generators at existing underground sources;

(*b*) assistance in creating the temporary installations required for a carted water service, i.e. vehicle filling stations and water retailing stations. (Sappers are too valuable to be used for operating as distinct from constructing this type of service);

(*c*) assistance in re-starting lightly damaged pumping stations;

(*d*) assistance in gaining access to and turning off valves on water mains leading into heavily damaged areas.

(Information about the position of these valves would be supplied by the water undertaking. It is intended that duplicate sets of plans concerning each undertaking would be held by their neighbouring undertakings.)

(3) During reconstruction—

(*a*) assistance in re-starting pumping stations which have suffered medium damage to the buildings;

(*b*) restoring flow past damaged parts of major aqueducts and pipelines;

(*c*) assistance generally in mending water mains in area which have only suffered light damage and where the breaks are few in number.

Such assistance as Sapper units may be able to give would be organized through the normal channels of the Civil Defence chain of control and would be supplementary to the major works assistance which would be given through the civil defence organization of the Ministry of Public Building and Works. This organization would also be the source through which construction materials, cement, steel and so on, would be allotted and which would also control the surviving resources of construction plant.

It will be seen that the whole of these tasks are well within the competence of normally trained Sapper units. Thus, although the restoration of water supplies would be a vital matter, it would appear that no special training will be necessary to enable the Royal Engineers to participate in this to the maximum.

Designing Roads by Computer

By Major A. S. Hogben, RE, AMI Plant E, AF Inst Pet

Introduction

In Lieut-Colonel K. R. Hasildon's article "The Critical Path Method—Some Simple Practical Considerations", published in the December 1964 issue of the Royal Engineers Journal, he made mention of computer programmes being used for both the Critical Path Method and the Project Evaluation and Review Technique (PERT).

It is felt that the use of computers in PERT, and indeed in other applications, may not be generally understood, nor may it be realized the wide scope of work which a computer can undertake and thus save the design engineer many hours of laborious work. It is, therefore, proposed to give in this article a general idea of what a computer is capable of in one example of project planning, i.e. road construction.

Road design and construction was selected because in this field considerable progress has been made in recent years; mainly on the Continent but now on an ever-increasing scale in Great Britain.

Scope

Computers have been used for several years as an aid to the rapid production of bills of quantities, basic calculations in all phases of civil engineering work and more recently in the complete planning and design of major highway construction. Complex road systems can now be designed and planned almost completely by computer. The technique can even produce perspective sketches and cine films of the road as it would appear when driving along it, and this all before a single sod of earth has been turned.

Background

Planning and building a road is a most complex activity especially if the road is to be of present Motorway standard. It involves numerous engineeering calculations and detailed mathematical analysis of traffic requirements. Many consultant engineers and contractors in Great Britain use computers to solve them, but road planning requires, above all, a high degree of organization. Each section of the road presents hundreds of problems, and has to meet just as many requirements. All of these are interdependent and if any one factor has to be revised, each individual computation may have to be repeated.

Many European countries have been quick to realize that this is a situation that can be handled "in toto" by a large computer. They have developed systems in which the information for each problem is fed into a computer and, as before, each problem is individually worked out, but the information remains in the computer store. The whole road design is completed, and if adjustments to any previous calculations have to be made the necessary adjustments to other calculations can be made automatically by the computer.

This then provides a final detailed plan for the road which has taken into account everything from the cost of labour to the amount of earth to be moved. If subsequently any revisions in the plan have to be made, these will occur before there is any wastage of human labour, although costly computer time will have been wasted.

Since 1959 the Swedish Board of Roads and the firm Nordisk of Stockholm have been steadily developing a scheme of this kind. Indeed the construction of all new roads in Norway, Sweden and Finnland is now aided by the calculations of Nordisk. More than 8,000 miles of road have been planned by the system at a financial saving, it is claimed, of 20 per cent in the planning stage.

In 1960 Nordisk ADB began to develop programmes to suit German conditions and road standards. Now most Autobahn construction is based on this system using a computer installed for the purpose in Düsseldorf and operated by Nordisk ADM GMBH, Fig. 1.

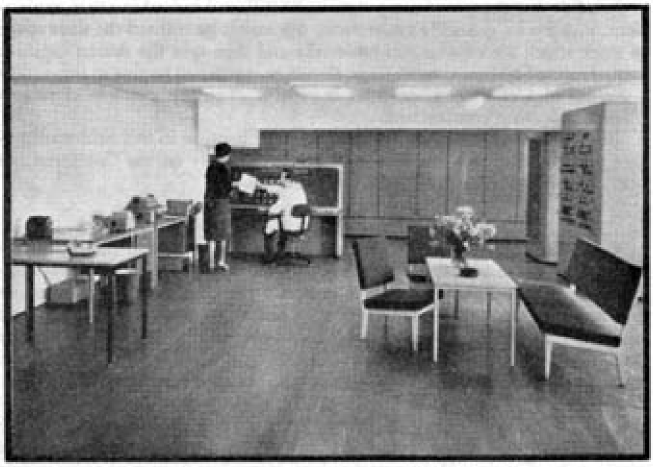


Fig. 1. The computer control room, DUSSELDORF.

In 1961 a Company was formed in Great Britain to provide a similar integrated data-processing service for civil engineers and contractors. This company is Computaquants Ltd which works in collaboration with Nordisk ADB. Although similar to its Swedish forerunner, Computaquants Ltd use a system based on the integration of aerial survey, photogrammetry and computer techniques. This technique it is claimed results in the quicker construction of roads, a better use of limited resources and a saving in cost of approximately 10 per cent. It is interesting to note that this is half the saving claimed by Nordisk of Sweden. This then is the background to the existing systems; ever-increasingly sophisticated systems are, however, being developed.

Method of Working

Photogrammetry lies at the heart of the scheme. This technique is not new and most people are now aware of the principles involved, but in this system under consideration, the information obtained via the scanner is fed directly into a computer. If the scanner is moved round contour lines, for instance, all the information concerning the rise and fall of the terrain can be

Designing Roads By Computer 1

recorded in the form of co-ordinates in the computer. Details of wooded areas, villages, other roads, etc, can be recorded by the same method. In this way the computer is provided with a detailed "model" of the terrain. The model will be a direct reproduction from nature, and furthermore it will have been obtained quickly and accurately.

A physical model could of course have been produced from the aerial survey or by detailed field surveys but since the areas are large, this production of a physical model involves considerable expense in terms of man-hours.

Because it can handle large volumes of arithmetic so quickly, a computer can calculate the volume of earth which may have to be moved for each possible road route. It can also allow for variations in the cost of land, in the total length of route, and other factors. Thus by making these calculations for a number of alternative routes, the computer can "optimize" and choose the most economical route.

Road design takes place in three stages, namely General Location, Exact Location and Final Design. *General Location* gives one or two strips of country up to a mile wide in which the road will be built. *Exact Location* gives a final route within the selected band of country, and the *Final Design* provides the engineer with detailed working drawings of the road as it will be constructed.

The general location, in Great Britain certainly, does not require the use of a computer since ground development is so dense there can only be at the most three possible general routes for the road. The consideration of which general route to be taken is then often based on the views of local organizations, wild fowl trusts or political opinion.

The exact location within the selected general route is then determined by the computer using the computer "model" as described above in conjunction with the results of field studies and analysis of technical and economic problems which are also fed into the computer. At this stage it may become apparent that the proposed route has some serious drawbacks; it may, for instance, not have provided easy access to a large industrial concern which is also only at the planning stage. In the normal process of road design this could be a major set-back and require many hours of tedious calculations to find a suitable solution and drawings and models would have been wasted and need to be reproduced. In the computer system, however, basically all that has to be done is to feed the new restrictions into the computer and wait for it to produce an alternative. In practice the feeding in of the new restrictions may be rather complex, but nevertheless the saving of time and physical effort is great.

When the final route has been selected a more detailed and accurate computer "model" is made incorporating the results of geological surveys, subsoil structure and possible drainage problems. Details of intersections, bridges, etc, are calculated and the computer is then in a position to give the final design in such detail that marking stake positions, exact cut and fill at any point and the host of detail required for engineers working drawings can be provided.

The planning is now complete but even at this stage, if circumstances require a rerouting of any part of the road, this may be done at little financial loss by the same method as described after the second stage. The final end products from the computer are automatically drawn cross-section sketches of the roadway and even if desired, a 16 mm film which makes it possible to "drive along the road" while it is still at the planning stage. More details of this somewhat expensive by-product of the computer will be considered later.

The expression feeding information into a computer has been rather loosely used but obviously the skill in making this system work is knowing when and what information to feed in. This is planned in the same manner as the designers' work load would be planned were all calculations being prepared manually.

The design is split into a series of separate programmes which will be interconnected in the computer, see Fig 2. For example the first programme will consist of origin and destination (O & D) studies, a detailed study of traffic requirements which, among other things will determine the best place to start and finish the road. The planners will also need to know whether it is more economic to dig through a hill or run the road over it (vertical alignment), taking into account that this latter course would increase the fuel consumption of the traffic and slow down the average road speed. This and the first problem are obviously interrelated. If the road is to carry heavy traffic between two industrial towns it may well be better to make a cutting through the hill.

So the various factors are dealt with separately, and the conclusion from each programme is either sent direct to an automatic line plotter, or used as input data for another programme at a later stage. This is more clearly shown in Fig 2.

Future Development

Mention has been made of the 16 mm film of the proposed road produced via the computer. This is done by connecting the computer output to an oscilloscope. The computer is then asked to give the cross section details of

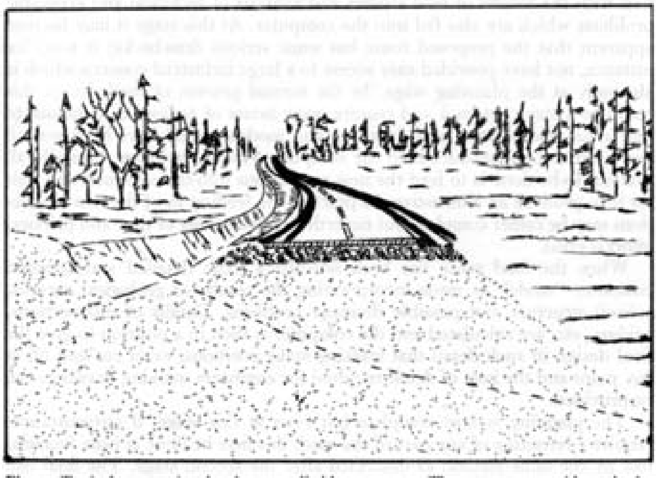
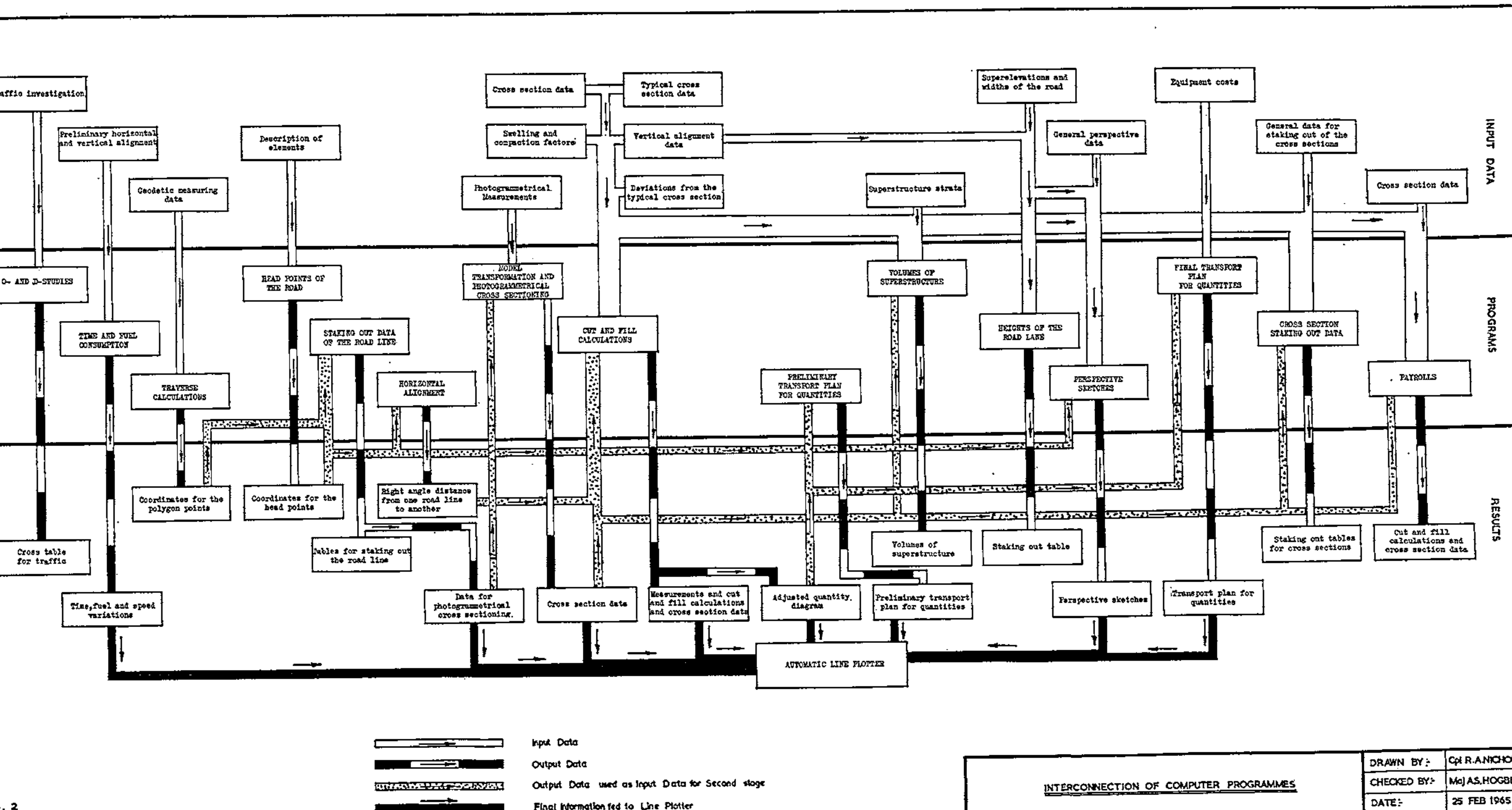


Fig. 3. Typical perspective sketch as supplied by computer. The computer provides only the heavy black lines denoting the run of the road and the dotted line which shows the amount of cut and fill when superimposed upon a base line.



. 2

INTERCONNECTION OF COMPUTER PROGRAMMES

DRAWN BY:-	Cpl R.A.NICHOLLS
CHECKED BY:-	Maj A.S.HOGBEN
DATE:-	25 FEB 1965

the road at one metre intervals. By adjusting the controls of the oscilloscope, the cross section of the road can be made to appear as if seen in perspective by a driver, Fig 3. The patterns on the screen are then photographed so that each frame on the film represents a view of the road at one metre intervals, and when the film is shown, the viewer gets an impression of driving along the road, Fig 4.

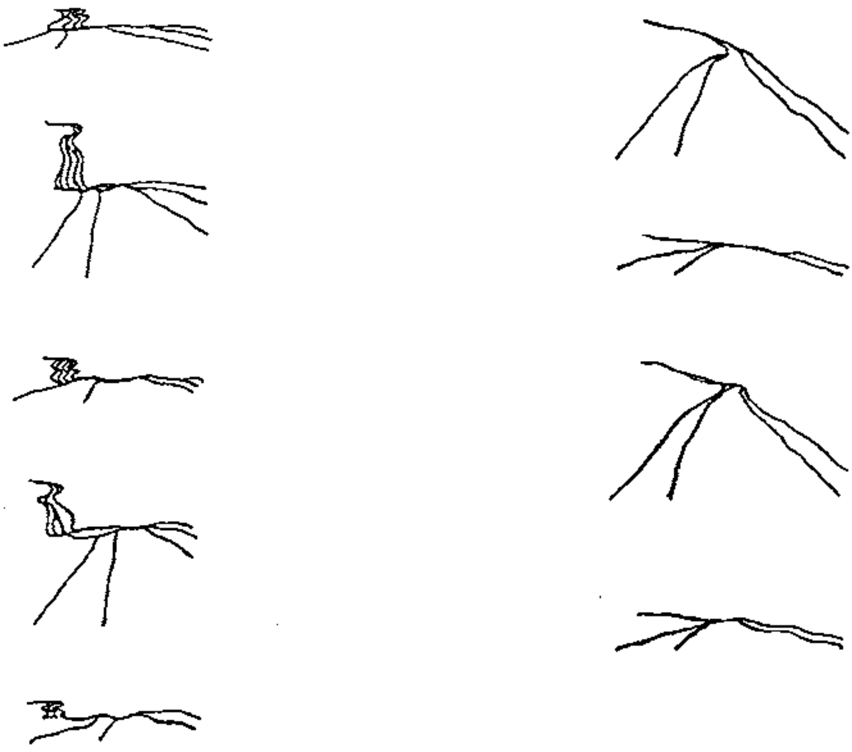


Fig. 4. Typical series of perspective sketches, which would appear as separate frames on a 16 mm film.

This is not, however, a cheap process. Until the latest Holywood motion picture Colossus was produced, a film of two kilometres of a proposed Swedish road was the most expensive movie per ft of film ever made. On the other hand the potential of this method is unending. From the film or perspective sketches the safety requirements of a road can be ascertained, checked and rectified. A road may be perfectly designed from an engineering standpoint and yet contain hidden dangers. A common fault is that a perfectly correct set of bends may at some stage give a driver the optical illusion that the road is slipping sideways away from him. Such an effect was spotted in a film made in Sweden and was rectified before the road was constructed. Had the film not been produced, this fault would not have been noticed until the road was opened to traffic. Manually prepared perspective drawings could be drawn for every suspect section of a proposed road but the cost and labour involved would be huge. By exploiting the computer it is claimed that these perspective sketches can be produced at a relatively low cost and with a minimum of labour.

When this technique has been reduced in cost, it may be possible for any interested parties to view a proposed road before it has passed the design stage.

Looking still further ahead, it is possible that a computer film could be produced which would show the road complete in all detail. This would enable the efficiency of road signs and possible lighting to be tested before work starts on the construction.

Implications in UK

As was stated earlier, most of the work on this system was developed and used in the Scandinavian countries and then later in Germany. All are countries which are building large quantities of motorways. Great Britain, which also plans to build an ever-increasing amount of motorways, is an ideal country for further development of this system. Yet at the moment, although computers are in use for individual sets of calculations, only one stretch of road has been designed by the Nordisk system. This was the Sheffield to Leeds Motorway.

It is the flexibility of the computer system which makes this method so suitable for roads in Britain, where industrial and residential conditions are rapidly changing. Although governments change, it is a fair assumption that Britain will be spending an ever-increasing sum on motorway construction. Money will be the eventual factor which will govern the extent of Britain's road net work, but another almost equally important factor will be the amount of strain which can be placed upon the engineering and technical resources available. If we continue to use the present methods of planning, it is possible that there will not be enough trained personnel available and, therefore, the advent of the computer into civil engineering design must be encouraged.

Advantages of Computer Planning

Since each problem at every stage of the planning has to be fed into a computer, the procedures have to be standardized. This then makes the training of designers, engineers and architects much simpler since the presentation of their various problems must be in the same form. Other advantages of the system are more obvious. The routes selected are more economical and safer, detailed knowledge of quantities involved provides a better basis for tendering, and correct planning simplifies the work on the site and increases the efficiency of available plant and equipment.

Acknowledgements

Nordisk ADB—Düsseldorf. For permission to use their photographs.

Computaquants Ltd—London. For the personal help given by their Managing Director.

For Valour

Two Sapper VCs

The Victoria Cross was instituted by Queen Victoria on 29 January 1856. Until then medals had only been awarded for campaigns or for long and meritorious service. The new decoration was to be given to officers and men alike of the Army and Navy as a rare mark of honour for bravery in action before the enemy. The Cross bore the now-famous simple words "For Valour", and it is known to this day throughout the world as the highest possible award for heroism.

Since its institution forty-six Victoria Crosses have been awarded to Royal Engineers and to Sappers and Miners, later incorporated into the Corps of Royal Engineers. Two Crosses have been awarded to officers of other Corps who began their military careers as enlisted Boys in the Royal Engineers. The Royal New Zealand Engineers can claim two Crosses and the Royal Canadian Engineers and the Indian Engineer Corps one each. A present member of the Engineer and Railway Staff Corps RE (TA) holds a Victoria Cross, which he won as a Commando Lieut-Colonel during the raid on St Nazaire in 1942.

True to the traditions and Motto of our Corps the Royal Engineer Victoria Crosses have been won everywhere, on land, at sea, in the air and in the "water that is under the earth", alone or accompanied by other brave men, by day and by night, in attack and in withdrawal, in successful operations and in glorious failures whilst performing Sapper tasks in every major war in which our Country has taken part.

The Corps has recently acquired two Victoria Crosses, those awarded to Corporal John Ross of the Royal Sappers and Miners, a Crimean hero, and to Sapper William Hackett, the tunnelling hero of the First World War. The Corps now possess eleven of the forty-six Crosses awarded to the Royal Engineers.

The first Royal Engineer Victoria Crosses were awarded retrospectively for acts of gallantry performed during the siege of the fortress of Sebastopol during the Crimean War 1854–1856. This was the last time that traditional siege operations were carried out in war. A First Parallel was opened out of musket shot of the fortress in which batteries were installed. Under the covering fire of these batteries saps were dug obliquely forward and other parallels opened, where further batteries were installed, and rifle pits dug once the saps came within musket range of the fortress. Saps were then pushed forward to within assaulting distance of the walls themselves. In this maze of earthworks, trenches, saps, breastworks, batteries and rifle pits only the RE officers and the Royal Sappers and Miners, who were constantly employed on their construction and their repair after heavy enemy bombardment, knew their way about. It was, therefore, the custom to use Sappers and Miners as guides to parties going up the line. These guides wore a white band around their hat and "Follow the Sapper, Quick March" became a well known order. Victoria Crosses were awarded to one RE officer and two Royal Sapper and Minor NCOs for extreme gallantry during these sapping operations. On 18 June 1855 the British forces launched an attack on the Redan, a formidable high-walled battery containing seventeen heavy guns, which dominated their positions. The assault was delivered by three columns,

Corporal John Ross VC

each headed by storming parties of RE officers and detachments of Royal Sappers and Miners equipped with heavy scaling ladders, sacks of wool to throw over the abattis and cheveaux de frise surmounting the walls and tools for tearing down defences and consolidating ground won. A Royal Naval Brigade, working with the Royal Sappers and Miners, formed part of the scaling ladder parties in one of the columns. Despite the greatest dash and gallantry of these ladder parties the assault was repulsed with heavy loss. Two RE officers and two Royal Sappers and Miners were awarded Victoria Crosses for heroism displayed on that day.

The final Sapper VC of the war was won by Corporal John Ross, Royal Sappers and Miners. It was awarded for two outstanding acts of gallantry, on 21 July 1855 and 23 August 1855, during sapping operations after the repulse of the attack on the Redan and for intrepid conduct on the night of 8 September 1855 when Corporal Ross crept up alone to the formidable walls of the fort, scaled them and found that the Redan had been evacuated by the Russians.

At the conclusion of the Crimean War the Royal Sappers and Miners were, on 17 October 1856, incorporated into the Corps of Royal Engineers thus terminating the long-standing anomaly of the military engineer officers and other ranks belonging to separate Corps.

On 26 June 1857 a great parade was held in Hyde Park at which Queen Victoria made the first presentations of Victoria Crosses. Corporal John Ross, now a Royal Engineer, was personally invested with his Cross on that parade.

The Cross was entrusted to the Corps, through Brigadier R. L. France, MC, Chief Engineer, Western Command, on 21 April this year by Miss Mary Evelyn Ross, of Pontypridd, grand-daughter of Corporal Ross, now in her seventies and the last of the family. She also presented her grandfather's Baltic Medal 1854–55, the Crimean Campaign Medal with Sebastopol clasp and French and Turkish medals for valour.

The second Victoria Cross was acquired through Mrs M. W. Hopkins of Mexborough, the daughter of Sapper William Hackett, VC. It was accepted on behalf of the Corps by Brigadier W. M. Inglis, Chief Engineer, Northern Command. Hackett's was a posthumous award.

William Hackett was a married man aged 41 years with two children, a boy and a girl, at the outbreak of war in 1914. He could neither read nor write. He was a miner by profession and employed at Manvers Main Colliery, Mexborough. His son left school to go down the mines at the age of 14 and, a month before his father died, he was involved in an accident which necessitated the amputation of a leg. Hackett tried three times to enlist in the York and Lancashire Regiment, but on each occasion he was rejected on account of age. In October 1915, however, he was accepted as a Sapper in the newly raised Tunnelling Companies. Men for these units were recruited from the mines; they were hastily kitted out and, after the scantiest military training, they were immediately posted overseas. By early 1916 over 20,000 British, Canadian, Australian and New Zealand Sappers were employed in Tunnelling Companies on the Western Front.

On 22 June 1916, eight months from the day he enlisted, Sapper Hackett with four other men of the 254th Tunnelling Company, RE were working in a mine gallery, known as Shaftesbury Avenue, near Grivenchy. At about 3 am an enemy counter-mine was fired which destroyed a part of the front-line trench system close by and the shock of the explosion shattered the

Sapper William Hackett, VC

Sapper William Hackett VC

timbering of the Shaftesbury Avenue mine gallery. The roof near the entrance collapsed and the party working in the shaft were trapped. After digging feverously for twenty-four hours a narrow escape tunnel was excavated through the fallen earth and broken timbers by means of which Sapper Hackett was able to assist three of the party to make their way out to safety. His fourth companion, Private T. Collins of the 14th Battalion the Welch Regiment, a miner also by profession attached to the 254th Tunnelling Company, was badly injured and had been unable to escape with the others.

Sapper Hackett had not seen the light of day, nor breathed a lung-full of fresh air for over twenty-four hours, he was almost famished and desperately tired from his unceasing toil in the darkness and dangers of the crumbling mineshaft. To most it would have seemed that he had done enough. He was, however, confronted with the fearful choice of either facing certain death underground by returning to help Private Collins, or leaving an injured comrade to die there alone. Thinking, perhaps, of his own small son so recently crushed in a pit accident at Mexborough, he did not hesitate. Well knowing the odds against him, he went back: "I am a miner" he said: "I must look after my mate".

Shortly afterwards the whole shaft collapsed and, although a rescue party worked desperately for four days, the attempt to reach the two buried men failed. For this act of great gallantry and self-sacrifice, Sapper Hackett was posthumously awarded the Victoria Cross.

Mrs Hopkins was insistent that there should be no ceremony when she entrusted her father's Victoria Cross to the Corps. She declined suggestions that the handover should take place either at the local TA Drill Hall, or at the colliery where her father once worked and is still remembered. As she placed the small bronze Cross in Brigadier Inglis' hand she remarked: "It seems such a little thing in exchange for a life."

Greater love has no man than this, that a man lay down his life for his friends. "Quo Fas et Gloria ducunt".

Correspondence

Nuclear Power Field Office,
US Army Engineer Reactors Group,
Fort Belvoir, Virginia, USA.
8 April 1965

The Editor
RE Journal

MILITARY APPLICATION OF NUCLEAR POWER

Dear Sir,

After almost a year with the US Army Nuclear Power Programme, I would agree with most of the basic facts in Major Whitaker's article in the *Journal*. The gas cooled mobile reactor is very expensive and is a prototype to develop doctrine on the use of mobile reactors in the field. Small portable reactors have not proved as reliable as was hoped during their first two years of operation.

It should be remembered, however, that these first generation nuclear plants are essentially pioneer efforts in an exciting new field. The US Army Engineer Reactors Group recognize current deficiencies in these systems and are working to correct them but they should not be overemphasized. When the US submarine *Triton* made an eighty-six-day underwater circumnavigation of the world under nuclear power this was hailed as a major achievement in the world's press. The Army Nuclear Power Programme's PM-1 was shut down in April 1964 for maintenance after a 110-day power run; the SM-1A completed a 115-day power run last August. These, too, are real if less spectacular achievements in the nuclear field. Experience with these first generation systems has been invaluable in identifying possible problem areas when considering future designs. For example, inherently safe reactor cores are now envisaged with prompt negative temperature coefficients which would obviate the need for reactor control rods with their associated complicated electronic circuits.

I would agree that the British Army should not attempt to buy or develop similar first generation plants. Information on the operating experience of the US systems is readily available to the Corps. However, I cannot agree with Major Whitaker when he states that there would be little point in the British Army becoming too interested in this type of equipment. Second generation reactors could have vastly different military and technical characteristics when compared with existing systems.

At present I cannot give details of new designs but it would seem imperative that our Corps, with its tradition of forward thinking when science is used to forward the art of war, should remain extremely interested in the military reactor field. We are now acquiring a limited expertise on nuclear reactors within the Corps. At the appropriate time we should be ready to participate actively in the task of bringing land based nuclear power to the British Services. It would be particularly unfortunate if, because of the occasional traumatic experience with first generation US Army systems, the Corps lost interest and missed the "nuclear bus".

Yours faithfully,
J. D. Isaac, Major, RE.

Headquarters, RSME,
Brompton Bks,
Chatham, Kent.

The Editor
RE Journal

ROYAL ENGINEERS AND THE GEORGE MEDAL

Readers may recall the article bearing the subject heading that was compiled by the Royal Engineers Historical Society and published in the *Journal* of December 1964.

The article included a list of Royal Engineer recipients of this award which was thought to be complete as it was compiled from the copies of the *London Gazette* held by the Institution. However, thanks to the interest shown by some readers and a subsequent research into other gallantry awards, it has been determined that the following awards should be added to those already published:—

Name	*Date of London Gazette*
Lieut Michael Arthur Clinton, GM (bar to GM)	17 August 1943
2nd Lieut (A/Lieut) Lewis Gerhold, GM (bar to GM)	
Lieut Thomas Blackshaw	
1894353 Sergeant Thomas Hall	
878335 Sapper Robert Southall	28 September 1943
1894307 Sapper Kenneth Hutton	14 October 1943
2009340 Sergeant Arthur John Ashmore	19 November 1943
1893128 Sergeant Leonard Charles Hollands	
Lieut Gordon Martin Jensen	
2127158 Corpl (L/Sergt) James Baird Renfrew	
Lieut Robert Sharp	
2009432 Sergeant Cecil Simpson	
Lieut Alexander Charles Thomas	
Lieut (T/Capt) Edward Louis Bourne	23 December 1943
Lieut John Stuart Pullinger	December 1943
WO II L. C. Sims	6 February 1951
2nd Lieut J. Sturgess	

One correction should be made to the original list published, ie 2nd Lieut (A/Lieut) Clive Nevil Hewitt should read 2nd Lieut (A/Lieut) Clive Nevil Newitt. This error is regretted.

With the additional names given above the number of George Medals awarded to Royal Engineers, including bars to GM, totals 144.

F. T. Stear, Lieut.Colonel
Secretary, Royal Engineers Historical Society

Coton Grange,
Corporation Lane,
Shrewsbury.
Telephone 4171, Salop.
28 January 1965

The Editor
RE Journal

Dear Sir,

In view of the "rationalization" of the services now taking place, it is hoped that the enclosed documents—almost twenty years old—may be of interest.

My recollection is that the article was conceived from the germ of a "spanner D.E. $\frac{1}{2} \times \frac{5}{8}$ in" which at that time could have any one of three "vocab numbers", ie, E or Ordnance or RASC—according to the type of equipment with which it was issued!

Apart from the transfer of Postal Services to Royal Signals (which I still consider to be logical) the proposals bear a surprising resemblance to the changes now being implemented.

Yours faithfully,
Lieut-Colonel N. L. Blandford, MA (retd)

CE 1156, 52/1
31 May 1945

CE HQ L of C (167 CE Wks)

The attached paper has been prepared by Lieut-Colonel Blandford.

The reasoning appears to be logical and the conclusions interesting, it is therefore forwarded for such action as you may consider suitable.

A. C. Baillie, Colonel.
CE (Wks) 11 L of C Area.

BLA
ACB/AJS

ENCL:

When REME was formed, a valuable step in rationalizing the organization of the Army was taken. This was, however, only a first step, and it is suggested that the time has come for further changes.

The following ideas, which cross from a discussion on the relationship of RE Works in Tn, come from the consideration of the problem from the RE point of view, and are based on experience in L of C units and formations. Their scope is therefore limited accordingly.

The basis is that the duties of Corps and services should be rationalized so that each has its own clear cut responsibility to the Army as a whole; and the divisions suggested are as follows:—

RE (Works)	Civil and General Engineering
REME	Electrical and Mechanical Engineering
RASC	All forms of transport (other than unit transport)
Ordnance	Universal Providers
R. Signals	Communications

A rough outline of the scheme is attached at Appendix "A".

The main matters in which these proposals are different from present-day practice are:—

(*a*) Port, railway and canal construction and repair are now the responsibility of "Transportation"—a hybrid which is of the Corps, but scarcely in it. It is suggested that all this is in fact "Works".

(*b*) Within the Works Organization certain responsibilities would, owing to their geographically widespread repercussions, be better directly controlled by CE (Wks), if necessary through Specialist CRE, eg, railway, canal, and main road construction and repair. Pipe lines. Long distance HT power lines.

(*c*) Dock canal and railway operation are all component parts of the organization to get personnel and stores from A to B. As such, they should be co-ordinated with Road Transport Operation.

At present, road, rail and docks are under "Transportation", and road transport is operated by RASC.

It would be logical for the whole to be organized under "Tn", as the name is appropriate. Tn is not, however, an existing Corps, and RASC is, so it is suggested that "Transport Operation" become the main role of RASC.

(*d*) At present, G.1098 stores are provided by Ordnance; Rations and POL, and in some cases Accommodation Stores, by RASC; Engineer Stores by RE (who in some cases get them in the first place from Ordnance).

It is generally agreed that requirements of RE Stores are so large, diverse in types, and different in function from all other stores that it is necessary to have an RE Stores organization.

It is suggested that the provision of all other stores and equipment including expendables such as rations, POL, and ammunition should be the responsibility of one "universal provider"—ie, Ordnance.

(*e*) Recovery and repair of railway stock, MT stock, dock cranes, etc., now a Tn responsibility, should obviously be brought into the sphere of REME activities.

(*f*) Postal Services, although nowadays nothing to do with the Corps, still wear RE badges. It is suggested that letters, like telegrams and telephone messages, are dealt with in civil life by the GPO. Why not co-ordinate in the Army, too, by making Postal Services a branch of R Signals?

A result of these changes would be an increased demand by Ordnance for transport. This would be met by attaching RASC units for work with Ordnance, as is at present done very successfully for RE Works (when any RASC Tpt is available!).

Another result which would probably follow is that "Movements" would come to be mainly staffed by RASC officers instead of RE—a reasonable and logical development, on which it is not necessary to dwell.

Appendix "A"

Division of Responsibilities as Between Services

RE (Works)

Port, Railway*, Canal*, Road* — Construction and repair. Including bridges

Provision and repair of accommodation and its ancilliaries (ie, drains, water supply, electric light and power, etc.)

Erection, operation and maintenance of power houses, pumping stations, pipelines,* etc.

General engineering work other than REME work.

Provision of Engr Plant and Stores.

Ordnance

Provision of all non-expendable war-like stores, other than RE stores.

Repair of Ordnance stores, other than REME work.

Provision of rations, POL and ammunition.

Provision of accommodation stores.

Signals

Signals.

Postal Services.

* Railway, canal, main roads and pipe-lines under direct control of Chief Engineer.

REME

Recovery and repair of all forms of machinery, including guns, tanks, vehicles, mechanical equipment, cranes, railway and IWT stock, pumps, generators, etc.

RASC

Docks operating.
Canal operating.
Railway operating.
Road operating.

Major D. R. Whitaker, RE, MA, MINucE,
United Kingdom Atomic Energy Authority,
Bld A 70.2, Atomic Weapons Research Establishment,
Aldermaston,
Berkshire.

The Editor,
RE Journal.

22 April 1965.

THE CRITICAL PATH METHOD

Dear Sir,

The article by Lieut-Colonel K. R. Hasildon, published in the December 1964 *Journal*, on the Critical Path Method of analysis has served me as an excellent text book on the subject, but I feel that I am already able to add some embellishments to his system. I do in particular think that he has neglected to give all the advantages of using a computer for interpreting the original arrow diagram and for making the inevitable amendments to it as estimates of time change and delivery dates drop back. A CPM programme called CAPSTAN is now in general use in this Authority and is backed up by a most efficient programming service. All that an engineer is required to do is to hand to this staff his arrow diagram which should contain only a brief description of each activity on top of each arrow and a figure representing estimated time underneath. If the diagram has been constructed on a blackboard by a conference then the staff will photograph this on a polaroid camera. Forty-eight hours later the print out will include an actual bar chart showing duration and float times, together with a bar chart showing only the critical activities, and a series of charts showing any other critical paths which would be exposed if the main critical path were somehow shortened by a stated time. If activities are classified on the arrow diagram into individual responsibilities, particular workshops or some similar division then separate bar charts are printed out for these. It is normally more convenient to add labour figures and other resources after this first print out, when they will be presented on the bar chart in the usual way.

The usual effect on an individual handed a bar chart showing his own personal jobs within a scheme, and showing which of these is critical is to cause him to sit down at a telephone and revise all his delivery dates with the firms concerned, and to take more advice on the time estimates he previously gave. Such a series of amendments can be telephoned to the computer staff (regardless of their location) and a reprint can be made of the entire scheme within an hour or so. Minor changes during the execution of a scheme are thus no longer to be feared as the cause of some hours revision of laborious manual calculations.

Lieut-Colonel Hasildon is lucky indeed if his committee of three can with confidence arrive at accurate estimates for each job. If outside contractors are concerned this task becomes even more difficult. I have found that one way of allowing for an estimate for an important part of a job which may reach you as "between a week and a month" is to write on to the arrow diagram the same job twice, once as taking a week and again as taking a month. If neither appear on the critical bar chart then there is no need to press for a better estimate. If only the one shown under the longer duration shows up then the charts showing "exposed" critical paths will indicate the duration of the job which should be aimed at. If the shorter shows up then here is trouble indeed, but at least everyone will know that the whole forecast depends on this one difficult estimate.

A few further points. Nodes should be numbered as 5, 10, 15 in the first place so that additional activities can later be added without renumbering them all. Float is often referred to as "slack". If estimates are given in days then the bar chart will be printed on a 5-day time scale, and if each 5 days is treated as a week the weekends will be allowed for. CAPSTAN also has a facility for allowing for public holidays!

One inevitable comment on this insistance for using a computer is that these are not normally available in peacetime to the military engineer, let alone on active service. CPM is now the indispensible tool of the engineer. Will the planners please try the system and then stress its value as a bit more ammunition in the fight to get us access to these aids?

Yours faithfully,

D. R. Whitaker.

Memoirs

BRIGADIER C. V. S. JACKSON, CIE, CBE

Brigadier Cecil Vivian Staveley Jackson, elder son of the late Major-General Sir Louis Jackson, one time Chief Engineer Southern Command, India, died at Altdinnie, Aboyne on 14 November 1964 in his seventy-eighth year.

He was educated at Clifton and after passing through the Royal Military Academy, Woolwich, he was commissioned into the Corps on 25 July 1906.

After his initial training at Chatham he was posted to Aldershot where he served in the 11th Field Company and later in the 1st Airline Telegraph Company. Towards the end of 1911 he went to Sierra Leone as a Company Officer in the 36th (Fortress) Company.

On the out break of war in 1914 he joined the West African Expeditionary Force and saw active service in the German Cameroons and in Nigeria. The following year he was posted to the Western Front where he served in the Territorial 222nd (Tottenham) Field Company until being invalided home in March 1916. Following a short period at the School of Military Engineering he returned to Sierra Leone early in 1917 where he remained for a further year. He was then selected to attend a short staff course before joining the North Russian Expeditionary Force in June 1918. He remained in Archangel until June 1919.

On returning home he became Adjutant of the Territorial (East Anglican) Divisional Engineers, and during the first half of the 1921 Trooping Season he sailed for India.

During his first tour of duty in India from 1921 until 1927 he served successively as DAD Military Works, Western Command, SORE2 at Quetta and ACRE Quetta. A tour of duty at home then followed when he became DCRE at Hounslow and, prior to his promotion to Lieut-Colonel in September 1930, he attended the Senior Officers' School, Sheerness.

His second tour of duty in India, which was to last from 1931 until 1943, began with a posting as CRE Lahore. In March 1923 he became CRE Dera Ismail Khan and during the following year he served as CRE in the Waziristan operations where he was mentioned in despatches. Then, as a full Colonel, he became SO RE1 at Headquarters Northern Command. In May 1936 he was appointed Deputy Chief Engineer and in December of that year he was again on active service as Deputy Chief Engineer Wazirforce, Razmak. The following December he resumed his appointment of Deputy Chief Engineer Northern Command. In July 1939 he was made a Brigadier and appointed Chief Engineer Southern Command. He retired on 18 November 1943. For his services in India he was made a CBE in 1935 and awarded the CIE in 1942.

In July 1915 he married Margaret Jean, daughter of Lieut-Colonel and Mrs Davidson of Altdinnie, Aboyne. They had two sons and two daughters.

R.L.B. writes:

"Jacko" as he was affectionately known to a large circle of friends, was a man of wide interests. Whatever he did he mastered his subject in great detail. His enthusiasm and high spirits were infectious; above all he had the endearing characteristics of understanding, sympathy and a rare kindliness.

Brigadier CVS Jackson CIE CBE

The writer had an instance of this in early life when arriving at a small prep school in the Cotswolds as a new boy, Jacko, some three years his senior, defended him from the unwelcome attentions of an old-fashioned type bully. Many a young officer had cause to be grateful for his help and understanding; no one came to him in difficulty without receiving a helping hand.

As a Sapper officer perhaps his outstanding work and greatest memorial was the construction of the famous Wana–Razmak road through the turbulent heart of Waziristan, varying in height from 5,000 to 7,000 ft. Its admirable alignment, carried out under most difficult active service conditions, was Jacko's work. He became a well-known and respected figure amongst the Mahsuds and Wazirs, mountain folk whom he understood and whose company he enjoyed.

Later, during the last war, as Chief Engineer, Southern and Central Commands, India, he had the direction of a vast programme of Engineer works; camps for thousands of Italian prisoners, a huge hospital expansion programme immense camps for training and troop concentrations and many new airfields, all of which he handled with success. He had a highly individual approach to contractors; rules and regulations did not appeal to him, but the work got done. He still found time, with his dear wife, wherever they lived, to make their residence a centre of delightful hospitality to all and sundry.

On his retirement Jacko and his wife settled down in her old home in Aboyne, Aberdeenshire. Here he entered with his usual zest into every aspect of life on Deeside: Boy Scouts, Education, British Legion, the Church, the Aboyne Games and many others.

Scouting was a natural activity and he became not only District Commissioner for Deeside but also ran his local troop. An Assistant County Commissioner writes "He was indeed a fine DC in the most difficult district in Aberdeenshire. Visiting Scout camps was a major task and he never failed to visit every one".

The same writer adds: "I served with him for many years on the Youth Employment Committee where his advice was always useful and to the point".

Lord Glentananar writes: "My most vivid memories of Cecil are of the extraordinarily wide range of knowledge and interests he had. One could talk to him on almost any subject and find a wealth of information combined with an originality of thought which one rarely meets."

As Vice-Chairman of the Aboyne Games his tall-kilted figure was a familiar and striking sight. Sir Thomas Innes of Learney (Lord Lyon) writes of "how happily the Brigadier fitted into the history and great tradition of the Highland country". He harmoniously achieved with skilful diplomacy the not easy task of adjusting the interests and tribal status of the chieftains and clans who gathered round the green of Aboyne. He was always able to smooth the road for a display of colour, dancing and heraldry which attracted visitors from all over the world . . . his findings and rulings in the intricate arrangements, which could so often lead to altercation, were received with interest and acceptance. In all these matters in place of being a centre of controversy the Brigadier turned them into the form of peaceful discussion and research.

He was a member of the Aberdeen, Banff, and Kincardine War Pensions Committee. The Manager writes: "His interest and sympathy, ever present courtesy and good humour justly earned the admiration and affection of all who knew him."

His work for the British Legion in Scotland in general and Deeside in particular, as the General Secretary writes, "will long be remembered". He was made the first Honorary President on Deeside.

Perhaps his chief hobby was the construction of models of ancient warships. These were most beautifully constructed and Jacko went to incredible trouble to get every single detail of armament and rigging, to the smallest spar or block, correct. He had many notebooks filled with these details and his ships are museum pieces. He was a member of the Society of Nautical Research and did the sail plan for the Elizabethan ship in the South Kensington Museum.

In later life he took to weaving and soon became an acknowledged authority on tartans.

It is impossible in the short space of this memoir to touch on all the manifold interests of this remarkable man. Suffice it to say that in the passing of Cecil Jackson his great circle of friends and admirers have lost one whose brilliant intellect, infectious enthusiasm, wide knowledge and, above all, human sympathy and understanding will long be remembered with affection.

BRIGADIER H. S. ANDERSON

HECTOR STEEDMAN ANDERSON, the son of Lieut-Colonel A. V. Anderson of Stoneham, was born on 14 May 1897 and commissioned into the Royal Engineers in October 1915.

He attended a short war course at Chatham and at the Signal Service Training Centre before being posted to the Western Front in May 1916. He served with the Guards Signal Company and later with the 62nd Divisional Signal Company with the British Army of the Rhine.

On returning home in 1920 he completed a Supplementary Course at Chatham and at Cambridge University, after which he was seconded to the Egyptian Army as Assistant Director of Military Works, and later as a Company Officer, Engineer Troops Sudan Defence Force.

Reverting to the home establishment in 1928 he was given command of 33rd Fortress Company at Queenstown Harbour, Co Cork and in 1931 he was appointed Adjutant 52nd (Lowland) Divisional Engineers at Rutherglen.

His next overseas tour was spent in India where in March 1934 he took command of 19th Field Company, Royal Bombay Sappers and Miners at Kirkee. After three years in command he served for a short while as Garrison Engineer, Rawalpindi before returning home to become ACRE Northumberland Area at Darlington.

During the Second World War he served in the Middle East, becoming in 1943 Deputy Chief Engineer and Deputy Director of Works in Iraq.

In January 1945 he returned to the United Kingdom to become Chief Engineer Home Forces, and in January the following year he became Chief Engineer Singapore, his last appointment. He retired in September 1947.

In April 1931 he married Mona, only daughter of Mr and Mrs James McCabe of Co Cork. They had two sons.

He died on 3 February 1965 in his 68th year.

BRIGADIER F. C. W. FOSBERY, CBE

FRANCIS CHARLES WIDENHAM (PAT) FOSBERY, the only son of Major Widenham F. W. Fosbery, CMG, OBE, was born on 24 July 1899. He was educated at Uppingham and at the RMA, Woolwich and commissioned into the Corps on 6 June 1918.

After completing a short course at Chatham he was sent to Singapore towards the end of 1919. He did not, however, stay long in Malaya and was almost immediately posted to India to join the 2nd QVO Madras Sappers and Miners. He served with the 65th Field Company in Persia and with the 96th Field Company at Bannu and was then appointed Adjutant to the 4th Burma Sappers and Miners at Mandalay.

In September 1923 he returned home to complete a Supplementary Course at Chatham and at Cambridge University after which he rejoined the Burma Sappers and Miners where he served with the Defence Electric Light Section at Rangoon and then with the 15th Field Company at Mandalay. During his tour of duty with the Burma Sappers he became a first class interpreter in Burmese and successfully passed into the Staff College, no easy task for a Sapper officer in those days particularly for one serving overseas with native troops.

After graduating from Camberley in 1930 he joined the Royal Bombay Sappers and Miners as Assistant Superintendent of Instruction before obtaining his first staff appointment as GSO III at Army Headquarters, a post he held for almost four years. During the final stages of his tour of duty in India he served successively with the Military Engineering Service at Rawalpindi and as an Engineer Staff Officer at HQ Northern Command.

On reverting to the home establishment in 1936 he joined the 1st Anti-Aircraft Battalion RE at Blackdown. After a year with the Battalion he was selected to attend the RAF Staff College, then at Andover. From there he was posted to the Military Training Directorate at the War Office where he served during the post-Munich period when compulsory service in the Militia was introduced and the strength of the Territorial Army doubled, and during the early period of hostilities.

He was appointed Deputy Chief Engineer for the planning of operation Torch, and he remained as Deputy Chief Engineer Allied Forces Headquarters during the British/American landings in North Africa and the advance on Tunis. In January 1944 he returned to the War Office to become Brigadier E and Deputy Director Royal Engineers responsible for the development of engineer equipment, primarily for RE assault, field and specialist units.

In February 1947 he became Chief Engineer West Africa Command and two years later he returned home to become Chief Engineer at Aldershot.

His final appointment was that of Deputy Engineer-in-Chief at the War Office. Whilst in that appointment he was among the few connected with the highly secret project to detonate the first British atomic bomb, and he was personally responsibible for the raising and equipping of an RE unit that went to Monte Bello Island off Western Australia and carried out all the engineer work connected with the successful firing of Dr Penny's device and the detailed testing of its effects. Shortly before his retirement on 29 January 1955 he was created a CBE, a most fitting, if somewhat belated, recognition of his outstanding contribution to the Corps and to the Army.

Brigadier F C W Fosbery CBE

Pat Fosbery must surely be accorded a place among the most outstanding Sapper Staff officers. He was a graduate of both Camberley and the RAF Staff College. His capacity for work was enormous, yet he was never ruffled. He absorbed "flaps" and never passed them on. The elegant and concise prose of his minutes was renowned. To work under him was a great privilege, experience, education and joy. His kindness and consideration for others was proverbial, and throughout the rough commotion, tumult and hurly-burly of his exacting military career he never lost his deep love of classical music and the gentler arts.

He married Jean Helen, the only daughter of the late Lieut-Colonel H. M. Cowie, RE on 23 April 1928. They had one son.

He died, suddenly, after a short illness, on 13 November 1964 in his sixty-sixth year.

BRIGADIER S. G. GALPIN, MIMECHE

Stephen George Galpin, the third son of the Rev Canon F. W. Galpin, MA, LittD of Faulkbourne Rectory, Essex was born on 14 November 1898. He was educated at King's School, Canterbury and the RMA, Woolwich, when he won the Pollock Memorial Medal, and was commissioned into the Corps in January 1918.

After a short course at Chatham he was posted to the Western Front, joining the 92nd Field Company. In the autumn of 1919 he attended a special course at the School of Oriental Studies after which he was seconded to the Intelligence Corps and posted to the Army of the Black Sea where he was employed on special duties in Constantinople. He was mentioned in despatches in 1921.

He returned home in 1923 to complete a Supplementary Course at Chatham and at Cambridge University, and in 1926 he went on a Long E & M Course which was followed by an attachment to the Military Intelligence Branch of the War Office.

In 1929 he became SO RE (E & M) Scottish Command but shortly afterwards he was selected to attend an Advanced MT Course. This was followed by a year with 59 Field Company at Canterbury before being posted as Military Superintendent, the Experimental Bridging Establishment (now MEXE), Christchurch in November 1932 where he stayed for four years. The Folding Boat Equipment was, perhaps, the most outstanding new item developed for the Corps and brought into general service use during his time at Christchurch.

On leaving the Experimental Bridging Establishment he attended a further E & M Course before being posted to Malta where he served successively as a Company Officer in the 24th Fortress Company, in command of 16 Fortress Company and as SORE, Malta.

His unique technical skill and experience were utilized to the full during the war when he was employed in the Ministry of Supply where he served in the Tank Design Department and later he became responsible for the research and development projects connected with the enormous range of engineer equipments and stores required by all types of Sapper units in every theatre of war. In May 1945 he became Brigadier (Technical Services), Control Commission Germany and later Director-General Mechanical Engineering at HQ BAOR.

In April 1947 he returned home to become Director Royal Engineer Equipment, a post he held until his retirement in January 1951.

He married Elizabeth Maud, daughter of J. Thorburn Irvine, Esq of Aldeburgh, Suffolk on 7 July 1928. They had one son. He died on 23 January 1965 at Newmarket. A memorial service was held for him at Hatfield Broad Oak Church, Essex on 1 February 1965.

BRIGADIER E. N. CLIFTON, CBE

EDWARD NORTON CLIFTON was born on 26 December 1896. He was educated at Harrow and the Royal Military Academy, Woolwich and commissioned into the Corps in April 1915.

After a short course at Chatham he was posted to the 11th Field Company in Flanders. He was wounded in 1916 and when fit for duty again he was appointed Adjutant, 30th Divisional Engineers with which formation he served up to the end of hostilities.

Having completed his Supplementary Course at Chatham he was posted to the War Office where he served as Assistant Secretary to the RE Board and later as Staff Captain in the Directorate of Fortifications and Works.

In 1926 he was posted to India where he spent almost ten years, during which time he served in various Military Engineer Service appointments, as a staff officer in the Adjutant General's Department at Army Headquarters and in command of 18th Field Company, Royal Bombay Sappers and Miners. His Company took part in the 1936–37 Wasiristan operations where it greatly distinguished itself by the excellent and speedy work carried out on the Khaisora Road.

On returning to the home establishment he was given command of 59th Field Company at Canterbury.

He was appointed CRE Airfields of the abortive expedition sent to Narvik in April/May 1940, and later, as a Brigadier, he became Chief Engineer Gibraltar, at that time the only place on the mainland of Europe where British soldiers still stood, an important Naval base and a most important strategic centre of communications. During his tour on the Rock British and Canadian Tunnellers were feverishly excavating underground works and, with the spoil from these works, land was reclaimed for the extension of the North Front Airfield.

On returning from Gibraltar in November 1943 he spent a short while as an Assistant Director of Fortifications and Works at the War Office before becoming Chief Engineer London District. He was created CBE in 1944. In January 1945 he was appointed Chief Engineer, East Africa Command where he stayed until the end of the war.

His last appointment was Chief Engineer, South West District. He retired in August 1948.

In November 1933 he married Marcella Vere, younger daughter of E. H. Webb Esq of Folkestone. They had a son and a daughter.

He died at Folkestone on 17 February 1965.

COLONEL SIR RALF B. EMERSON, Kt, CIE, OBE, MICE, MInst MILocoE

COLONEL SIR RALF BILLING EMERSON who, after a distinguished career in the Corps and in the Railways of India and Nigeria, became chairman of the Metropolitan-Cammell Carriage and Wagon Company in 1961, died on 30 January 1965, aged 67 years.

He was educated at Bradfield College and in 1915, at the age of 18, he enlisted in the Royal Flying Corps. He served with that Corps in France until he was sent to the Royal Military Academy, Woolwich in 1917. He was commissioned into the Royal Engineers in June 1918.

After completing a short course at Chatham he joined the North Russian Expeditionary Force where he stayed for a year before being recalled to complete a Signals course.

In 1920 he was posted to India where he joined the 2nd (QVO) Madras Sappers and Miners, and took part in 1923 operations in Kurdistan where he was mentioned in despatches.

He then returned home to complete his Young Officer training at Chatham and at Cambridge University and came back once more to India in 1926 where he was employed continuously with the Great Indian Peninsula Railway, finally becoming its General Manager in early 1939.

On the outbreak of war in September of that year he was recalled for military duty and served the Directorates of Movements and Transportation in the UK, the Middle East, Sicily and Italy. For his war services he was awarded the OBE and he was mentioned in despatches.

He was released from military duties in 1944 to reassume the post of General Manager of the Great Indian Peninsula Railway. In 1946 he became Chief Commissioner of Railways, Government of India, and was awarded the CIE. He attended the International Railway Congress at Lucerne in 1947 and retired from the Railway Board that year.

In 1948 he joined the boards of the associated companies of the Dowsett Group. On its formation in 1955, he became the first Chairman and General Manager of the Nigerian Railway Corporation which appointment he held for five years. He was awarded a Knighthood in the 1956 Birthday Honours. He was subsequently appointed a Director of the West African Provincial Insurance Company Ltd of Nigeria and he later joined the board of the Provincial Insurance Company Ltd. In 1961 he became Chairman of the Metropolitan-Cammell Carriage and Wagon Company Ltd.

He married Grace Everard, younger daughter of the Rev and Mrs J. R. Napier of Old Windsor in September 1926. They had no children.

Emerson was a keen yachtsman. He was Commodore of the Royal Bombay Yacht Club from 1944 to 1945, and he was a member of the Royal Ocean Racing Club.

He served on the Council of the Institute of Transport from 1959 to 1962 and became their Honorary Librarian in October 1963.

He was an enthusiastic member of The Blythe Sappers and, while at home, he rarely missed joining his colleagues at their functions. He was installed as Chairman in 1963 and his personal charm made his year a successful and memorable one.

Colonel A W Stokes DSO MC

COLONEL A. W. STOKES, DSO, MC

ALEYN WHITLEY STOKES, the only son of Major-General Sir William Stokes, Surgeon to Queen Victoria, of Dublin and Howth, was born on 18 April, 1880. He was educated at Shrewsbury and the Royal Military Academy, Woolwich, and was commissioned into the Royal Engineers in November 1899.

After a short course at Chatham he was posted early in 1901 to South Africa where his father had been serving throughout the Boer War. Father and son, however, did not meet; Sir William died a few days before his son sailed from England. On arriving in South Africa Stokes joined the 23rd Field Company. Later he was invalided home and posted to C Depot Company at Chatham. For his service in South Africa he was awarded the Queen's Medal with three clasps.

In 1904 he was posted to Egypt—a country in which he was to serve with great distinction many times throughout his long military career. He was seconded to the Egyptian Army where, after a short time in Cairo, he was posted to Khartoum as a Bimbashi in the Department of Works. He later became Assistant Director of Works at Port Sudan and in 1907 he assumed a similar appointment in Cairo which he held until 1911. Whilst serving in Cairo he married, on 24 January, 1910, Cecilia Mary, youngest daughter of the late Sir H. W. Parker and Lady Parker, a first cousin to General Sir Bindon Blood. For his seven year's excellent work in Egypt and the Sudan Stokes received the Order of Mejidieh.

On returning home he was appointed Adjutant 54th (East Anglian) Division whose headquarters were then at Bedford. From the outbreak of war in August 1914 until May 1915 the Division was employed on home coast defence duties. But greater things were in store and the Division fought with great distinction in Gallipoli, in the Sinai and with the Egyptian Expeditionary Force in Allenby's victorious campaign in Palestine. Stokes rose to become CRE of the Division; he was awarded the MC in 1916 and the DSO in 1918; he was mentioned in despatches four times. After the disbandment of his division at the cessation of hostilities Stokes became CRE 10th Division for a while before being appointed CRE Cairo.

Returning home in 1922 after almost seven years continuous overseas service, he became CRE Northumbrian Area at Catterick. In 1925 he attended the Senior Officers' School at Sheerness and, on promotion to Colonel, he was made Chief Engineer, British Troops in Egypt—a most fitting appointment, as was his final one namely Assistant Adjutant General, Royal Engineers, a post he held from 1932–1936.

With the coming of the Second World War this veteran of the Boer War and the First World War became Head Warden of Roehampton, where he had settled on retirement and, when fighting once again stopped, he became President of the local British Legion and a constant visitor to officers in Queen Mary's Hospital, Roehampton, and to retired and sick officers at Scio House, Roehampton.

He died suddenly on 20 February, 1965, in his eighty-fifth year.

Book Reviews

THE INDO-CHINA WAR, 1945–51. A STUDY IN GUERILLA WARFARE

By Edgar O'Ballance

(Published by Faber & Faber, London. Price 35*s*)

The more one reads of the operations conducted by the French in Indo-China, the more one becomes aware that the French never had a chance of winning it by the methods they adopted. They pursued a "conventional" military policy against a wil-o'-the-whisp foe; and they did not even refrain from making the cardinal error of putting their field army in the fortress of Dien Bien Phu. The guerilla leader, Ho Chi Minh, conducted his operations in what has now been recognized as the conventional guerilla pattern. He, too, made mistakes but they were, by comparison, trivial.

Throughout the Japanese occupation of French Indo-China (1940–5) the Communists cultivated the masses of the population, presenting themselves as the only resistance movement capable of freeing the people. This was not difficult, as news from the outside world was non-existant, and the French officials civil, military and police—were in internment camps. When the atomic bombs on Japan forced a capitulation there was a hiatus in government in Indo-China. The Japanese ceased to be the masters, yet the Allies had not arrived. The Communists stepped into the void.

Meanwhile, however, the Allies had decided at Potsdam (the French not being consulted) to partition Indo-China at the 16th parallel of latitude. The northern part was to be managed by the Chinese (Nationalists, not Communists) and only the southern part by the French. British and Indian troops landed in the south, and Nationalist Chinese forces came in from the north. A highly confused state of affairs thus existed, in which resort had often to be made to employing the surrendered Japanese forces to help restore law and order.

Gradually the British and Indian forces were withdrawn to cope with their own affairs in India, Pakistan and elsewhere, and the Chinese Nationalists faded away in face of Communist successes in China proper. The French and the indigenous Communists were thus left to grapple with one another in a disorganized turmoil.

The book under review tells the tale (of which the above is perhaps an oversimplification) from the beginning of the French afflictions to the armistice after Dien Bien Phu in 1954. The author tells it very well: it is easily read, it is well explained and the maps are sufficient. He also gives an analysis of how guerilla movements are born, nurtured and finally employed victoriously against an occupying power. It is all very convincing; but it seems to your reviewer that two aspects of the business are insufficiently studied. The first is the time-honoured method of subduing a country by road making. Although this has been a sovereign remedy of armies since the heyday of the Roman Empire it seems to have been curiously neglected by the French in Indo-China. And the author of this book does not seem to have commented upon this. As a Sapper, your reviewer feels that perhaps the French engineers were not held in high enough esteem; and their advice, if given—as presumably it must have been—was disregarded.

The second point that your reviewer feels is insufficiently studied is a political one. What steps, if any, did the French take to "win the hearts and minds of the masses?" Apparently none; though this is hard to believe. The sword is the last argument of an emperor; but when he draws it he must not forget the politicians. The author of this book gives an admirable account of the cuts and thrusts of the sword-work; but the political struggle, which your reviewer believes to be the more important in this type of warfare, is insufficiently stressed. And that appears to be a blemish in an otherwise excellently clear book.

M.C.A.H.

LIKE IT OR NOT

By Lieut-Colonel Kirkbride

(Published by Arthur H. Stockwell, Ilfracombe, Devon. Price 12*s*)

It is seldom that a book is presented for review today that can fairly be called "a slim volume"; but *Like it or Not* qualifies for the description in every way. Its size is modest ($7\frac{1}{2} \times 5 \times \frac{3}{4}$ in); it is short (127 pages); it is light both in content and *avoir du poids*; the price is right, and it is very well made. It is easily read from cover to cover at a sitting; and in perhaps a hundred years' time it may be valuable as a period piece, depicting the social life of a British Army Officer between the wars.

The author seeks to avoid professional, military matters as far as possible in his progress through the Shop (1921–2), the SME, Garrison Engineer at Lichfield, Salisbury Plain and then service in the Far East. Here the author was stationed on Singapore Island, but visited far and wide.

He went to Sarawak, where he witnessed the flogging of a Chinese prisoner in the jail; to Hong Kong and on to Shanghai as an "indulgence" passenger in a troopship. He paced the famous Long Bar and found it fifty yards long, thronged six deep with tycoons, scrumming for a drink on a Saturday noon.

He says "we played hard, and we drank hard, and I am bound to admit that we did not overwork . . ." Indeed he describes an existence in the Far East—and later on in Egypt—the like of which your reviewer, who was in austerer climes at the time, hardly knew existed: where butterflies gleamed in the light of the sun and nautch girls danced by the light of the moon—and not alone.

After returning from the Far East in 1932 the author married and transferred to the RAOC. He then served in Woolwich, Hilsea, Aldershot and Chilwell. He spent three years in Egypt and returned home (on page 126) a few months before World War II started and his chronicle ends.

There are good, though rather conventional, descriptions of places and scenes; but perhaps the author misses a chance when describing people. For instance, he was in close contact with the young Wingate at the Shop, but only gives us a glimpse of him. Your reviewer would not class this as a great work; but it is a pleasant enough companion for an hour or so in the train.

M.C.A.H.

CONVENTIONAL WARFARE IN THE NUCLEAR AGE

By Otto Heilbrunn

(Published by George Allen & Unwin Ltd. Price 21*s*)

Once again Dr Heilbrunn has gone into print on the study of a subject closely connected with his favourite topic, warfare in the enemy's rear; and once again he has undertaken a prodigious amount of research. He almost overwhelms the studious reader with his copious references to and quotations from previously published books, articles, lectures and opinions.

He has discussed just about every possible major factor which might affect the basic principles of deployment of the NATO forces in a war against Russia which starts off without either side using nuclear weapons, and he just about gets nowhere in the end—apart from what was obvious before he started. In fact it is not until we reach the final sentence in his book that we realize he never intended to get us anywhere. The avowed purpose of his book, he concludes, is "to initiate the search for an agreed conventional doctrine and to make a contribution towards its formulation". This limited purpose he achieves admirably, but he would have avoided disappointing the reader if he had made it clear at the beginning. Even this final sentence is based upon a "64,000 dollar" statement and basis for his study, made in the very first paragraph of his book, where he naively states that "only if an attack against the Western Alliance cannot otherwise be repelled, should the West resort to nuclear warfare".

The NATO Powers have as yet inadequate conventional strength seriously to consider repelling an all-out "conventional" Russian assault in Europe with conventional forces alone and there are, as yet, no signs that they are likely to possess such strength in the foreseeable future.

Nevertheless this book is much better written than Dr Heilbrunn's previous solo literary efforts; its contents are well assembled and his analytical study of the many factors should be of value to the student of future warfare, if only as a mental stimulant.

E.C.W.M.

HYDRAULIC CONTROL OF MACHINE TOOLS

By E. M. Khaimovich,
Kiev Polytechnic Institute
Translated from the Russian by O. Tedder
Translation edited by K. Foster
Lecturer, Mechanical Engineering University of Birmingham

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price £6)

This book is a completely revised edition of the book with the same title published in 1953. Like its predecessor it summarizes the theory and application of the standard hydraulic systems used in the USSR to drive and control machine tools.

The first eighty pages detail the theory and calculation of hydraulic systems in general, but from there on the chapters deal individually with the design and operation of: drives, regulation and oil distribution mechanisms, auxiliary equipment, position control mechanisms, automation equipment and examples of hydraulic calculations.

The text is given in considerable detail and well illustrated with circuit diagrams and drawings of specific mechanisms. In some cases the author has listed the salient points of design and operation which should be considered when selecting mechanisms. These lists are very useful additions to the descriptive text.

F.T.S.

SIX-FIGURE LOGARITHMS, COLOGARITHMS AND ANTILOGARITHMS

By C. Attwood, Principal, Apprentice Training, Ford Motor Co, Ltd

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 12*s* 6*d*)

The compiler regards this soft-covered book of tables as a new work, because it includes cologarithms in lieu of the logarithmic trigonometrical functions published in his earlier book of tables that was reviewed in the *Journal* of March 1962.

This book also includes the functions of π, the multiple functions of π and e, notes on using the tables, and the finding of hyperbolic logarithms. Of historical interest are the three reproductions of the title pages from early tables published in 1642 and 1742 by Henry Briggs, Edmund Gunter and James Dodson, who were pioneers in the field of logarithmic calculation.

The cologarithm of a number is the log of the reciprocal of the number, and cologarithms enable combined multiplication and division to be performed as a single calculation. An example of their use is given.

The compiler stresses the care taken to ensure the accuracy of the tables, and also includes mean proportional parts to enhance this characteristic.

F.T.S

VECTOR ANALYSIS FOR MATHEMATICIANS, SCIENTISTS AND ENGINEERS

By S. Simons, MA, PhD

Lecturer in Mathematics, Queen Mary College, University of London

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 17*s* 6*d*)

This soft-covered text book is Volume 6 of the Physics Division, The Commonwealth and International Library. Its purpose is to present to students of universities and colleges of technology some new concepts of vector algebra and calculus which will enable them to understand other works which utilize these methods to solve mathematical problems.

The text includes a discussion of rotational invariance of the Gradient, Divergence and Curl; the direct evaluation of line, surface and volume integrals. The power of vector methods is illustrated by tracing electrical theory from basic electrostatics to the Maxwell's equations which determine electric and magnetic fields in free space.

The concepts are explained by worked examples and a number of unworked exercises are provided at each chapter end.

F.T.S.

A COLLECTION OF PROBLEMS OF MECHANICS

By I. V. Meshcherskii

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 84*s*)

This book is Volume 65 of the International Series of Monographs on Pure and Applied Mathematics. It was translated by R. Romicki from the twenty-sixth Russian edition issued in 1960.

The first printed edition of the *Collection* was compiled in 1914 under the supervision of I. V. Meshcherskii, who obtained the problems from a group of lecturers in theoretical mechanics at the Petersburg (now Leningrad) Polytechnic Institute. Since then the problems have been regularly revised and their scope enlarged, and used for courses in mechanics at all Russian polytechnic institutes.

The book now contains 1,363 problems which cover the statics of Rigid Bodies; Kinematics; and Dynamics. The problems range in difficulty and extend over the syllabi of students of applied mathematics and engineering in the senior forms of schools, technical colleges and universities.

Attention is drawn to the fact that this book does not include any explanations of the principles of mechanics, or worked examples, it merely details the various problems and gives the answers, although a few brief hints are given in recommendation of the methods which will help students solve specific problems. Many of the problems are illustrated by small, but well-drawn, diagrams. The standard of production is very good.

F.T.S.

PRACTICAL AERODYNAMICS

By A. K. Martynov

Translated from the Russian by V. H. Brix, BSc, ACGI, AMIMechE and *translation edited by* R. C. Pankhurst, PhD, FRAeS

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 80*s*)

This book is Volume 4 of the Aerodynamics Division of the International Series of Monographs in Aeronautics and Astronautics. The original edition was published in 1950 under the title *Experimental Aerodynamics* to serve as a textbook for Soviet Institutes (Colleges) of Aviation. The change of title for this second edition became necessary when the author included the elements of aircraft aerodynamics.

The first four chapters are devoted to theory and cover: the physical properties of air; the fundamental laws of air flow; co-ordinate axes; basic definitions of experimental aerodynamics; and the laws of similarity.

Chapters 5–9 deal with experimental applications involving the use of sub and supersonic wind tunnels; balances; flow visualization; the measurement of pressures and velocities; boundary layers and turbulence; and the theory and design of wing span and profiles.

Chapter 10 covers basic aircraft aerodynamics; the drag and interference of individual parts; the characteristics of control surfaces; and the elements of stability and control.

Except for Chapter 3, and one or two other passages, the Russian symbols have been replaced by British equivalents. Means of correlation with British axis systems is provided by the addendum to Chapter 3, whilst corresponding Russian and English symbols are set out in the appendix to the book.

This comprehensive work will be of considerable use to aeronautical engineering students of universities and colleges of technology, and will also serve as a guide to teachers who wish to acquaint themselves with the range of subject matter presented to Soviet students.

In common with the other scientific and technical publications of Pergamon Press Ltd, the standard of production is first-class.

F.T.S.

CARGO HANDLING AND THE MODERN PORT

By Colonel R. B. Oram, OBE, ERD

(Published by Permagon Press. Price 20*s* Soft Cover, 30*s* Hard Cover)

If it is true, as the author suggests, that "no single cause contributes more to the cost of living of a maritime country than the speed at which ships are turned round in her ports", the knowledge, experience and ideas of a man who has devoted a working lifetime to the study of port operations world-wide, merit examination by anyone interested in the future development of a country such as Britain.

This book is not a collection of "pie in the sky" ideas which are unrelated to reality; it is both a means by which the reader can explore the jungle of geographic, economic and political factors which govern the nature and shape of the sea ports of the world, and a pointer to the paths along which development can progress.

In the opening chapter of the book, the functions of a port are concisely and accurately defined, and this sets the stage for an absorbing analysis of the many components which comprise the whole. The discussion ranges widely and freely over such subjects as the relationships between port and ship: ship and cargo: cargo and handling equipment: management and labour: explaining what they are, why they exist in the form that they do, and how they can be improved to the general good.

Advocates of the introduction of new types of ship: palletization and containerization of cargo: mechanical handling: new tallying procedures: simplified customs arrangements: etc, will be encouraged by what they read but, in the authors own words, "seekers of a simple panacea for the malaise of the world's ports" will be disappointed.

The final chapter, which deals with the port of the future and outlines the cases of the two schools of thought on the subject, also summarizes the development programmes of some of the major ports of the world. This can be described as interesting but somewhat unexciting and tends to develop a sense of anti-climax which is, however, short-lived. In the final pages, the author gives free reign to his imagination and sketches the shape of things to come, if only the integration of all interests can be achieved. This prospect is a very exciting one.

P.K.A.T.

AN INTRODUCTION TO PRESTRESSED CONCRETE. Vol. I

By Paul W. Ables

(Published by Concrete Publications Ltd. Price 60*s*)

This book is the first of an ambitiously planned series in which Dr Abeles hopes to cover the whole field of Prestressed Concrete. Three independent books are envisaged: "An Introduction to Prestressed Concrete"; "The Theory of Prestressed Concrete", and "The Practice of Prestressed Concrete". The present work is Volume I of these books, which will be in two parts.

The opening pages are very "un-textbook like", with the author establishing his basic principles for design and construction by ruminating, almost whimsically, over eight well-known sayings. The mood changes, however, and soon the reader is led on to the essentials of prestressing, followed by an excellent review of present methods of pre- and post-tensioning. This section is commendably complete, and includes such interesting developments as the Preflex system and the use of glass-fibre tendons.

Chapters 6 to 12, representing very nearly half the book, are devoted to a study of the properties of materials used in prestressed concrete. This undoubtedly is the most valuable part of the book. It might be argued that the treatment is too lengthy and elaborate for an introductory work, but there is no doubt that even a quick study of the contents will clarify the thinking of any student or designer on the true behaviour of the materials he is handling. Enough of the mathematics of stress and strain is included to make the treatment complete in itself; indeed the section on principal stresses is better presented than in the majority of text-books on Strength of Materials.

A criticism of the chapters dealing with concrete as a material might be the scant treatment of additives; little indication is given of the author's views on their application, or indeed of their worth. Some aspects, also, of methods of testing have been overtaken by the publication of papers in connection with the Symposium on Concrete Quality held in London in November 1964. One excellent innovation in a book of this nature is a section on Resinous Plastics and their application to prestressed concrete work.

The remainder of the book deals with the behaviour of both reinforced and prestressed concrete under working load and at failure, and with fire resistance and durability.

It is to be regretted (as the author himself writes in the Preface) that no universally accepted system of symbols and sign conventions exists for prestressed concrete. Even so it is surely illogical for compressive stress to be treated as negative in this book and as positive in the author's widely used book "The Prestressed Concrete Designer's Handbook". One consolation for the military reader is that the sign convention used in the new book is in line with that adopted by ME Vol XIV, Part III!

Altogether, this is an excellent introductory book on the subject. It is comprehensive, well-written, and the layout and illustrations are of a high standard. The following books in the series should be interesting, though it is to be hoped that their publication will not be too long delayed. The techniques of prestressing are changing so rapidly that any text book suffers from the danger of being at best partially outdated soon after publication, as the author's of ME Vol XIV found only too well.

C.F.R.

ENGINEERING MATHEMATICS

By A. H. Douglas

(Published by Concrete Publications Ltd. Price 63*s*)

This book is described as an introductory survey of modern developments, but it attempts to be very much more than this; it covers an extremely wide field of both mathematics and engineering, varying from determinants to spherical trigonometry, and from stressed shells to earth satellites and rockets. The wide coverage has resulted in the majority of the descriptive parts of the book being too condensed and difficult to follow. There are several worked examples, and the book could possibly be used as a textbook; it seems most suitable, however, for use by someone already holding a mathematical degree and who wishes to revise general principles and possibly develop further applications from known theory. The scope of the book is so great that few readers will need to refer to more than parts of it.

The publishers say that this volume is an attempt to survey the field of mathematical knowledge with the emphasis on the trend towards more general use of modern electronic computation, and to demonstrate the unity rather than diversity of the methods available to engineers and technologists. In addition to covering such diverse procedures as matrix algebra, solutions by power series, relaxation and other iterative techniques, operational calculus, vector methods, transformations and statistical procedures, there are also descriptions of the fundamental principles required, and of some of the historical background behind the development of the modern methods.

The examples and most of the figures have been reproduced directly from clear freehand originals; this has eliminated the incidence of typographical errors, but has made the text more difficult to follow; the descriptions are frequently several pages from the examples and figures to which they refer, and the printed pages are often interspersed at random by pages of examples. One of the highlights of the book is an excellent glossary of mathematical terms applicable to engineering work; there is also a good index. There should be a demand for this book in many engineering consultants' and university libraries, but not at a lower level.

J.C.P.

THE PRINCIPLES OF POWER GENERATION

By G. Ye Kholodovskii

Translated from the Russian by V. H. Brix, Principal Scientific Officer, Scientific Civil Service

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 30*s*)

Any layman who wishes to learn the basic principles of energy and its transformation, and understand how they are applied in a modern, coal-fired,electrical generating station, could not do better than digest the contents of this book. The translator's note in no way exaggerates the excellence of its style or the brilliance of its exposition. He says:—

"This booklet is one of many published in the Soviet Union which set out to explain various aspects of Science and Industry in a clear and concise manner, so that the reader has an opportunity of grasping the general principles and is not confused with a welter of irrelevant details, photographs, etc., of selected equipment and components which happen to be in use at some particular time and place. It is, perhaps, a failing of textbooks published in the West that they are either too theoretical for the practical man or, on the other hand, too empirical to give adequate guidance to true seekers of knowledge and understanding. It is hoped that this book may help to fill this rather wide gap in our technical literature."

The eight chapters of the book are titled: Energy and its Transformation; Heat, Energy and How it is Transferred; Heat Transfer in the Boiler System; The Conversion of Water into Superheated Steam; Water Conditioning and Steam Quality; Energy Transformation in the Steam Turbo-Generator; The Efficiencies of a Thermal Power Station and its Elements; Features of Energy Transformation in Nuclear Power Stations. Each chapter is concise and the acme of clarity.

First year students of electrical and mechanical engineering would find the text amply rewarding, it is a very good primer indeed.

F.T.S.

MECHANICS OF MACHINES VOLUME I

By H. E. Barnacle, BSc (Lond), AMIMechE
Senior Lecturer in Mechanical Engineering, and
G. E. Walker, MIMechE
Head of the College of Civil and Mechanical Engineering, Oxford College of Technology

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 25*s*)

This soft-covered textbook is the first of two volumes on the subject matter which are included in the Mechanical Engineering Division of the Commonwealth and International Library.

Each volume investigates and analyses the nature and extent of the forces and motions to which machines and their parts are subjected. In this volume, which has been compiled to suit the needs of students working to obtain the Higher National Certificate in Engineering, the text covers the theory of: Velocity and acceleration in link mechanisms; Simple harmonic motion and the reciprocating engine; Cams; Toothed gearing; Dry friction; Belt drives and brakes; Static and inertia forces in machines; Turning moment diagrams and flywheels; Engine governors; Balance; Gyrosopic action; Elastic vibrations; General dynamics and lubrication.

The descriptive matter is cut to a minimum and the theory is concisely explained with the aid of worked calculation examples, and diagrams. Reliance is placed on the student to consolidate his knowledge of the information presented by tackling the unsolved problems given which, incidentally, were previously set in the examinations of the Institution of Mechanical Engineers.

F.T.S.

BASIC STATISTICAL METHODS FOR ENGINEERS AND SCIENTISTS

By A. M. Neville and J. B. Kennedy

(Published by the International Textbook Company, Scranton, Pennsylvania. Price $8.50)

The authors, in the order named, are respectively the Chairman, Division of Engineering, University of Alberta, Calgary, and Associate Professor of Civil Engineering, University of Windsor.

The text is presented in a manner that will enable an engineer or scientist to teach himself the basic statistical methods. Alternatively, he could use it as a reference book when confronted with a specific research, laboratory or production problem needing statistical solution. It is also suitable for study by graduate students of engineering, who would quickly realize that the statistician plays an important part in most aspects of design and production.

The twenty chapters of the book cover most of the commonly used methods and each is laid out in the same form. Firstly the theory of the method is explained, the means of its application are then discussed, a number of solved problems are worked out, and finally a set of practice exercises are offered for solution by the reader. The solved problems cover a wide range and vary, for example, from a statistical assessment of the strength of building bricks, to the life span of steel plates in waters of different quality, and the strength of steel wires under different stress conditions.

Included also is a chapter on the design of planned experiments, which, to the statistician, are infinitely more valuable as they give far more information for any experimental effort.

A number of useful appendices and reference tables are included which have a direct use in statistical work.

The standard of production is first-class. F.T.S.

ELECTRICAL ANALOGUES OF PIN-POINTED SYSTEMS

Edited by Professor K. K. Keropyan. Translation from the Russian edited by D. P. Atherton, Lecturer in Electrical Engineering, University of Manchester

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 45*s*)

This book is Volume 30 of the International Series of Monographs on Electronics and Instrumentation as published by the Pergamon Press.

Over the past ten years electrical analogues have been introduced into many spheres of science and technology with the object of avoiding complicated calculations, and they have also been used to solve problems concerned with structures. In Russia much of this work has been done by the scientists of the Rostov-on-Don Civil Engineering Institute under Professor K. K. Keropyan, and by the Taganrog Radio-technical Institute under Professor G. Ye Pukhov, whose joint aim was to establish analogies between bent beam equations arising in building mechanics and the network equations of certain electrical circuits.

The book contains papers from members of both Institutes describing analogues which they have tested experimentally and found satisfactory for use in the research and practice of structural mechanics. The analogues apply individually to either plane rod systems, the design of beams and frameworks, bent conical beams, the calculation of the deflections of pillar foundations, the comparison of building dynamics, variable profile beams, and bent and thin-walled rods.

Most of the analogues are of the computing three or four-terminal circuit type designed to enable certain stresses etc to be calculated from the magnitudes of currents and e.m.f.'s set up in the networks.

The papers, with their mixture of electrical theory and mechanics, are rather advanced technically and only suitable for scientists and others employed on research work of this nature.

F.T.S.

COMMUNICATION PROCESSES

Edited by Frank A. Geldard (Chairman, NATO Advisory Group on Human Factors)

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price £5)

This book, Volume 4 of the NATO Conference Series, presents the proceedings of a Symposium held in Washington in 1963. It has been published for and on behalf of The Division of Scientific Affairs, The Science Committee of NATO, and records the addresses made and the papers read and discussed by international delegates over a range of diverse aspects concerned with communication processes and related human factors.

The Symposium was divided into six sessions. The first covered the role of science and technology in the Atlantic Community. Then followed five paper sessions that covered Data Presentation; Data Transmission; Language Barriers and Language Training; Group Communication; and Man-Computer Communication. The whole being summarized by the Chairman in the sixth and final session.

Each of the paper sessions, which are fully recorded, followed a set pattern. The subject paper was presented by a chosen delegate. Three or more delegates then expressed their own views on the paper before the subject was passed to open discussion.

The papers are only of interest to psychologists and others who are concerned with the application of the theories and facts of mass communication.

It should be noted that the Group Communication session, presided over by Colonel C. A. Chandessais, is printed in French.

F.T.S.

INTRODUCTION TO APPLIED THERMODYNAMICS

By R. M. Helsdon, BSc (Eng & Gen), AMIMechE

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 21*s*)

This soft-covered textbook is Volume 6 in the Mechanical Engineering Division of the Commonwealth and International Library.

The author is Head of the Department of Mechanical Engineering, Bournemouth Municipal College of Technology and Commerce, and his text covers the syllabuses for final last year Heat Engines and Applied Thermodynamics in the Ordinary National Certificate in Engineering and, in addition, introduces student readers to some of the more advanced thermodynamic topics which they will encounter in the Higher National Certificate course.

The book is roughly divided into two parts. The first chapters cover the definitions and explanations of: the various forms of energy; temperature; reversibility processes; the first and second laws; properties of ideal gases and pure substances; standard air cycles; and entrophy. The remaining chapters outline the principles of operation for gas compressors; internal combustion engines; steam and steam engines; refrigerators; together with the principles of combustion, psychrometry and heat transfer.

Printed in a modern style, with a wealth of diagrams and sketches to illustrate the concise text, this book gives a comparatively new and attractive look to an old and difficult subject. The author, however, realises that the theories presented cannot be thoroughly understood unless students are exercised in the solution of problems, and in view of this has included worked examples in the text and supplemented these with unworked exercise problems at each chapter end, with answers at the back of the book.

F.T.S.

NON-PLANAR CONCRETE ROOFS

By J. S. Terrington and F. H. Turner

(Published by Concrete Publications Ltd. Price 15*s*)

In this new book three previously published booklets by Dr Terrington, entitled respectively "Design of Domes", "Design of Arch Ribs for Reinforced Concrete Roofs" and "Design of Pyramid Roofs" are reproduced, together with a new chapter on Long Cylindrical Shells.

The style is straightforward and limited to essentials, and as an introduction to the analysis of the structures covered it could hardly be bettered. It is rather less thorough on design details. The diagrams are exceptionally clear, although in some cases they are separated from the text to which they refer.

It is a pity that one or two of the examples chosen to illustrate the methods described seem over-complicated. For example, a clear description of the analysis of a roof arch rib is followed by an exaggeratedly complex example which would cause the average student to lose heart before he was half way through the calculation. A simple, quickly solved problem would be much more likely to retain his interest, and maintain his morale! One could also criticize the absence of more than a mention of prestressing applied to these structures.

These minor criticisms apart, the book can be recommended as a good introduction to the subject, although it pre-supposes a fairly thorough grounding in structural theory on the part of the reader.

C.F.R.

Technical Notes

CIVIL ENGINEERING

Notes from *Civil Engineering and Public Works Review*, February 1965

ABILITY OF CLAY FILL TO SUPPORT CONSTRUCTION PLANT. This article considers the design of earthwork to suit site conditions (particularly the natural moisture content of the soil) and the capabilities of earthmoving plant, instead of by the use of arbitrary standard specifications for moisture content and density limits. Several graphs are given to show the relationships between shear strength, dry density, moisture content, plastic limit and percentage air voids for various soils. The contact pressures under the tyres of earthmoving vehicles are considered; the pressures to cause given degrees of sinkage and ground disturbance under both static and dynamic conditions are related to the shear strength of the soil; the maximum permissible tyre pressure to limit the wheel settlement to 2 in is approximately $5c$, where c is the shear strength. Further graphs show the theoretical maximum moisture content at which different cohesive soils can support loaded tyres at various pressures; these are related to the plastic limit to the soil. Normal tyre pressures for earth-moving plant are in the range of 45–70 lb/sq in. This article is to be continued.

THE CONSTRUCTION OF THE SYDNEY OPERA HOUSE. Mr Ove Arup gives a most interesting description of the design of this controversial project, and mentions some of the politics which have affected it. The building is undoubtedly of considerable architectural interest and originality, and its construction should provide valuable experience. The estimated cost which has risen from £3.5 million to £20 million should keep the Australian lotteries busy for many years to come.

OPTIMUM DESIGN OF SEWERS. The author shows the importance of their shape on the design of circular-sectioned conduits, and goes on to develop an expression for the optimum diameter to satisfy self-scouring requirements and carrying capacity. A design chart is included for use in solving general problems of this nature, and the method is illustrated by three worked examples.

ANALYSIS OF SKEW BRIDGE SLABS BY THE MOIRÉ METHOD. Interference fringe techniques can be used for experimental analysis of slab and plate structures where the theoretical approach would be unduly complicated. The use of the fringe method for determining the influence of the angle of skew on the distribution of bending and torsion within continuous slab bridges is described.

CONSTRUCTION OF THE LONDON–SOUTH WALES MOTORWAY, M4. This is the main feature article of the month; it includes many good photographs of work in progress, and there is a mass of factual information on dimensions and materials. The greater part is devoted to the construction of the Chiswick-Langley section of the M4, including the elevated viaduct section which is carried on stilts above part of the Great West Road. The article has unfortunately been spoilt by the inclusion of a vast number of advertising credits, giving the names and addresses of the various sub-contractors and materials suppliers; these could, to advantage, have been omitted from the text and listed separately. There is so much of interest, covering an immense subject, that it has had to be condensed to little more than facts and figures; there is hardly any comment or discussion on the reasoning behind the design decisions, or on any problems experienced. Some statements, especially in the complementary article on the manufacture of precast beam units for the viaduct, are a little misleading.

J.C.P.

Notes from *Civil Engineering and Public Works Review,* March 1965

NEW TASMAN BRIDGE AT HOBART. This is a high level bridge in prestressed concrete, most of which is built up from precast sections. The main river crossing has nineteen spans of 140 ft, two anchor spans of 197 ft, and a navigation span of 310 ft. The piers are supported on raking piles of reinforced Colcrete construction within steel tubes of 54 in dia. The pier columns are formed of precast sections stressed together. The beams are also formed of precast segments stressed together and have 3 in of fine concrete between each unit. Three steel stagings were built for erection of the bridge, with a platform above them to carry a 100 ton capacity Goliath crane; the stagings were floated in and out of position by a set of four pontoons with removable trusses spanning above them.

NEW METHOD OF JOINTING PC MEMBERS. This article reviews some experimental work designed to evaluate means of connecting tensile reinforcement of precast concrete members. The principle of the joint is that a short length of tube is welded to the end of one reinforcement bar, being placed so that the end of the tube is flush with the end of the precast unit; the other bar to be joined extends beyond its precast unit; the protruding bar is fitted inside the tube and the two are bonded together with a Portland Cement grout to which an expanding agent has been added. Epoxy resins are considered unsuitable as bonding agents since they have low fire resistance. Ciment Fondu grouts were tried and found less efficient than those made from Portland Cement. Joints of this type are shown to have more than adequate strength when made under laboratory conditions, though tests are not yet complete to show how they would behave if made in groups, rather than individually, under site conditions.

REDUCING SEEPAGE LOSSES IN IRRIGATION CANALS. Tests are described in which the permeability of porous soils is greatly reduced by the application of a bentonite slurry. Water losses from irrigation canals through porous media can thus be greatly reduced by applying bentonite during construction; care must however be taken to ensure that the bentonite is not directly exposed to running water since it could easily be washed away. Prices given show that the treatment is not unduly expensive.

ABILITY OF CLAY FILL TO SUPPORT CONSTRUCTION PLANT. The second half of this article considers aspects in the design, specification and necessary earthworks for cohesive soils. A firm clay with a shear strength of only 5 lb/sq in may only be able to support the smaller types of earthmoving machinery; a decision must be made on whether it is better to use such material for embankments and move it with less economic plant, or to import alternative soil from elsewhere. The safe angle of repose is also relevant to the economics; this also depends on the shear strength of the soil, and directly affects the quantity of earthworks. The degree of compaction can be specified, and related if necessary to unconfined compression tests or *in-situ* CBR tests; it may be sufficient to specify that sinkage under a given type of wheel should not exceed say 2 in; moisture content tests should not be necessary.

OPTIMUM DESIGN OF SEWERS. This article is concluded with further charts and tables, the use of which is explained in some detail. The range of design flows is from 1 to 100 cusecs. The use of the final chart should enable the diameter and slope of a sewer to be decided quickly to suit conditions of maximum and minimum flows and ruling velocities.

STEELWORK FOR THE TAY ROAD BRIDGE. This is a well-illustrated description of the fabrication and positioning of the welded steel box girders for this bridge. The spans range from 80 to 250 ft, the majority being 180 ft long. Use is made of both mild and high yield steels; the section properties are further augmented by casting an 8 in thick layer of concrete on the top flange which is designed to act compositely with the steel in resisting both dead and applied moments. The box units which weigh up to 200 tons, are taken out along a temporary bridge on bogies travelling on twin rail tracks; they are then lifted into position from portal gantries supported on the permanent columns.

Charts for Minimum Weight Design of Structural Steelwork Members. The article describes with examples a method of constructing and using charts for the design of steel stanchions subjected to axial loads and bending. Applied moments are considered in terms of the eccentricity at which the applied axial load would produce the same effect; separate charts are needed for each likely value of eccentricity. The effort involved in producing the necessary data for plotting on the charts is considerable, and is best done by computor; the charts themselves would make up quite a volume. The system is simple and straightforward, but is unlikely to be economic unless the charts can be made readily available at low cost. The effort in designing stanchions by the normal trial-and-error method, based on experience, is after all not unduly difficult or time-consuming. Different charts would be needed to show the sections for minimum weight, minimum cost, minimum loss of floor area, etc. The article is unfortunately spoilt by several obvious misprints.

High Tensile Bolts in Structural Connections. This is the first part of a report on a research project into the behaviour of joints made with high strength friction grip bolts. The work was done between 1954 and 1957, but mention is also made of the more recent developments such as "Torshear" bolts and load-indicating bolts and washers. Tests showed that the variation in bolt tension when tightened by the "torque" or "part turn" methods was considerable; the former method gave slightly better results than the latter. Experiments on typical joints were influenced by even small misalignment of the components; the minimum slip factor for double-bolted joints was found to be 0.39, which is less satisfactory than the assumed figure of 0.45 permitted by BS 3294 Pt 1, although still greater than 0.32, which is the slip factor divided by a load factor of 1.4.

Development of the Structural Hollow Section. This is a review of progress in the production and use of both circular and rectangular hollow sections. It contains little that has not already been published elsewhere; most of it is either too general or too brief.

The Interpretation of Radiographs. The amount of site welding being carried out on structural steel work is increasing rapidly, and amongst other methods, radiography is being widely used to check the quality of welded connections. This article explains the basic principles of radiography, compares the various emission sources and films, describes the advantages and disadvantages of various positions of the source relative to the weld, and gives some information on the types of defect which can be detected. It is an interesting and informative introduction to the subject.

Fillet Welds in Torsion and Direct Shear. The author describes some experments performed recently at the University of Malaya. Two plates were joined together by fillet welds, and loads were applied at various eccentricities to subject the welds to both direct and torsional shear stresses. The intensity of stress in the welds was measured by electric-resistance strain gauges. The results obtained showed that stresses set up are completely different from those assumed by normal design theory. The maximum stress recorded was four times as large as expected; the distribution of stresses around the welds was also completely different from that normally assumed. A new theory to suit the observed results is suggested, being based on membrane analogy principles.

Steel Sheet in Civil Engineering. This article reviews the current British Standards relating to sheet steel suitable for structural work, and describes some recent developments in wall and roof cladding, curtain wall panels, floors, and protective treatment. Speed of erection is stressed as a particular advantage of sheet steel over other materials for many structural uses.

J.C.P.

Notes from *Civil Engineering and Public Works Review*, April 1965

PRESTRESSED TIMBER BEAMS. A year ago, an article was published in the CE and PW Review on "Model Tests on Preflexed Timber Beams". This type of beam is prestressed by preflexing and fitting stressing wires. On releasing the flexing load, the wires in the top flange are initially in compression and those below the neutral axis are in tension. On loading, the pre-stressing wires resist the applied bending moment and the timber resists the shear forces. This article is an extension of the previous article and discusses the creep of the timber in shear. It gives results of tests on prestressed beams using curved wires to reduce the shear stress in the beams and, hence, reduce the creep.

STRUCTURAL MODELS IN EXPANDED POLYSTYRENE. In these days, many structures take forms which make mathematical analysis impossible or extremely tedious. In such cases, model analysis is often used. This article describes the use of expanded polystyrene in structural analysis by model testing. As this material is relatively easy to make and it is very easy to prepare models by cutting to shape, the costly process of casting in an accurate small scale mould is avoided and likewise the doubtful method of building up the model from flat sections. The very low value of Young's Modulus for the material means that only a very small load is required to produce a measurable strain. However, this means that the choice of strain gauge is limited as, for many types, the force required to operate the gauge would affect the stress distribution.

USING STUD WELDED HEADED SHEAR CONNECTORS FOR CONVERSION OF TROUGHED DECK BRIDGE TO COMPOSITE DESIGN. As part of the southern extension of the M1 certain improvements are necessary to the link roads. An extremely interesting form of construction is being adopted to improve one of the bridges involved. The original bridge was designed to carry the MOT standard train and was constructed in 1924. The original beams 44 × 12 in built up riveted 'I' beams, have been incorporated in the new bridge by stud welding $\frac{7}{8}$ in dia × 4 in long headed shear connectors to the top flanges of the beams so that the beams and the new 9 in concrete deck act as a composite deck. This increases the capacity of the bridge to MOT HA and HB 45 Units loading.

BRIDGE DECK ANALYSIS—ELECTRONIC COMPUTERS VERSUS DISTRIBUTION METHODS. Concrete bridge decks vary from a plain slab to a grillage of longitudinal and transverse beams. In general, plain slabs are designed by the use of distribution coefficients, normally published in the form of design curves. Grillage systems are commonly analysed by moment distribution or some other relaxation method and today, most computers have a programme prepared for this type of work. This article sets out to show that the extension of the analysis for a grillage system to a plain slab, that is, ignoring the plate action of the slab, produces results which are in closer agreement with experimental results than the results using distribution coefficients. As the distribution coefficient system is simplicity itself when used for right bridge decks of uniform sections, computers are not likely to be used for this type of design. However, the correlation of the experimental results and the predicted results from the computer programme indicate that the grillage design method could be used for the design of skew and varying cross-section slabs without any appreciable error.

THE ULTIMATE LOAD CARRYING CAPACITY OF PRE-STRESSED CONCRETE COLUMNS UNDER DIRECT AND ECCENTRIC LOADING (PART 1). The first part of the article discusses the circumstances where pre-stressed concrete columns could be used in preference of plain reinforced concrete columns. It also describes the preparation of the test columns and testing equipment used in a large number of tests

FUNDAMENTALS OF THE USE OF HIGH TENSILE BOLTS IN STRUCTURAL CONNECTIONS (PART 2). Completes the article on a research project on high tensile bolts carried out at the University of Leeds. This part deals with the general behaviour of friction grip joints and includes a discussion on the mechanics of slip between plates.

THE CUMBERLAND BASIN BRIDGES SCHEME (PART 1). The Cumberland Basin Scheme at Bristol Docks is designed to overcome the traffic congestion on the route from South West England to the North, Midlands and Wales. This part of the article consists of two sections. The first describes the general arrangement of the scheme and the main planning data. The second part describes the design and construction of the new swing bridge. This is a 270 ft long double cantilever weighing nearly 1,000 tons on a single central pivot.

D.F.M.

THE MILITARY ENGINEER

JANUARY–FEBRUARY 1965

A CHRONICLE OF MAPPING. PART I by Kenneth R. Stunkel. This is an account of map making in the world from the earliest known maps 500 B.C. to the twelfth century. It is very clear and interesting and is well illustrated with reproductions of many of the early maps referred to. Part II which will be published in the next number of the *Military Engineer* continues the story into the fifteenth and sixteenth centuries.

CONSTRUCTION FOR TO-MORROW'S SPACE FLIGHTS by Colonel J. Newton Cox, Corps of Engineers. This article is a description of the launching system for the Mobile Orbiting Laboratory (MOL) designed to orbit the earth and permit astronauts to live in space in a short sleeve atmosphere and conduct experiments and observations for periods of a month at a time. The novel feature is the Integrate-Transfer-Launch (ITL) system for assembling the boosters and transporting them to the launch pads. This allows for more than one launch vehicle, a Titan III, to be under assembly at the same time and for the use of the launching pad for a succession of launches. Much detail is given of the building in which the Titan III boosters are assembled and checked and of the transportation system by which they are transferred to the launching pad. There are clear photographs and diagrams.

EQUIPMENT READINESS by Colonel John D. McElheny, Corps of Engineers. A unit's state of readiness for an operation depends to a large extent on the condition of its equipment. Owing to the lack of any agreed way of assessing the readiness of equipment it was not possible to express the degree of readiness in a manner that would be uniform throughout the service and related to an accepted standard. This article describes the system which is being introduced in the US Army to overcome this difficulty. The Army has compiled a list of items of equipment which are particularly important to the unit in respect of its readiness with a list of serviceability critera for each item. By inspection, marks are allotted against each item in the criterea from which the classification of readiness can be assessed. The classifications are Operational, ie good for ninety days of operation, Limited Operational and Non-operational. The system seems to give the required result and is simple to understand and use.

GUYED TRANSMITTING TOWER by E. Cohen and V. R. Bonvissuto. A description in some detail of the design and erection of the low-frequency transmitting tower on the coast near Thurso which forms part of the world-wide communications network of the US Navy. The mast is 601 ft high.

ENGINEERS IN STRIKE OPERATIONS by Colonel H. F. Cameron, Jr, Corps of Engineers. The United States Strike Command is a joint force which has to be ready to deploy at short notice anywhere, prepared for immediate operations ranging from a show of force to nuclear war. This article lists the engineer tasks involved and emphasises the importance of forward thinking by engineers on how to carry out their tasks in view of the limitations imposed by air transport of equipment.

ASSAULT LANDING ZONE CONSTRUCTION. JOINT EXERCISE DESERT STRIKE, by Lieut-Colonel B. P. Pendergrass, Corps of Engineers. Exercise Desert Strike was carried out by United States Strike Command referred to in the previous article. It was on a very large scale more than 100,000 men were engaged. The article describes, with much technical detail and photographs, the construction of Advanced Landing Zones for an assault division.

ROAD CRATERING TECHNIQUES by Lieut-Colonel James A. Dennis. Experiments to produce more effective anti-tank craters and also to eliminate the excessive time and labour required to prepare them have been carried out at the Engineer Research and Development Laboratory Fort Belvoir. This article is an account of the conclusions arrived at. It is in considerable detail and is well illustrated by photographs. The use of shaped charges to make the initial boreholes is recommended and the importance of the shape of the crater in providing a good obstacle to tanks is brought out. A crater with a wide bottom is much the most effective. Such a shape is achieved by firing two rows of charges. Aluminized paste explosive consisting of aluminium powder and C4 explosive fluidized with oils blasted craters that were much larger than those for which C4 was used.

MILITARY ENGINEER FIELD NOTES

EQUIPMENT RETRIEVAL IN THE ARCTIC by 1st Lieut Thurston S. Fox, Corps of Engineers. This is an interesting account of how two dozers were recovered from a swamp, which was covered by a thin sheet of ice, into which they had sunk 13 ft. There are good photographs.

SOIL CEMENT BASE AIRPORT by Joseph P. Ricker. An account of the technical considerations which led to the decision to construct the first civil airport in the United States with a soil cement base. Details of the cross section of the paving are given.

J.S.W.S.

MARCH–APRIL 1965

HIGH WATER IN THE FAR WEST. FLOOD PROTECTION RESULTS. From southern Washington to northern California and as far East as Idaho floods brought disaster in December 1964. These are two articles dealing with the success of measures already taken to deal with flood waters and with the emergency work undertaken at the time. The articles are well illustrated and a good deal of detailed information is given. The level of the flood water was controlled to some extent by the use of emergency storage reservoirs. The construction of more reservoirs is being undertaken which should make the control more effective.

DEEP OCEAN BUOYANT MATERIALS. By R. F. Hinton and R. G. McCarty. In the early days of the "Bathysphere" the limitation to the depth which could be reached was not the pressure resisting capacity of the spheres but the practical difficulty of constructing a cable able to stand the weight of the sphere plus its own weight against the surges created by surface wave action. In this article the various materials which were considered are described. The most promising seem to be syntactic foams. One example described consists of glass microspheres held in an epoxy resin.

BRITISH HOVERCRAFT. By F. C. Livingstone. A short, appreciative, and well illustrated article on the subject.

THE COMPUTER AS A TOOL FOR ENGINEERS. By Glenn L. White, and Paul D. Spindel. This article describes the progress which has been made in increasing the ways in which computers can be used by engineers. Methods of programming are described and among other things the way in which a computer can be used to make the engineering drawing.

SOLVING SIMULTANEOUS EQUATIONS BY SUCCESSIVE APPROXIMATION. By Major John M. Hingst. Corps of Engineers. An article which is of interest to mathematicians only. There is a comment by Brig Hotine of the United States Coast and Geodetic Survey to which the author has replied.

A CHRONICLE OF MAPPING (PART II). By Kenneth R. Stunkel. This covers the development of map making from the eleventh until the beginning of the seventeenth century. By the end of the period covered by the article maps were nearing their modern form and Ortelious and Mercator were working. There are good reproductions of mediaeval and later maps of the world. There is a short account of the survey instruments in use. A third instalment covering the seventeenth and eighteenth centuries will appear in the next number of the *Military Engineer.*

EPOXY PROTECTION AT MILFORD DAM. By Captain Donald R. Pope, Corps of Engineers. An important use of epoxy resins is as a water-erosion-resistant protection in outlet works construction. This article describes the design and construction of the Milford dam and reservoir which forms part of the Kensas River Basin flood control system, and the way in which epoxy resins are being used. There is plenty of detail.

MILITARY ENGINEER FIELD NOTES

INNOVATION WITH THE BAILEY BRIDGE. By 1st Lieut Edward M. Jansen, Corps of Engineers. A 100 ft double-single Bailey is rated Class 30. This article is a description of a method by which its capacity can be increased to Class 60 by using two Class 60 trestles.

ROAD WIDENING NEAR ORLEANS, FRANCE. By Major Wilbert K. Richard, Corps of Engineers. A clear well illustrated account of the design and method of construction used in widening a road. Of distinct interest to anyone faced with a similar problem.

J.S.W.S.