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CONTENTS

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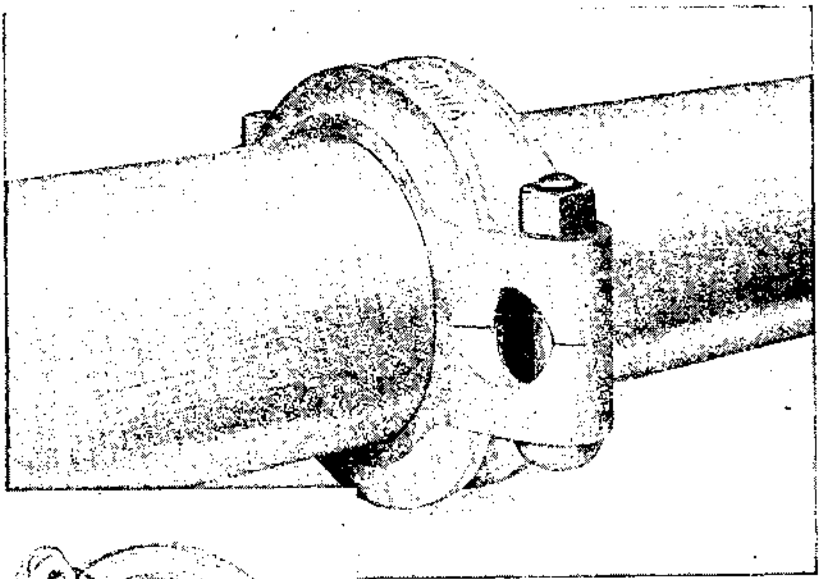

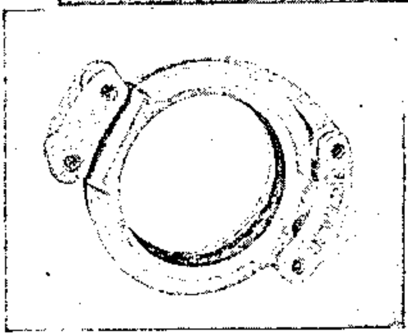

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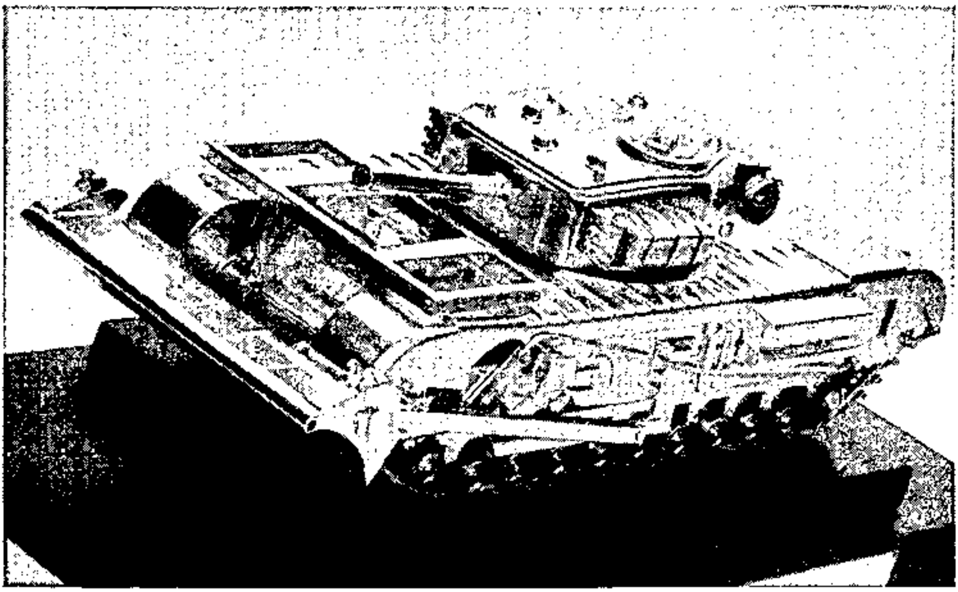

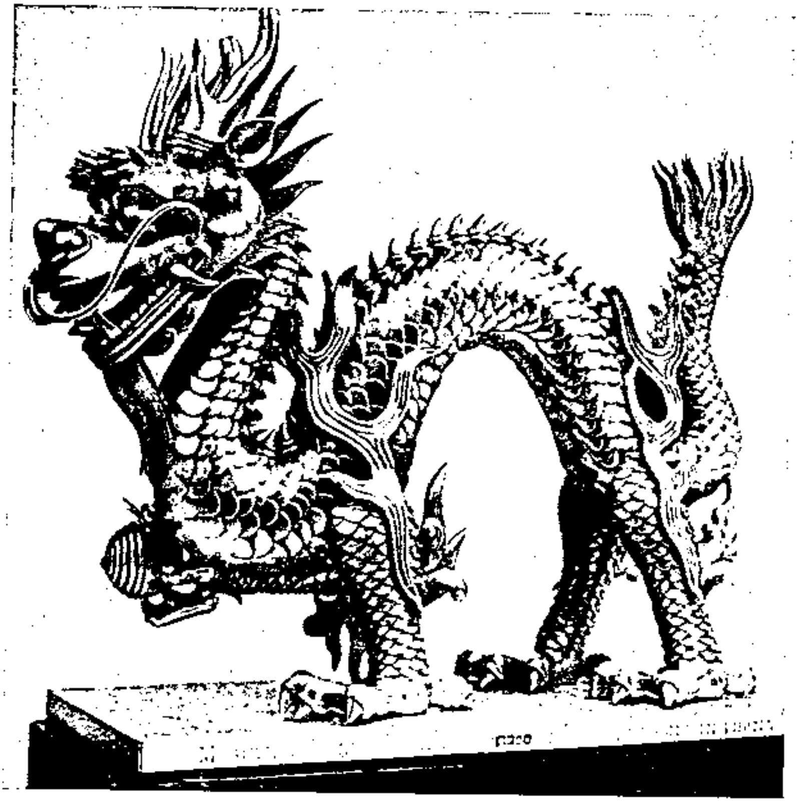

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VOL. LXXVIII

CONTENTS

MARCH, 1964

Presentation of Set of Volumes of Corps History to the Ecole d' Application du Génie, Angers

By Colonel J. R. Cave-Browne, MC

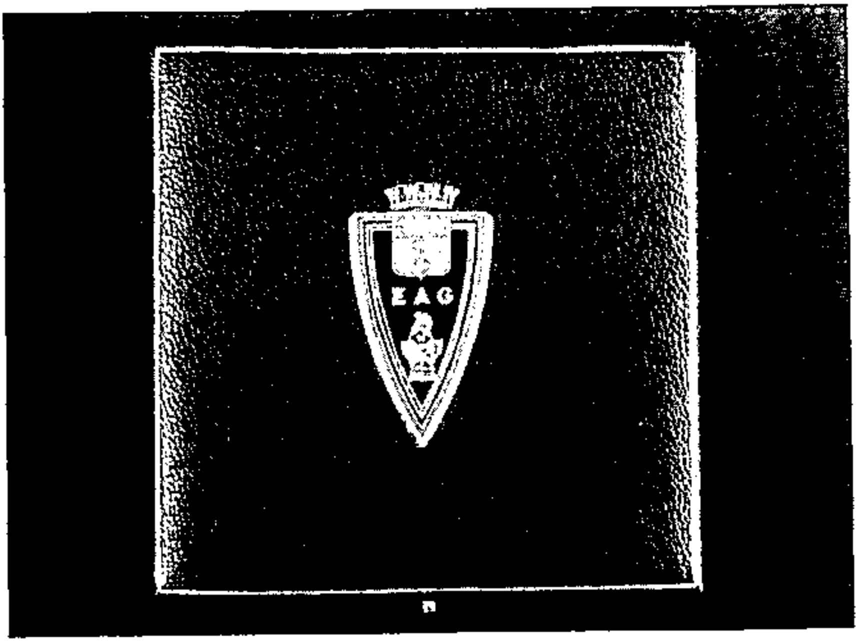
Early in November 1963 I learned that I was to pay a liaison visit to "L'Ecole d' Application du Génie" at Angers and that during the visit I would have the pleasure and the privilege of presenting on behalf of the President and Members of the Institution of Royal Engineers, a set of volumes of the History of the Corps of Royal Engineers to the School.

On the advice of Alan Ross, our Liaison Officer there, my visit was arranged to coincide with St Barbara's Day, as on that day the School holds a dinner in honour of the patron saint of all Sappers and Gunners.

So on 4 December 1963, St Barbara's Day, I spent a very interesting morning and afternoon visiting the School. In the evening, before dinner, all the permanent officers of the School and the officers on courses, some 320 in all, gathered in the "Salle d'Honeur". Gatherings of this nature take place periodically, and on this particular occasion the proceedings started with a presentation of the Medal of the Commander Legion of Honour to General de Nadiallac, Commandant of the Ecole d'Application du Génie, carried out by his second-in-command.

The Commandant then introduced me, and I, on behalf of the President and Members of the Institution of Royal Engineers, said a few words and presented an inscribed set of volumes of Corps History to the School.

General de Nadiallac asked me to convey his thanks and that of the members of his School to the President and Members of the Institution of Royal



Engineers for the gift. He also asked me to accept, on behalf of the Commandant and officers of the Royal School of Military Engineering, a most magnificent medal being a replica in silver of the one struck in gold and given to the Queen on the occasion of her State visit to France in April 1957. Photographs of the obverse and reverse of the medal and its case, bearing the shield of the Ecole d'Application du Génie, illustrate this article.

Presentation to Joint Services Staff College

At a guest night held at Latimer on Tuesday, 7 January 1964, the Engineer-in-Chief presented to the Joint Services Staff College a silver statuette of a Cormorant, the badge of the College.

Introducing Major-General G. W. Duke the President of the Mess Captain J. M. Townley, RN, drew attention to the fact that more than one hundred officers of the Corps of Royal Engineers had qualified as "jssc" and that this represented almost 20 per cent of all British Army officers who had attended courses at Latimer since the foundation of the College in 1947. He also pointed out that the first Army Commandant, Major-General W. H. Stratton, had also been a Sapper.

The present Commandant, Major-General C. M. F. Deakin, has directed that at times when the statuette is not in use at mess functions it shall be displayed in the entrance hall of the mess, beneath the portraits of the Chiefs of Staff under whose aegis the College was formed.

Kenya Flood Relief Operations

By Lieut-Colonel F. W. E. Fursdon, MBE, RE

Kenya, in recent years, has been one of the finest overseas areas for combat engineering to be found anywhere in peacetime. In particular, from January 1961 until September 1962, 34th Independent Field Squadron, which had the great fortune to be based there, led an extremely full, hectic, and often adventurous life. This is no place to record the many and varied activities of the unit during this period, which led it at varying times and in varying strengths not only throughout the length and breadth of Kenya, but also from the Congo border to Kuwait, from the Ethiopean border to the Rhodesias and beyond, and from the tribal war no man's land of Northern Uganda to the palms of Zanzibar.

There was, however, one common thread which ran through all the pattern of work done. This was the reliance, self-discipline and initiative demanded of the junior officer and NCO. To 'live, move and have their being" in the bush was in itself a challenge of real account: administration, particularly water supply, was certainly not just an "exercise requirement", nor were the wild animals a "controlled enemy"! Demolitions, improvized bridging, roads and tracks, airfield construction—never once were any of these done as an exercise, but always because a "real life" end product was required by someone.

As will be apparent from the story told later in this article, the success of the Flood Relief Operation, one of the major tasks undertaken and for part of which period the combat engineer resources in Kenya were reinforced from UK, lay particularly with the junior ranks. It rested firmly upon the sense of responsibility, the ability to improvise and the response to the challenge of the unrehearsed by every subaltern, NCO and on many occasions, each Sapper. There are some people today who are dubious and frightened about delegating so much responsibility to a low level and who decry the ability of the young Sapper to rise to the occasion. True, it takes courage for an OC to do so and he must be prepared to "carry the can" for those mistakes which will inevitably occur, largely through inexperience, despite his precautions. On the other hand, the ultimate benefits to the Corps are not only immeasurable, but essential to its continued healthy existence in the future. To be worthy of the great inheritance of implicit trust reposed in the Corps by Other Arms and Services, there is a crying need to take every opportunity of giving real delegated responsibility to junior ranks, preferably through independent task detachment: there is no substitute for experience so gained.

That the young officer, NCO and junior Sapper still can and assuredly will rise to the occasion, is the major lesson to be gained from the swirling chocolate-coloured waters that swept so suddenly and powerfully through Kenya in the autumn of 1961.

In the *Royal Engineers Journal* of December 1962, Lieut-Colonel Younger gave a brief account of that particular part of Operation "Late Water" with which he had been concerned. For the sake of an accurate historical record, however, it is worthwhile now to add such further information which, for various reasons, he did not include, but is essential in order to present a complete picture of this unusual and stimulating operation.

In the event, work in support of the Kenya Flood Emergency started early in October 1961 and did not end until 1 April 1962, a total of some five and a half months. The RE units originally involved early in the October were:—

1. HQRE East Africa and CRE Kahawa. (Lieut-Colonel J. R. de G. Pilkington, MC, RE, in whom was also combined the role of official RE adviser to HQ East Africa Command.)

2. A composite combat engineer force under Bt/Lieut-Colonel S. A. Frosell, MC, RE (OC 3 Field Squadron) which comprised:—

(*a*) 3 Field Squadron (less Rear Party in UK). This unit was part of 19th Infantry Brigade which had temporarily replaced 24th Infantry Brigade in Kenya, until the latter's return from Kuwait.

(*b*) 23 Field Squadron (one field troop only). This sub-unit was part of the battalion group of 3rd Division which rotated in Kenya every six months as a reinforcement measure.

(*c*) 34 Independent Field Squadron (at approximately two-thirds strength). This was the normal engineer unit of 24 Infantry Brigade, and so was Kenya-based. The balance of this squadron, with the OC, was still away in Kuwait.

The tasks in the early days were mainly those connected with route recce and damage assessment, particularly in the Garissa-Galole-Garsen-Malindi areas, and detachments were deployed accordingly. Then, quite suddenly, the swollen Sabaki river swept away the large bridge on the coast road just north of Malindi. Captain Burnet of 34, with Lieutenant Mornement and his troop of 3 Field Squadron, were the first people on the scene. They constructed an improvised Class 12 raft to keep communications going, and also carried out flood damage reconnaissances beyond the river up towards Garsen. The raft was later replaced by an improvized aerial ropeway, and this carried across many tons of vital food supplies and local trade before its far pier was undermined months later, and the raft came back into service. During this latter period at the Sabaki, Lieutenant Mornement was succeeded by Lieutenant Jameson.

With the return of the OC and the remainder of 34 Independent Field Squadron from Kuwait, 3 Field Squadron returned to UK in mid-October and the OC 34 took over command in the field from Lieut-Colonel Frosell. The tempo of flood work increased, however, and before long detachments and field troops from 34 were deployed and hard at work with route repair and aerial ropeways in the Kajiado, Machakos and Kitui areas. In many other parts of Kenya routes and possible alternatives had to be constantly patrolled under squadron arrangements in order to keep up with the situation generally, and in particular to assess the effects of the floods on 24 Infantry Brigade's deployment plans for other types of operations. In fact the whole of 34 Independent Field Squadron (which included a large Park Troop), less one Field Troop kept permanently on operational standby, became committed to Flood Relief, and a special squadron operations room was set up under Captain Eagle. On 20 November the troop from 23 Field Squadron returned to the UK.

It was not until 21 November that RE reinforcements arrived from Maidstone in the form of a small Tac HQ (Lieut-Colonel A. E. Younger, DSO, RE) and 24 Field Squadron (Major E. F. Twiss, RE), both from 36 Corps

Engineer Regiment. Although the Kenya sappers were delighted to see new arrivals, the East African newspaper banner headline "The Sappers are here" was naturally received with some hollow laughter by those who had now been working in the wet for many weeks!

It had been previously agreed by Lieut-Colonel Pilkington with the OC 34 that for reasons of simplicity and "re-orientation", 36 Corps Engineer Regiment would take over all the then current squadron tasks in areas convenient to Nairobi. This was now done, and freed the OC 34 to go northwards to contact the Provincial Security Committee of Central Province at Nyeri, and discuss with them a plan for deploying his squadron into the more remote areas east of Mount Kenya. Tactfully rejecting the local Police Commissioner's forthright requirement for Bailey bridges by the dozen, the OC's plan eventually crystallized into two priority areas, one each in the eastern parts of Meru and Embu Districts: these were given to Captain Burnet (No 2 Troop) and 2nd Lieutenant Davies (No 1 Troop) respectively. At the same time Captain Dennison (Park Troop) was working independently in the Thomson's Falls-Nanyuki area, and Squadron HQ, based on its permanent camp in Gilgil, carried out frequent local route reconnaissances, particularly around Naivasha, and happily blasted away the rockfalls which blocked the Nairobi–Nakuru railway. Even the operational reserve troop, No 3, was let loose to replace local timber bridges. Lieut-Colonel Pilkington now withdrew from active Flood Relief Operations, but remained as an invaluable source of engineer supply and "chaser-up" of mechanical spare parts and repairs. 24 Field Squadron settled into Rifle Range Camp in Nairobi under fairly basic conditions, (at least 34 were able to help out by lending their OC a proper bed!). Tac HQ 36 Corps Engineer Regiment moved into an office in HQ East Africa Command.

The main tasks for 34 Field Squadron in the Meru and Embu Districts were the traditional sapper ones of opening up routes for wheeled axes. The reason for this was that the local populations of these remote eastern areas were literally living off the RAF food airdrops, and it was a matter of operational urgency to get a road supply system through to them to replace the air delivery. On the routes themselves, Nature had played the part of a determined enemy in the withdrawal battle. The surfaces were of earth and had no proper foundation. Long stretches were frequently flooded, and the patches of black cotton soil made bottomless pits for any normal "fill". Streams of negligible size had grown to rivers ten times the width. Major bridges had been washed away, usually through failure of the built-up approaches to take the side-loading of flood water pressure. Culverts had been blocked by the debris with which the rivers were full, and the resultant upstream pressure had carried them away. A few drifts had been undermined and the haunches gone. Small bridges had lost their wing walls, and the water had surged through behind the abutments. One war-time Bailey bridge had been uplifted and slewed on its bankseats; the balance beam assembly on the centre pier had been washed away. In places unknown springs just appeared overnight, and within a short time had carved out great ruts in the roadway.

From the field squadron's point of view this type of work presented a wonderful challenge, and the best possible form of operational training imaginable. Many new lessons, particularly those derived from the extensive use of helicopters for reconnaissance, and also many old ones were learnt or re-learnt. The handling of local tribal and sometimes prison labour, calls on the art of improvisation, and reliance on the use of such few suitable local materials as existed in those remote areas tested the initiative of officers and NCOs alike. Staff/Sergeant Dawe, operating on his own in the eastern region of Meru District with two sections, had his one and only 3-tonner completely bogged down to the axles for several days, but, using it as his base, continued to rebuild the road ahead: the District Commissioner eventually came to his rescue with a fleet of six Administration Land Rovers to get him on his feet again. No 1 Troop, working east of Embu, had a Land Rover caught and half immersed by a sudden burst of flood water. The only answer was for the troop fitters to strip it down, dry it out, and put it together again—which they did successfully. The whole business of living in small detachments of section strength, when out in the bush on an independent task, taught many invaluable lessons, particularly to junior NCOs, and gave them an unparalleled opportunity for displaying leadership. On one occasion Corporal Leigh with his section of No 1 Troop was cut off from his troop by new floods, yet cheerfully he went on opening up his particular route from culvert to culvert, living on a miniature air supply delivered by the brigade reconnaissance flight. From all ranks was demanded a minimum knowledge of the outline of the machinery of District Administration and of the place of local African chiefs within it. It was because of this awareness, and the ordinary sapper's politeness, cheerful good humour, hard work and natural British diplomacy, that the morale of both helper and helped remained so high. The degree of co-operation shown by the African population varied intensely with the degree of civilization of the area. In some highly developed areas co-operation was practically nil, whereas in the more remote areas the local Africans were extremely helpful. Finally the worries and difficulties of Squadron HQ in Gilgil concerning transport, repair and recovery, pay and mail, rations and clothing, welfare and families and all the detailed day-to-day administration of Field Troops, spread over separate and somewhat tenuous lines of communication often of over 200 miles in length in flood conditions, can well be imagined. Every detachment moving out from Gilgil throughout the whole period of Flood Operations had to join the Squadron radio net, and come on the air twice a day. Besides providing first class training for the Troop and HQ Signallers, this greatly assisted command and control, and although quite a strain to maintain, proved its worth in emergencies.

Even before the tasks in Embu had been completed at Christmas, the OC, acting on information received from the appropriate District Commissioner, was already carrying out further flood relief reconnaissances in the Cherangani Hills some 40 miles north-east of Eldoret, and some 200 miles north-west by road of Squadron HQ. Here, before the floods, an 8-mile long mountain side-cut track dropped down some 4,500 ft from Chesoi to a small post called Tot in the valley below. Now it only existed in parts. At first it seemed a hopeless task, for in places the whole roadway had been washed far away below and in places it was blocked by landslides from above.

However, the track had been the lifeline to the surprisingly large population of 5,000 who lived on the lower escarpment slopes. At that time the only way for the District Officer himself to reach Tot, let alone urgent medical, food or other supplies, was on foot with head loads. The human problem therefore was urgent but its solution difficult and certainly very consuming in materials, equipment and labour. With a conviction strengthened by experience of a very similar problem that had faced him on a reconnaissance in North-East Uganda nine months before (of a task which had recently been carried out by Lieut-Colonel Frosell's composite combat engineer force referred to at the beginning of this article) the OC accepted the task. In fact the Chesoi track was to become by far the biggest single engineer task undertaken by the Royal Engineers on Flood Relief Operations in East Africa.

Lieut-Colonel Younger returned to the UK early in January. In the meanwhile 24 Field Squadron had been very busy, initially working in the Kitui and Machakos areas where it had relieved 34 Independent Field Squadron at the end of November. The work consisted mainly of repairing the severe damage to the roads, culverts, timber bridges, drifts and in particular the well-known drift at Mwingi. At the same time its No 1 Troop (2nd Lieutenant Hume) was opening up the Namanga–Amboseli–Laitokitok road, familiar to visitors to the Amboseli Game Reserve and to climbers of Kilimanjaro. Later on, as work was completed and priorities changed, the troops were redeployed farther afield.

No 1 Troop was sent to work in the Archer's Post area north of Isiolo. Even with plant assistance from 34, the tasks expected of it were really far beyond the military resources available, a fact quickly appreciated by both Squadron Commanders involved and also by the Provincial Engineer. Such things do happen, though, on occasions when tasks have to be undertaken for "political" reasons. Archer's Post, for both 24 and 34 Field Squadrons, was the only unhappy task of the whole Flood Relief Campaign.

No 2 Troop (2nd Lieutenant Hacker) moved north-west to Kisumu, where, being on the shores of Lake Victoria, the land is very low-lying and had suffered extensive flooding. The troop repaired a ferry, built one Bailey (70 ft) and two timber bridges, did the usual road work and also operated assault boats. No 3 Troop (initially 2nd Lieutenant Gasser), after finishing the Mwingi drift, set off for Garissa away to the east on the Tana river. Here they found the large Inglis bridge had collapsed, having lost two piers and a bankseat into the swirling waters. To keep communications open they first built a normal light floating bridge raft (for costing purposes £23,000 worth!) and then later assisted the Ministry of Works in extricating and repairing the Inglis bridge until the time came for them to return to England. Months later, after a new far bankseat had been completed and the damaged bridge parts made good but with the central piers still deficient, the Ministry opened the bridge for traffic, up to Land Rover class only. For heavier loads the raft was still used, reinforced by an extra pontoon to give better buoyancy when working near the river banks. This was rigged as a captive ferry and operated in a very ingenious manner by a continuous cable driven from the wheel hubs of a jacked-up tipper. This method was described in detail and illustrated in Royal Engineer Training Memorandum No 42.

Early in January 1962, Lieutenant Lloyd of 34 Squadron left Gilgil with his No 3 Field Troop for the Chesoi track. He was away for a little over two months, complete with additional RASC transport and an RAMC orderly. In many ways it was a perfect task for a troop commander. It was impossible to fly to the area by light aircraft and virtually impossible to find a large enough area of flat ground on which even to land a helicopter. For the last 13 miles, road access to his camp involved a hair-raising drive of an hour along side-cut tracks and literally strewn with double hairpins. For the last

5 miles the very wary Land Rover descended in full observation of the camp, so it was impossible for the Troop to be taken by surprise!

Starting at the top of the escarpment, drilling and blasting all the way, the track gradually came to life again. Where the work was held up on a major section of fall-away, or of rock face, a section would leapfrog forward on foot in single file with explosive and an Atlas Copco Cobra (hired locally in Nairobi for the task) and take on the smaller jobs ahead. As the work progressed, so the troop vehicles were required to drive down and up the track carrying men and stores. To drive a 3-ton truck with the offside wheels often within a foot of a sheer drop of thousands of feet was no job for anyone with nerves, but the drivers had to do it, and on occasions even had to back up! A few, somewhat naturally, could not "take it", and on one occasion even the SSM, visiting with the OC, had one leg poised over the tailboard of an RASC truck muttering unprintable comments on the driver's capabilities! The District Officer, John Allen, produced some local African labour to help on the job, and these men were remarkably useful in an unusual way. They were experts at splitting rock. After watching three sappers unsuccessfully bashing a rock with sledge-hammers, for instance, they would politely edge the soldiers away from the undefeated object. Then after what appeared to be only a passing preliminary glance at it, they would quickly and effortlessly tap the rock hard in a series of places, and it would fall apart!

In many places the track had fallen away completely, and after preliminary blasting to create a "cut" way, there remained the difficulties of constructing frequent cross-drains, and of building up long retaining walls, often of large height, with which to maintain the strength of the surface. The requirement was for courses of pure dry rock and stone, without any intervening "mortar" layer of earth, in order to achieve a self-draining or percolator action. This was because any rain or flood water would subsequently wash away the earth "mortar", the rocks would move or subside relative to one another, and collapse would follow swiftly. Dry walling is not a common art today, and even many of the troop bricklayers learnt it for the first time. Lieutenant Lloyd had the greatest difficulty with the local labour over this technique: unless closely supervized, they just would not do this odd thing that the "bwana" wanted, and which was obviously contrary to their tradition!

Another aspect of construction which created problems was the original choice of alignment of the old track, which for obvious reasons could not now be altered. In several places the side-cut had been made into the hillside where it ran downwards into the valley below at an angle of 80 degrees. This would have been quite all right had not the underlying rock strata in the hillside been running in the same direction at only 70 degrees. In the appalling rain conditions, this had naturally given rise in places to wholesale slips of the surface earth layer, and unless the new cut and retaining wall were really well keyed into the underlying rock face, the track's foundations would always be unstable. This was not easy to do, and in some places proved well nigh impossible.

Near the bottom of the escarpment an extraordinary thing had happened. A whole part of the mountainside near its summit had been broken away by the exceptional rain, and this huge piece, some four acres in size, had roared 5,000 ft down the mountainside like some fiendish lava flow, taking all in its path. It had spewed down the lower slopes and now, at the bottom, its energy spent, lay this river of soft mud some 5 ft thick, slowly attempting to dry itself out. This was No 3 Troop's final hurdle, in complete contrast to their earlier assaults on massive granite rock faces.

No account of this task would be complete without reference to the African Inland Mission Hospital at Kapsowar, 12 miles short of Chesoi. This isolated community, with its devoted little team of missionaries led by Dr Lindsay, provided medical treatment, warm hospitality and a change of scene from the working site for members of the Troop over the whole period, and for this they will long be remembered.

Whilst the saga of the Cherangani Hills was being played out by No 3 Field Troop, Captain Burnet had completed his many and varied tasks in Meru District, and had returned to Gilgil. Apart from his several tasks of route opening and improvised timber bridging, there had been one major landslide to clear which was effectively blocking the only "eastabout" road around Mount Kenya, a twisting and slightly hazardous route well known to keen followers of the annual East African Safari. Due to a remote secondary blast reaction during the clearing operations, Corporal Morley had been hit by a flying stone which damaged his skull. He was quickly evacuated by helicopter to hospital in Nairobi, and emerged a week later none the worse for his adventure.

In support of the field troops of 34 Squadron throughout, and of the troop of 24 Squadron whilst in the Archer's Post area, was the highly independent plant detachment of 34 Squadron's Park Troop. This little private army normally spent its life constructing a pattern of airfields throughout the more isolated parts of Kenya. In their own peculiar way they had already spent four months out on detachment before Flood Operations started, and so their subsequent redeployments were so much routine as far as they were concerned. How this little band of men and cumbersome machines, under command of Corporal Davies, literally lifted and hauled itself for miles across river beds, rock outcrops and vanished track alignments as they travelled from job to job, was at times almost unbelievable. Often they had to select, clear and build their own road as they went. Flood tasks completed, the detachment reverted to airfield construction once more, and in fact did not return to Gilgil for a further seven months.

On 12 February, 24 Field Squadron returned to UK, leaving Lieutenant Tansley's field troop behind with 34 Squadron. As its departure date at the time was then uncertain, this troop was given the straightforward task of building a Kenya "tree trunk" stream bridge on a local track to the Cartwright farm to replace yet another flood casualty, but this one had a different priority. The Duke and Duchess of Gloucester had to cross it in seven days' time as they were due to stay the night at the farm concerned. The job was done, but the OC was told later rather pointedly by the MA that the Duke had been "rather amused" by the bump he had noticed as the car drove on to the decking! This troop flew back to the UK a few days later.

North-west of Kisumu, and on the road from there towards the Uganda border, lies the small township of Mumias'. This little community had once been well known as the terminus of one of the old Arab slave-trading routes up from the coast. Indeed, as one moved around, Arab features were clearly discernible in the dark faces of the local population. Before the floods, and a mile west of Mumias', there had been a substantial suspension bridge. Now it was a bridge no more, and had not been so since the previous November. This main route to Uganda had been well and truly cut, and none of

Photo 1. Improvised bridging in Embu District.

Photo 2. Improvised bridging in Embu District.

Kenya Flood Relief Operations 1,2

Photo 3. Improvised bridging in Embu District.

Photo 4. Mud, mud, glorious mud! (34 Indep Field Sqn, No 1 Troop).

Kenya Flood Relief Operations 3 & 4

Photo 5. "All together lift . . . hup!" (No 1 Troop land-rover, Embu).

Photo 6. Mumias' Bridge (34 Indep Field Sqn, No 1 Troop).

Kenya Flood Relief Operations 5 & 6

Photo 7. The river of soft mud, which had roared down the mountainside, after partly drying out. (Chesoi-Tot-track).

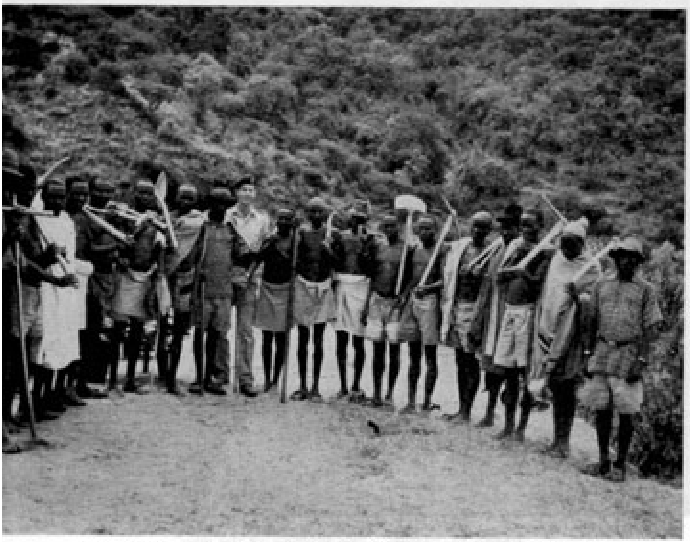


Photo 8. Lieut A. C. D. Lloyd, RE with No 3 Troop's local "gang".

Kenya Flood Relief Operations 7 & 8

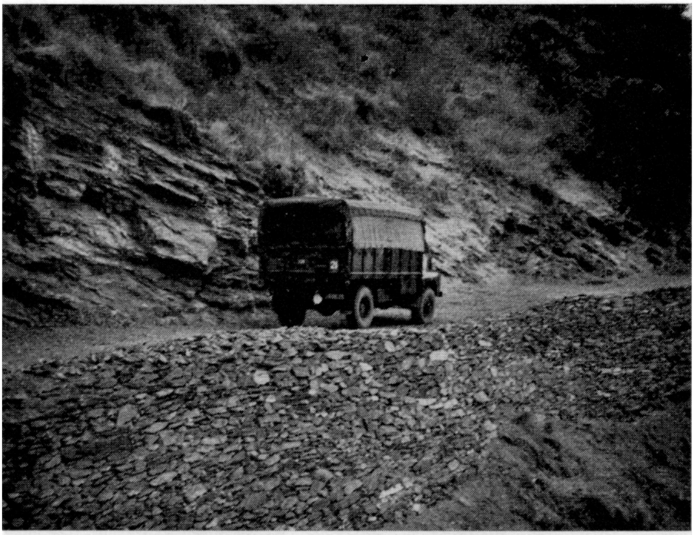


Photo 9. A RASC 3-tonner passing over a "dry wall" section (Chesoi-Tot track).

Photo 10. "Drilling and blasting all the way".
Sappers of No 3 Troop on the Chesoi-Tot track.

Kenya Flood Relief Operations 9 & 10

Photo 11. "In places it was blocked by landslides from above" (Chesoi-Tot track task).

Photo 12. The Garissa ferry (built by 24 Field Sqn).

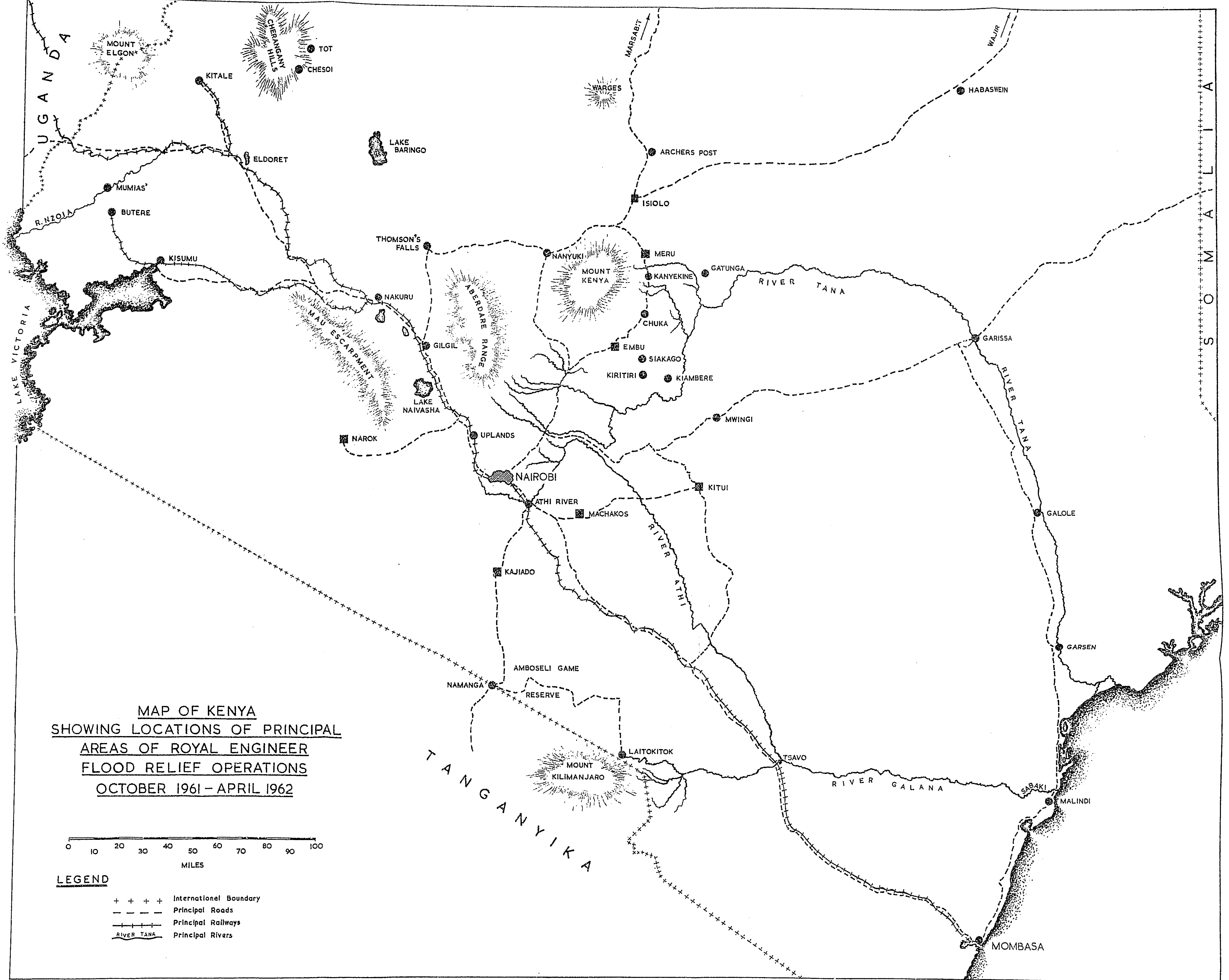
Kenya Flood Relief Operations 11 & 12

Photo 13. The Inglis Bridge, Garissa, with ferry in foreground.

the usual busy trade traffic had been possible over the nearly 200-ft width of swirling foaming chocolate coloured water. The site had been visited in January 1961 by Major Twiss, OC 24 Squadron, who had subsequently suggested that the remains of the old bridge be removed and an EWBB built to replace it either by his Squadron or, if he had gone, by 34. This view had been supported later by HQ East Africa Command at a meeting of the Flood Relief Committee.

One day at the end of February the Provincial Engineer Nyanza walked into the OC 34 Squadron's office in Gilgil and asked him whether the Squadron would be prepared to build him a Bailey at Mumias'. Not knowing anything whatever of the previous negotiations or decisions, this naturally took the OC somewhat by surprise. However, with Captain Burnet's troop back in Gilgil to act as operational reserve or "point troop", 2nd Lieutenant Davies was in fact free to go out again and so Mumias' became his next troop task.

First a detailed reconnaissance had to be carried out on site and the problems of the removal of the old bridge gone into with the Nyanza Provincial authorities. It was found that the existing pier would have to be modified slightly, but this, together with some abutment work and the removal of the old bridge, would be undertaken by the civil authority. The design finally adopted was for a 150-ft broken span Bailey bridge, launched as one and then broken over the pier and jacked down. Next, with the help of the CRE Kahawa, the bridging had to be checked over in Nairobi, loaded on to the railway and progressed to the nearest railhead to the site which boasted a crane: this turned out to be at Butere, 10 miles away. Finally local transport delivered the equipment to the site. With the Troop camp site set



MAP OF KENYA
SHOWING LOCATIONS OF PRINCIPAL
AREAS OF ROYAL ENGINEER
FLOOD RELIEF OPERATIONS
OCTOBER 1961 – APRIL 1962

up in the old District Officer's area—too many of the old DO's graves were there too, all victims of blackwater fever—construction could begin. All went well, and within two days of arrival, surrounded by hundreds and hundreds of Africans lining each bank of the river, the bridge was opened to traffic. The local African King made a speech, the noise was terrific, and the Troop were formally presented with a fine pair of rams.

The rams returned to Gilgil safely, and were firmly pegged out in No 1 Troop conservancy area. They did valiant work, but had to be supplemented by mechanical grass-cutters during the week before the Unit Administrative Inspection months later.

With the opening of the Mumias' Bridge on 1 April, 1962, Flood Relief Operations by the Royal Engineers in Kenya officially came to an end, although minor connected tasks tended to arise for some time. Over a total period of five and a half months a variety of sapper units had worked hard under difficult conditions for very varying lengths of time in order to relieve distress to countless groups of Africans, and to restore communications in remote areas. Of necessity the work done had often been operational in standard, and it lay now with the Civil Administration to improve on this first-aid service, and carry out essential maintenance on the routes and bridges which had been constructed.

Throughout the entire operation, as can be imagined, morale remained exceptionally high. It was unfortunate, however, that the sappers at work for so many months on the various sites were hardly ever visited by anyone other than their own commanders or the local District Officers—a point that did not go unnoticed by the men. PR could have collected many good stories, but the Brigade Recce Flight proved far more attractive for them, and so even they never came! The only exception to the lack of visitors, however, was the Command CIV team. To its eternal credit for diligence, this team faithfully pursued 34 Squadron detachments to their remotest deployment, and in the middle of the Chesoi track task carefully inspected every item on charge to No 3 Troop! As can be imagined, Squadron transport generally had taken an appalling "bashing" in order to keep going, and the CIV report, made after four months on Flood Relief Operations, made interesting reading!

During the whole period from October to April, records of all the man-hours of work done and of commodities used had had to be submitted to HQ East Africa Command for costing action. Although this service had been given to others and would have to be paid for by someone, there was an immense gain by all the units that took part, not the least by 34 Independent Field Squadron which had borne the major load of the Emergency and had been committed for the full period of five and a half months. The operations had provided the ideal opportunity for realistic training under tough conditions. Lessons there were in plenty. Some of the important ones have already been mentioned; others were there, particularly for Commanders in the field at all levels as well as staffs, and one hopes that these will always be remembered by those who were lucky enough to have taken an active part in this unique experience.

US Army Airborne Engineers Build an Airfield

By Lieut-Colonel I. T. C. Wilson, MBE, MC, RE
(British Liaison Officer, Fort Bragg, USA)

Introduction

Two assault landing fields were built on Joint Exercise SWIFT STRIKE III in South Carolina in August 1963 by XVIII Airborne Corps. The first was contructed by 82nd Airborne Division and was surfaced to give it an all-weather capability. The first aircraft landed on this field at P+31 hrs, but it was not until P+78 hours that the field was completed with its surfacing. The second assault landing field was constructed under the supervision of 101st Airborne Divisional Engineers and required only 24 hrs construction time.

The assault landing field built by 82nd Airborne Division was planned for in the initial airborne assault and a site was chosen adjacent to one of the drop zones. It was to provide the main airhead for the assault force. Details of construction are shown below. Timings are taken from P hour and include the time for rallying of parachute troops and derigging and collection of heavy drop equipment.

The second landing field was designed to be a stand-by in case of any trouble or other circumstance which would prevent use of the first. A site requiring comparatively little earthwork and with good soil characteristics was chosen, although it was some distance from the drop zones and from a convenient road network. Earthmoving plant was moved to this site after the first landing field was completed and came under command 101st Airborne Division Engineers. Although the construction time appears remarkably short, it should be pointed out that this time was recorded from the arrival of the equipment and troops on site, not from a P hour. Furthermore more plant was available to work on this field than the first one because some came in by late drops, particularly scrapers. The landing field was not surfaced. It was used for 106 aircraft landings when a C-123 aircraft attempted to land short of the primary landing field and the subsequent recovery operations prevented its use.

Scope of the Exercise

Exercise Swift Strike III was a major joint conventional and unconventional warfare two-sided field training exercise involving more than 100,000 troops and airmen, using over 6 million acres of privately owned land over which manoeuvre rights had been acquired. It was perhaps the biggest peace-time manoeuvre ever held in the USA, and the first time since Operation Market Garden in Holland in 1944 that XVIII Airborne Corps has gone into airborne action as an integrated unit. The plan included an airborne assault by XVIII Airborne Corps and its supply entirely by air for the duration of the exercise.

Details of Construction of the Primary Landing Strip

Specifications. The specifications for an assault landing field for C-130 transport aircraft call for a runway 3,000 ft long and 100-ft wide with 300-ft overrun at each end. Because this landing field was to be used as an airhead, a taxiway was required parallel to the runway. Off the taxiway a parking area 500 ft by 200 ft was required. Both runway and taxiway were to be surfaced with Pierced Aluminum Plank (PAP) giving a 50-ft wide runway mat and a 25-ft wide taxiway. The specifications called for a PAP mat surface because meteorological statistics showed that rainfall was to be expected in South Carolina during August. This year no rain fell at all on the area of the landing fields throughout the exercise. Design criteria are shown in Annex "A".

Responsibilities. The initial terrain analysis was carried out by 517th Engineer Detachment (Terrain). The overall planning and direction of tasks was in the hands of XVIII Airborne Corps Engineer. The responsibility for detailed planning, command and control of the primary landing field was vested in CO 307th Engineer Battalion, the 82nd Airborne Division Engineers. The majority of the earthmoving work was carried out by 618th Engineer Company, Light Equipment, attached to 307th Engineer Battalion.

Planning. The exact location of the site was selected from aerial photographs (Annex "B") and preliminary measurements were made off them. A confirmatory reconnaissance was carried out on the ground by a party from 307th Engineer Battalion before the exercise started (Annex "C"). Contours were surveyed at 5-ft vertical interval and intermediate contours were interpolated at 1-ft vertical interval. Detailed calculations were then made of the quantity of earthwork to be moved and the quantity of plant required to do it was computed. The volume of earthwork was estimated to be 10,000 cu yds. The reconnaissance party also brought back soil samples for tests for optimum moisture, density and compaction.

AIRCRAFT ALLOCATIONS

Day	Aircraft	Load
D Day	9 C-130	Personnel jumping (540)
	69 C-130	Heavy Drop
	10 C-130	Ground Proximity Extraction (total of 16 loads only were extracted on this occasion)
D+1	105 C-119	Heavy Drop
	5 C-119	Heavy Drop
D+2	9 C-119	Heavy Drop
	8 C-130	Air Land

ENGINEER EQUIPMENT

The following equipment was finally planned for air delivery. The actual numbers which arrived are shown. The reasons for all the discrepancies are not known. In some cases the heavy drop malfunctioned, in some cases the rigging was bad and the rigged load was not accepted for loading by the Air Force, in some cases the sortie was not flown or the aircraft allocated failed to arrive for loading.

Air Drop Loads		Arrived on Site
Dozer D4	6	6
Dozer D6	6	3
Grader 212/220	13	8
Medium wheeled tractor (MRS)	9	3 on D Day, 3 on D+1

Air Drop Loads		Arrived on Site
7½-yd Scraper	9	8
Light wheeled tractor (Michigan)	4	3
2½ T Dump truck	9	5
210 cfm Air Compressor	1	1
Sheepsfoot roller	3	1
2½ T Cargo truck	1	not known
¾ T truck	16	not known
¼ T truck	23	not known
Pierced Aluminium Plank (PAP) bundles	927	
Fuel for plant	5 C-119 aircraft loads.	
Airland loads (including ground extraction)		
7½ T crane	1	
7-35 T roller	1	
PAP bundles	32	

NOTES

(*a*) In the US Army, heavy drop loads are dropped on unstressed platforms, that is to say the parachute risers are fixed directly on to strong points on the equipment to be dropped, and the platform serves mainly as a tray to carry the energy dissipating material to cushion the landing. Although this method has the disadvantage of not being able to drop tactical loads such as a truck and trailer, it seems to be entirely satisfactory for the heavier single loads such as bulldozers. It does mean, however, that equipment which might be heavy dropped must be provided with strong points to carry the opening shock of the parachutes.

(*b*) PAP M9 is supplied in standard bundles of thirteen full-length planks and two half planks. The weight per bundle is 1,107 lb. The full length plank is 13 ft 3 in long. For heavy drop 7½ bundles were rigged on each platform for C-119 aircraft, 11 for C-130 aircraft and 9 for ground proximity extraction. Two platforms were loaded on each aircraft.

307th Engineer Battalion jumped with the rest of 82nd Airborne Division at P hour and their initial heavy drop followed 20 minutes later. Further items of heavy drop followed some 6 hrs later and on D+1. The majority of PAP was dropped on D+1. In accordance with the Divisional Standard Operating Procedures, five of the Engineer Battalion's eight platoons jumped with their affiliated battlegroups and remained with them for the opening stages of the battle, so until those platoons returned, the Battalion was rather short of manpower. The DZ was adjacent to the site of the landing field so that the assembly of men went smoothly despite some last minute drop cancellations. The heavy drop was rather erratic and items were dropped all over a large area, and of course, engineer items were intermingled with heavy drop items from a number of other units. The collection of plant was relatively easy because it could be easily identified but there were problems with common user vehicles. Derigging teams had been carefully briefed on the chalk numbers of aircraft in which loads were, but the aircraft lost their flight sequence and confused the derigging teams. Collection of PAP bundles became a major task using up men, equipment and vehicles. In this the Michigan front loaders proved very useful, and locally employed civilian labour was also used.

Sequence of Work

On arrival at the site, a reconnaissance party confirmed the paper location of the landing field and marked it out. Centre line stakes were set and stripping of the vegetation and the top soil began using the dozers. A preliminary centre line grade was then established and grade foremen were told the approximate cut or fill at each station. Slope stakes were set. Final grade stakes were not used. The motorized scrapers (MRS towing 7½ yd scraper) proved to be efficient earthmovers, these required pushing with a dozer to fill. Graders were used for trimming the surface, cutting side drains and maintenance work; in fact, they were also used for some surface stripping and for minor cut and fill work where nothing else is available. It is not easy to cut to a fine grade with the light airborne grader but they were invaluable for rough shaping. Finish grading was omitted as not essential for assault aircraft and excessively time consuming. It will be noted that only three MRS tractors dropped on D-Day and, therefore, only three scrapers were available. Although the original task planning anticipated the use of rollers for compaction of fill, they were found to be unnecessary because the fill compacted adequately under the wheels and tracks of the plant; a CBR of 10-14 was produced. PAP was laid by hand after the earthwork had been completed.

Organization of Work

An outline work table had been prepared for the task but the actual completion of each sequence was not recorded. A percentage completion of task chart was displayed for the benefit of visitors. The supervision of the work was performed by Headquarters 307th Engineer Battalion who furnished a survey party for checking stake pegs as work progressed, and who made regular readings of the California Bearing Ratio of the working surface by means of the cone penetrometer (the Commanding Officer was limping due to an ankle injury, used a penetrometer as a walking stick). The Light Equipment Company provided foremen to supervise plant work and plant operators on a replacement basis so that work could continue around the clock. They also operated a central servicing system for maintenance of equipment. This unit possesses the capability of operating and maintaining its equipment but not of planning and overall supervision of work. Night work was carried out by the lights on the equipment and floodlights were set up in the servicing area. The floodlights were also used for laying PAP.

Surfacing

Because PAP mats started in different places cannot easily be joined, the laying of a runway mat can only absorb a limited number of men working at any one time and the progress is bound to be slow. An additional complication is that the mat requires to be stretched at intervals as it is laid to avoid future problems of buckling in use. The ideal method of working would be to start in the middle of the runway and work in both directions. On this landing field, because plant work at the normal touchdown end of the runway was finished last, PAP laying was started at the other end. This fact caused trouble on D+2 when the mat was incomplete and a C-130 aircraft landed rather far down the runway and in using his brakes hard on the beginning of the PAP mat caused it to buckle. There was some interference between flight operations and construction when aircraft arrived at unspecified times. The majority of the surfacing had to be laid by night. The laying parties deserve a tribute for the very smooth organization and extremely hard manual work that developed in laying the PAP mat. Rates of laying were some 300 sq ft per man per hr, or 120-ft run of runway per hr per laying party.

Mat was placed directly on the compacted surface at first, but could not seat itself into this surface. The hard surface provided fulcrums at either end of slight depressions and the planks bent under load rather than crushing down the high spots. The hard surface was also probably responsible for the tendency of the mat to slide. When this fact was noticed, the remainder of the plank was laid on a bed made by scarifying the top two inches of soil and hand-filling low spots, with far more satisfactory results. Mat laid on the compacted surface was left in place but covered with a thin layer of soil which vibrated through the perforations and was then heavily watered. Three junctions in the runway net were made by trenching and burying. This could have resulted in a soft transverse section had severe rainfall been experienced. The PAP appeared brittle and many breaks with sharp edges occurred due to various causes. Despite the watering and the mat, dust became a major problem and aircraft had to wait between landings to allow the dust cloud to settle, it was visible for miles and one hates to think of its effect on the air intakes of jet engines.

The first aircraft landed on this assault landing field at P+31 hrs at which time it received six fully loaded C-130 aircraft, at this time not only the runway was complete but also much of the taxistrip and the side drainage. The landing field was complete for full operations by P+78 hrs and was then christened *Sapper Field*. The airfield was used for a total of 130 aircraft landings.

COMMENT

While it is realistic to assume that topographical data might be available to the planners, it is considered unlikely that a reconnaissance party would be able to cover the ground in the detail which was obtained immediately before the airborne assault, even in the setting of this exercise where friendly guerilla bands were active. Therefore the planning for a task of this nature must not be too detailed and a well rounded equipment family is required to deal with the unexpected.

A study of the times worked by the various items of plant shows the following results:—

Plant	Hours to first aircraft landing			Total Hours to completion		
	Work	Maintenance	Total	Work	Maintenance	Total
Grader	210	26	236	285	31	316
Dozer	219	28	247	309	36	335
MRS w/Scraper	105	13	118	180	18	198

Bearing in mind that the unbalance of scrapers to other plant must have caused some diversion of equipments to tasks for which they were not best suited, also that much more than a runway had been completed by the time the first aircraft landed, and from personal observation, it is considered that the amount of earthmoving plant and equipment which was really essential to prepare this area of ground to a limited operational runway in 36 hrs was:—

MRS tractors	3
Scrapers	3
Bulldozers	3
Graders	4
Dump trucks containing water sprinkler attachments	2

This totals 15 platform loads and even allowing one-third reserve for drop casualties would require only 20 platforms. Allowing for the fact that most of these are large heavy drop loads and allowing aircraft space for dropping personnel, tactical vehicles and resupply, some thirty C-130 aircraft sorties would have sufficed.

The PAP for surfacing the landing field was very nearly all delivered by parachute. This is a most uneconomical method of delivery, both in terms of aircraft space and in terms of the labour and equipment to collect bundles dropped all over a large DZ. The decision to deliver it by this method was taken partly to save time in having it available without delay to the landing field construction party, but principally to prove that it could be done. It should almost always be possible to land a limited number of aircraft on an unsurfaced runway, and it is far more economical to fly in the PAP. The quantity required would have fitted into some 40 C-130 aircraft, in comparison to 114 C-119s and 18 C-130s actually used. In the case of this exercise the PAP surfacing was not necessary at all. There is considerable doubt, in any case, as to the value of the M9 aluminium mat for an aircraft runway, its effectiveness is marginal. It should only be used after other alternative solutions, soil stabilization or dust palliatives, such as oil, have been tried and found infeasible. There still seems to be much scope for research into the problems of providing a mat or membrane surface for airfields.

It seems wrong to interrupt construction work on a landing field for flight operations though this may have to be accepted in certain circumstances in which case aircraft usage must be at specified times only. If two fields are required, the alternate should be built first to minimum criteria, and all air traffic should use that until the primary is complete. If only one field is required, the taxiway should be built to emergency standards and that should be used until the main runway is complete. Had it been possible to construct the landing field in stages in this manner, the final completion time might have been shortened.

Aerial delivery of supplies and equipment seldom goes as planned. Organization is required for control and receipt of heavy drop loads and, in the rear echelon, to insure that deliveries are made.

Conclusion

The construction of an assault landing field by a parachute dropped force using air delivered equipment in a time of 31 hrs from P hour is a considerable achievement and great credit must go to all those concerned in the project. Without attempting to detract from their very fine performance, two points should be stressed. Firstly, there is an element of luck in the weather, the moisture content of the soil must have been just right to compact so readily, and rain, particularly in the construction phase could have caused all sorts of problems. Secondly it is considered that the material and equipment allotted for the task was greatly over-insured. It is rare that 215 transport aircraft will be made available for one task, and it is suspected that the choice of quantities of equipment was based more on the establishment of the Light Equipment Company than on very detailed calculations. It is evident that the planning did not take full advantage of the liberal grade and rate of change of grade criteria in order to reduce to a minimum the earthwork required. This was, however, done in practice. It is inevitable that to economize in time, some good construction practices may have been slighted, and the completed landing fields may not have met with the entire approval of a professional civil engineer, but any military engineer should be proud to be associated with the achievement.

Annex "A"

AIRFIELD, GEOMETRIC CRITERIA FOR C-130 ASSAULT LANDING STRIP

ITEM	36 Hours STAGE I	72 Hours STAGE II
Runway		
Length	3,000 ft	
Width	100 ft	
Subgrade Strength	CBR 6	
Type of Surfacing		M9 mat centre 53 ft
Longitudinal Grade	2.5 per cent maximum, 0.5 per cent maximum rate (1) of change per 100 ft, minimum distance between vertical curve PI's 400 ft, minimum sight distance 3,000 ft	
Transverse Grade	1 per cent minimum, 3 per cent maximum (2)	
Shoulders	10 ft wide	
Transverse Shoulder Grade	3 per cent minimum, 5 per cent maximum	
Overruns	300 ft each end, full width	
Longitudinal Over-run Grade	3 per cent maximum rate of change same as runway	
Approach Zones	5,000 ft length 300 ft wide at end of runway 1,500 ft wide at 5,000 ft from end of runway	
Glide Angle	30 to 1 beginning at end of runway	
Lateral Clearance to tree line	150 ft from C/L runway	
Lateral clearance to buildings	300 ft from C/L runway	
Taxiway		
Width		50 ft
Subgrade Strength		CBR 6
Type of Surfacing		M9 mat centre 23 ft
Longitudinal Grade		5 per cent maximum, 3 per cent desirable (1)
Transverse Grade		1 per cent minimum, 3 per cent maximum (2)
Shoulders		5 ft wide
Lateral Clearance to treeline or buildings		100 ft from edge of taxiway
Parking Area		
Dimensions		200 ft × 500 ft to be expanded as soon as possible to accommodate 10 C-130 aircraft
Lateral Clearance to tree line or building		100 ft from edge in area

Side Clearance all areas		1 on 20 from the edge of runways, taxiways and aprons throughout clear zones
Drainage		
Runway edge	V ditch 8 ft minimum width at shoulder elevation, maximum slopes 1 on 2	
Taxiway edge		V ditch 8 ft minimum, width at shoulder elevation maximum slopes 1 on 2

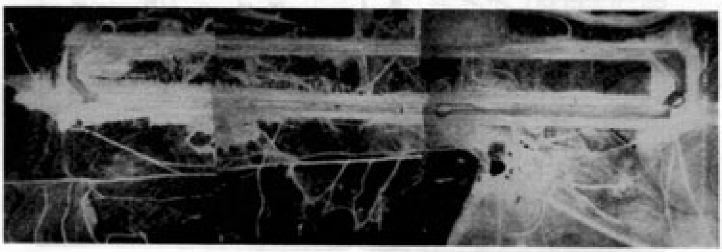
NOTES

(1) Longitudinal grades should be as small as possible and should include no more grade changes than absolutely necessary.

(2) Transverse grades may be sloped from a central crown or uniformly from one edge, but should not change either pattern or grade more than absolutely necessary.

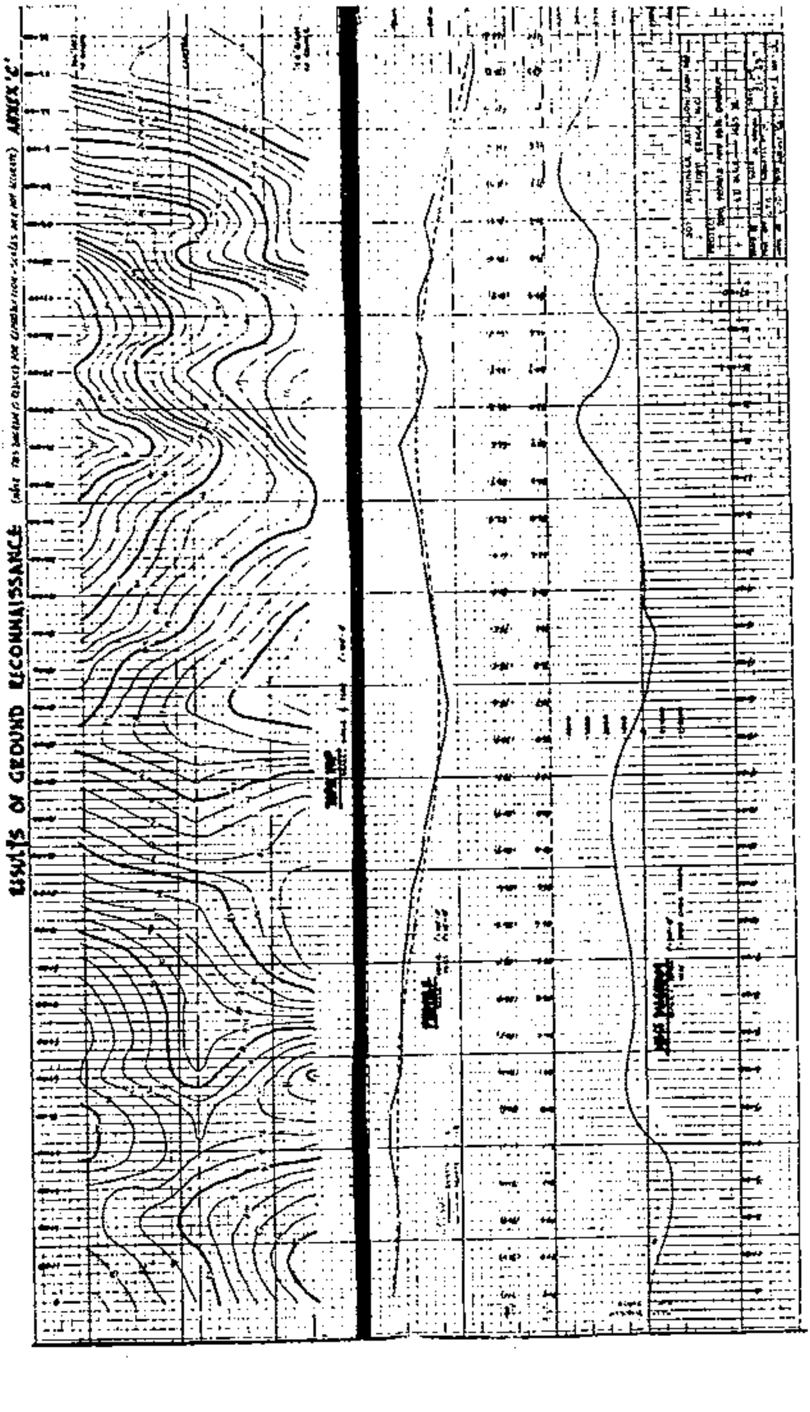
Annex "B"

Site selected from aerial photograph.



Completed landing field.

US Army airborne engineers build an airfield


RESULTS OF GROUND RECONNAISSANCE
ANNEX 'C'

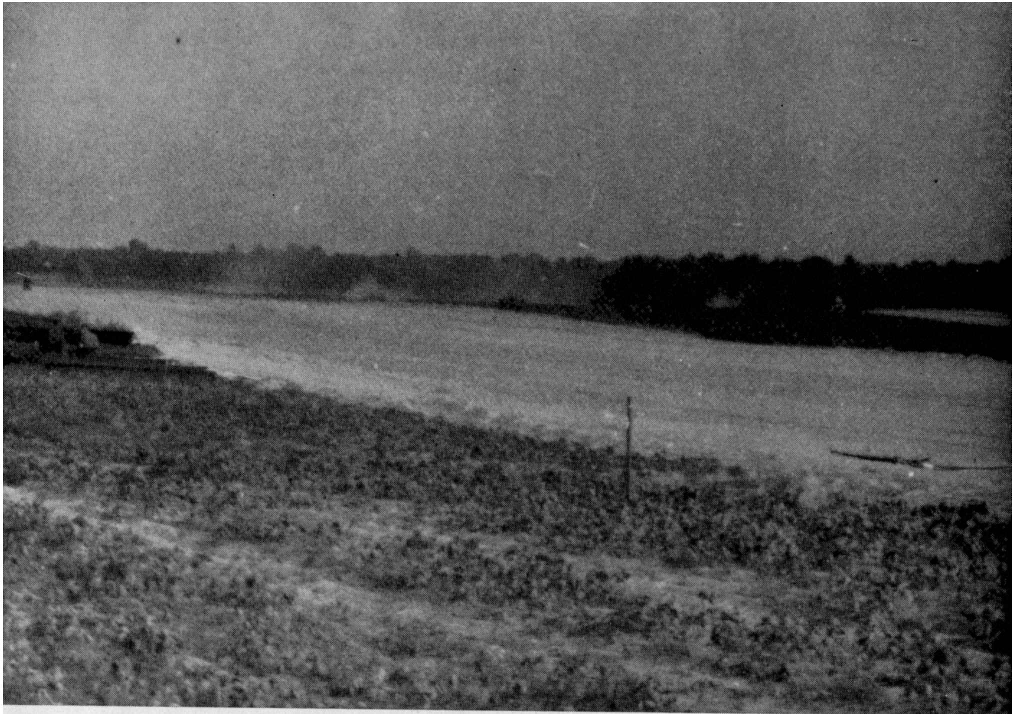


Photo 1. Ground view of landing field before laying PAP.

US Army Airborne Engineers build an airfield 1

Photo 2. C-130 Aircraft landing. Dust became a major problem.

US Army Airborne Engineers build an airfield 2

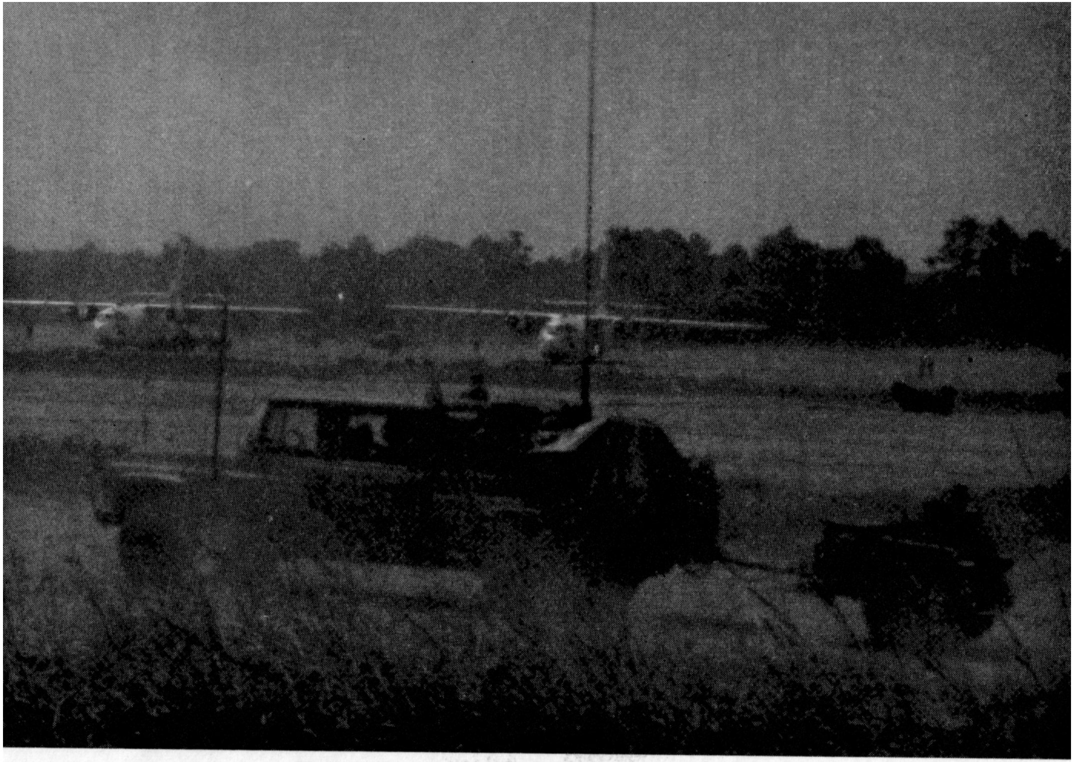


Photo 3. C-123 aircraft discharging cargoes in parking area.

US Army Airborne Engineers build an airfield 3

Advanced Demolition Techniques for Steel Cutting (US)

By Major A. M. Pyne, RE

Exchange Officer with the Engineer School, Fort Belvoir, USA

Introduction

General. In steel cutting charges, the use of standard packages of explosive, such as blocks of TNT, normally results in a considerable wastage of explosive. For every steel target there is an optimum shape for the explosive charge which is required to cut it, and it is seldom indeed that a standard package or combination of packages will approach that optimum.

The US Army has made use of this fact in devising certain advanced steel cutting techniques, known as the "Ribbon", "Saddle" and "Diamond" charges. These charges consist of bulk explosive formed in the shape which will achieve something close to maximum efficiency, and therefore minimum waste. The aim of this article is to describe these charges and to explain their value.

Economy and Time Factors. These advanced techniques are regarded as supplementing—but not replacing—the more conventional US methods, which are very similar to current British methods. In general terms, use of the advanced techniques saves explosive at the expense of a little extra time in preparation of the charges. For those who have to carry explosive on their backs, such as the US Special Forces, economy of explosive is likely to be a dominant factor.

US Bulk Explosives and Accessories

Bulk Explosive. The advanced techniques require a high explosive with a high shattering power. Those considered most suitable are known as Composition C-3 and Composition C-4. These are plastic explosives with detonating velocities between 7,625 and 8,040 metres per second. Both types are cast in blocks 11 inches long with a 2 in square cross-section, but they have different densities, the C-3 block weighing 2¼ lb and the C-4 block 2½ lb.

Accessories. Both types of explosive may be detonated directly by the standard US blasting caps, one of which is electric, and the other initiated by time fuze. The British No 33 and No 27 detonators respectively are the approximate equivalents, but the US caps are larger and more powerful, being designed for use without additional boosters or primers. The explosive may also be initiated directly by knotted detonating cord.

Cutting Explosive to Shape. The US Army stresses that the plastic explosive used for these techniques should not be moulded with the hands since this tends to reduce the density, and consequently the effective detonating velocity and shattering power, of the explosive. In fact, this is true of C-4, but not to any significant degree of C-3 or of British plastic explosives. When fractions or "slices" of a demolition block are required, the blocks are cut with a knife to the dimensions required.

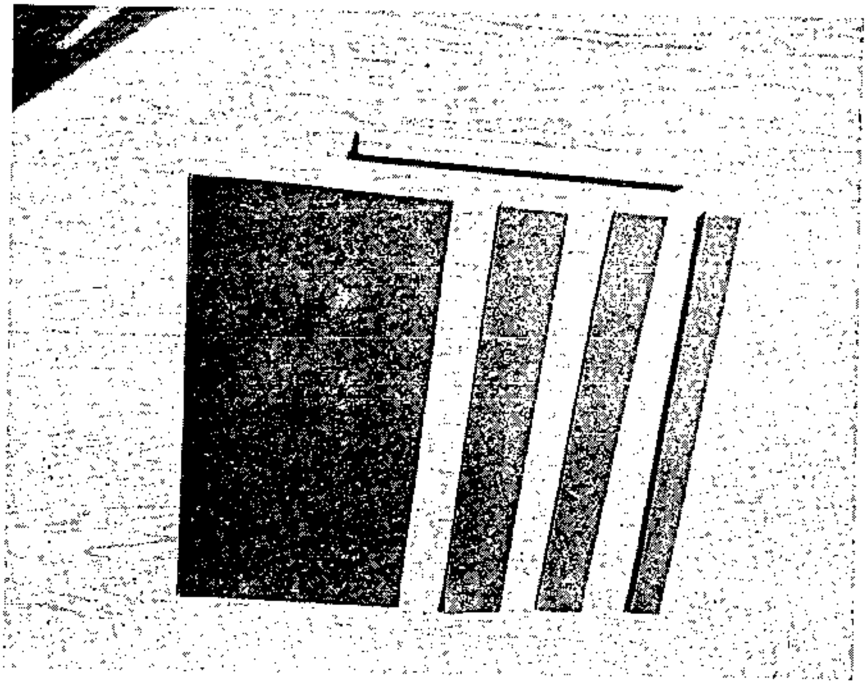


Photo 1. Sheet explosive.

Sheet Explosive. Preparation of the Ribbon, Saddle and Diamond charges is made a great deal simpler by the recent commercial development of a plastic high explosive in sheet form. (See Photo 1). The sheets can be readily cut with scissors to the shape required, and the desired thickness of charge can be achieved by placing sheets on top of each other. One side of each sheet is treated with an adhesive which makes the attachment of one sheet to another very simple, and also helps in attaching charges to the target.

The Mechanism of Steel Cutting

Principal Effects. In order to understand the reason for the effectiveness of the advanced techniques it is necessary to comprehend the mechanism of steel cutting. If a high explosive charge is placed on a steel plate and detonated *from one end*, four separate effects can be detected. Although these effects occur almost simultaneously, it is probable that the first is a depression in the surface of the plate of almost exactly the same area as the contact area of the explosive charge. This depression is caused by the high pressure of the compressed products of the explosion. The second effect is that a spall of metal is thrown off from underneath the plate. This is caused by a reverse shock pulse, which is a reflection of the main shock wave which travels downward through the steel. This reflected pulse actually tears the spall away from the back of the plate. The third effect—and this is the most important one in cutting steel plates—is a longitudinal split directly underneath the explosive charge. This split starts, perhaps surprisingly, from the back of the plate, and is caused by a combination of tension pulses which, being in excess of the tensile strength of the steel, physically pulls it apart. Photo 2 shows both the depression and the split quite clearly, while Photo 3 shows, in the centre, the spall which was thrown off from underneath. The fourth effect is a cross fracture at right angles to the main split, which occurs at the end of the charge away from the point of detonation. This is caused by a meeting of two tension pulses in an area of reduced pressure. This cross fracture starts within the plate and it effectively prevents further dilation of the main split, so that no further fracture occurs beyond the end of the charge. The cross fracture is especially important when the target is a bar or rod.

Point of Initiation. If the point of initiation is varied, the character of these effects changes somewhat. When the charge on a plate is detonated from the centre no longitudinal split seems to form unless the charge is considerably in excess of the optimum size; instead four separate cross fractures occur which meet at the corners of the charge, and so cut out a section of plate of about the same area as the surface area of the explosive. It matters little whether the successful result is achieved by a longitudinal split or by cross fractures, so the point of initiation is not an important factor when the target is a plate. It is, however, important—as will emerge later—if the target is a rod or bar.

Charge Proportions. Experiment shows that the ideally proportioned plate cutting charge has a width about three times its thickness. Any extra width is wasted. If the charge thickness is increased, but the width is unchanged, a point is reached when the extra charge thickness achieves virtually no advantage whatever.

Cutting Bars. To be effective a charge must not only have a certain minimum thickness and width, but also a minimum length if the longitudinal split is to form. When the target is a steel bar instead of a plate, a charge wrapped around the bar may not approach this minimum length. Internal fractures will probably be caused but the bar may not break. The charge should, therefore, be placed along the length of the bar on one side only, and the break will result not from the longitudinal split, but from the cross fracture. Furthermore, unless the total length of the charge is equal to approximately three times the steel thickness, a complete cross fracture may not take place.

Conclusions. The following general conclusions emerge:—

(*a*) Provided enough explosive is present to achieve the longitudinal split (for plates) and the cross fracture (for bars), any additional explosive used is wasted.

(*b*) Since the cross fracture prevents extension of the split beyond the end of the charge, the whole of the width of the target must be covered by explosive. (This rule, of course, is well known.)

(*c*) Selection of the correct point of initiation of the charge is important when cutting bars because of the need to ensure that a cross fracture takes place; but it is not important when cutting plates. Initiation of a plate cutting charge from one end is just as effective as initiation at the centre, even though this fact appears to conflict with current British doctrine.

(*d*) On steel plates, the width of a charge should be equal to about three times its thickness.

Photo 2. Depression and longitudinal split.

Photo 3. The spall.

Advanced Demolition Techneques for steel cutting 2,3

Comparison with British Deliberate Formulae

General. Descriptions of the three charges include tables to indicate the economy of explosive which may be achieved by their use. The "norm", for purposes of comparison, has been taken as the quantity of explosive required by standard British deliberate steel cutting formulae (extracted from *Military Engineering* Volume IV, Part I, 1956). Unfortunately these British formulae are only valid for steel thicknesses up to 4 in, making a true comparison difficult for thicknesses of the order of 12 in, which are well within the capability of the Diamond Charge. For Steel thicknesses over four inches the deliberate formulae provide an insufficiently large answer. These formulae have, however, been used in the tables, even for thicknesses over four inches, on the grounds that they tend to minimize rather than exaggerate the advantage of the advanced techniques—a fault on the right side.

Rounding up. The US explosive taken for calculation in the tables is Composition C-3. The British explosive used can be assumed to be any high explosive with similar properties, and a comparable detonating velocity and "explosive factor" (see *Military Engineering*, Volume IV, Part I, Tables 1 and 3). PE 3A is a suitable example. Both the British deliberate formulae and the US charges include safety factors, but no effort has been made to correlate them.

The Ribbon Charge

General Description

Shape. The Ribbon Charge, which is used to cut steel of rectangular cross section, has been found effective in tests against targets up to $3\frac{1}{16}$ in thick. The charge has a rectangular cross-section, and its length must, of course, correspond with the length of the desired cut. The other dimensions depend upon the thickness of the target as follows:

(*a*) *For targets up to 2 in thick.* Charge thickness should be equal to half the steel thickness. Charge width should be three times the *charge* thickness.

(*b*) *For targets over 2 in and up to $3\frac{1}{16}$ in thick.* Charge thickness should be equal to three-quarters of the steel thickness. Charge width should be three times the *charge* thickness.

Positioning. The explosive required is cut from the C-3 (or C-4) block with a knife to the desired shape, or can be made up from sheet explosive. The charge can be placed directly on to the target, but it is generally easier to prepare it on a sheet of cardboard and subsequently transfer it to the target. Preparation of the charge takes some time, but its attachment to the target is easy since its shape has been expressly designed to match the shape of the steel. Although the charge is usually initiated at one end, the precise point of initiation is immaterial. Photo 4 shows a Ribbon Charge in place on the same plate which was illustrated in Photos 2 and 3.

Photo 5 shows a Ribbon Charge in position on a steel beam and Photo 6 the results achieved. The slim configuration of the charge, as compared to charges made up from standard blocks of explosive, is self-evident. The relatively clean fracture is in contrast to the distortion normally resulting from an over-charge, such as a TNT slab.

Photo 7 shows a girder prepared for demolition with one continuous Ribbon Charge and two separate flange Ribbon Charges. If the continuous charge were to be initiated at one end there would be a possibility of one of the flange charges being blown out of position before detonation. The continuous charge is therefore initiated at the centre in this case.

Photo 4. Ribbon charge.

Explosive Requirement. Table 1 indicates that use of the Ribbon Charge on targets up to 2 in thick saves 59 per cent of the explosive required by the British deliberate formula. For targets over 2 in thick the saving is by no means so significant. Incidentally, the US standard steel cutting formula ($P = \frac{3}{8}A$ lb, where A is the cross-sectional area of the target in square inches) provides an appreciably larger answer than the British formula. The saving achieved by using the Ribbon Charge instead of the US formula is, therefore, even more striking.

TABLE I

Steel Thickness	Weight in lbs of PE 3A required per ft run, calculated by British formula $P = \frac{3bt^2}{2}$ oz	Approx weight in lbs of C-3 required per foot run, using Ribbon Charge	Percentage saving achieved by using Ribbon Charge
1"	1.13	0.46	59%
1½"	2.53	1.04	59%
2"	4.50	1.84	59%
2½"	7.03	6.47	6%
3"	10.13	9.32	11%

Note. The large increase in the Ribbon Charge for targets over 2 in thick results from the different basis for computing the thickness and width of the charge. In fact, the cross-section of the charge is more than doubled by making the charge thickness equal to three-quarters—instead of half—the steel thickness. It may well be argued that the Ribbon Charge's effectiveness *as an economy measure* is virtually limited to target thicknesses up to 2 in.

Photo 5. Ribbon charge on steel beam.

Photo 6. Ribbon charge results.

Advanced Demolition Techneques for steel cutting 5,6

Photo 9. Saddle charge in place.

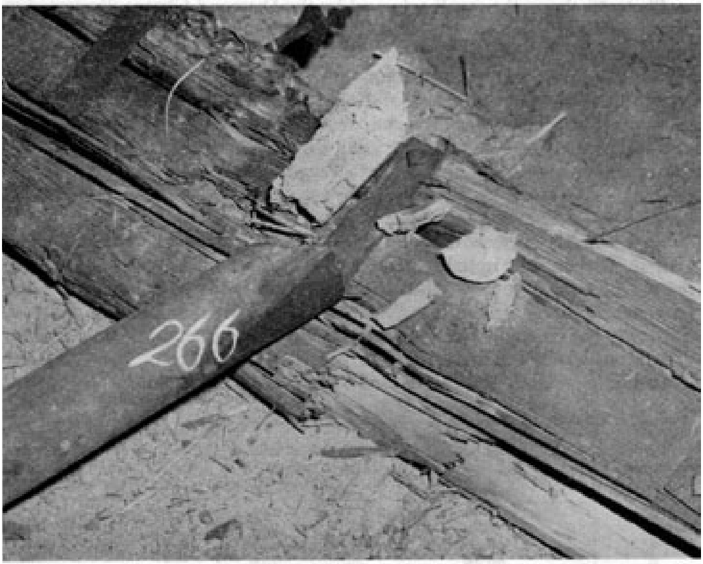


Photo 10. Saddle charge results.

Advanced Demolition Techneques for steel cutting 9 & 10

The Diamond Charge

General Description

Shape. Like the Saddle Charge, the Diamond Charge is used to cut cylindrical solid steel targets. It is effective not only against mild steel, but also against high carbon steels. Cylinders up to 17 in in diameter have been attacked successfully using this method. The charge is shaped as a diamond, the long axis being equal to three times the diameter of the cylinder, and the short axis equal to half the long axis. The charge should be ¼ in thick for mild steel and ⅜ in thick for high carbon steels. The Diamond Charge is, of course, capable of cutting successfully all cylinders which can be cut by the Saddle Charge, and to this extent it may be regarded as replacing the latter. It is important to note that neither the Diamond Charge nor the Saddle Charge will operate effectively against *hollow* cylinders. Photo 11 shows some typical Diamond Charges.

Positioning. Photo 12 shows the layout of this charge. The long axis of the diamond is wrapped around the cylinder, and the charge is initiated simultaneously from both ends of the short axis. This particular charge consists of sheet explosive. The white patches in the photograph are small blobs of C-4, used to initiate the sheet explosive. Experiment has shown, however, that sheet explosive can be detonated with complete reliability without these "boosters". When C-3 or C-4 is used instead of sheet explosive, the charge should be prepared on a thin cardboard template, which may then be formed into a complete "package" with the aid of adhesive tape. The simultaneous initiation can be achieved electrically, but it is better to use exactly equal lengths of detonating cord as tolerances in electric cap manufacture frequently prevent truly simultaneous detonation.

Photo 13 shows the result achieved by the Diamond Charge illustrated in Photo 12. The clean nature of the cut is particularly noteworthy. Had the initiation been by electric caps, a noticeably less clean cut would have been achieved. (Photo 14 shows an example.)

Explanation. The mechanics of the Diamond Charge vary somewhat from those previously described. The two shock waves travelling from the points of the short axis meet at the long axis of the diamond and are reflected upwards and downwards into the target, resulting in a fracture on the line of the long axis. The fracture is caused by tensile stresses induced, apparently, by the elastic component of the shock waves.

Explosive Requirement. Table III indicates the great value of the Diamond Charge. It should be noted that the charge is more difficult to prepare than the Saddle Charge (except when sheet explosive is used), but is much more economical. (Compare the Diamond Charge explosive requirement for 4 in, 6 in and 8 in diameter steel with the Saddle Charge requirement for these dimensions given in Table II). As before, the validity of the deliberate formula is most doubtful, but is used for want of a better "norm".

Table III

Target Diameter	Weight in lbs of PE3A required, calculated by British formula $P = 4d^2$ oz	Approx weight in lbs of C-3 required using Diamond Charge	Percentage Saving achieved by using Diamond Charge
4"	4.00	0.61	
6"	9.00	1.38	
8"	16.00	2.46	
9"	20.25	3.10	84%
12"	36.00	5.52	
15"	56.25	8.63	

NOTE: Targets are assumed to be mild steel.

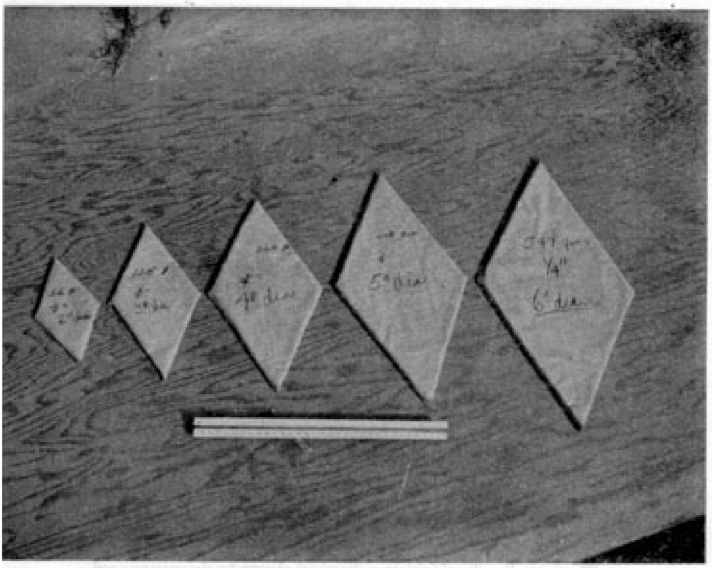


Photo 11. Diamond charges.

Photo 12. Diamond charge in place (sheet explosive used).

Advanced Demolition Techneques for steel cutting 11 & 12

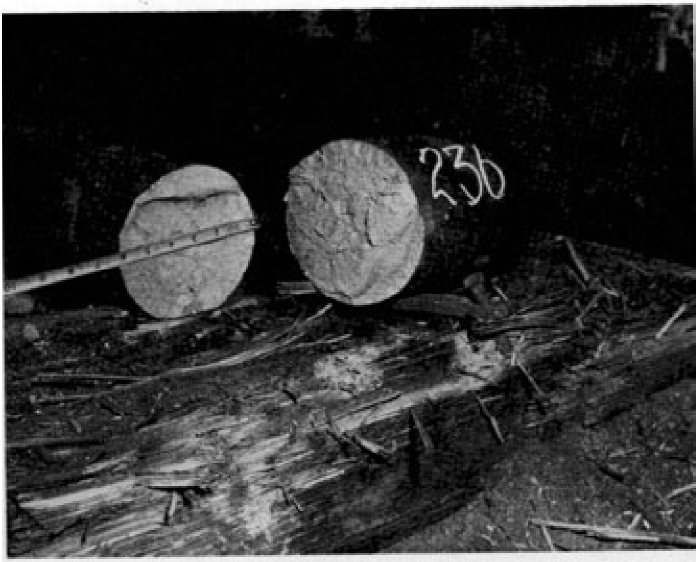


Photo 13. Results of initiating diamond charge by detonating card.

Photo 14. Results of initiating diamond charge by electric caps.

Advanced Demolition Techneques for steel cutting 13 & 14

Conclusion

Although the limitations of this article are clear, especially in view of the difficulty of drawing accurate comparisons, it should be evident that the US advanced steel cutting techniques offer certain definite advantages.

It may perhaps be argued that time will sometimes not permit the careful preparation which these charges require; but it must be remembered that the preparation of standard steel cutting charges from block explosive and their subsequent fixing to a target is by no means a rapid process either. Only Rapid Demolition Devices permit really fast charge preparation and fixing; and these, of course, waste explosive in order to gain time. The advanced techniques have quite the reverse property—a saving of explosive when economy, rather than time, is the critical factor.

Footnote. The three charges described in this article have been tested by several different agencies, and various combinations of charge dimensions have been published from time to time. Those given in this article are those which are currently (November 1963) considered by the US Army Engineer Research and Development Laboratories to be the most reliable.

Acknowledgement

Acknowledgement is due to Mr James A. Dennis of the US Army Engineer Research and Development Laboratories, who provided a good deal of the background information required for the writing of this article and gave much of his time to reviewing it.

The Critical Path Method

By Major J. R. Johnson, RE, BSc(Eng), AMICE, AMIStructE

Introduction

In 1956 the engineering services department of EI duPont de Nemours & Co, Wilmington, Delaware, initiated a study into the prospect of applying electronic computers as an aid in managing complex engineering projects. This study was completed in 1958, and from it a team of engineers from the duPont organization and a team of mathematicians and computer experts from Remington Rand UNIVAC developed the Critical Path Method (CPM) of planning and organization of work. The method was later introduced to this country by Mauchly Associates Ltd.

Quite independently, and during roughly the same period, a planning technique was devised for the Polaris missile programme. Here the problem was one of complex research and development, in which the target stages were known but the length of time needed for each stage was problematical. This planning method became known as the Programme Evaluation and Review Technique (PERT).

Although these and other methods more recently devised may differ in detail, they are all based on an arrow diagram principle of analysis which, being capable of presentation in a logical and mathematical form, lends itself to computer programming techniques. However, the basic concept of an arrow diagram is so simple that planning problems of, say, up to one hundred separate items can be solved quite easily without resorting to the use of computers.

The Critical Path Method of planning and organization of work has been taught in the Engineer Planning School of the RSME since early in 1962. The aim of this short article is not to compete with that teaching, but merely to explain the rudiments of the Critical Path Method as briefly and simply as possible to those officers who may not have had the opportunity of coming across it.

The Arrow Diagram

Throughout the whole of this article the construction of a simple RC beam and slab bridge will be used to illustrate the Critical Path Method of planning and organization of work. We shall assume that this construction task can be split up into the following jobs or "activities":—

(*a*) Launch main precast beams.
(*b*) Fix soffit shuttering for deck slab.
(*c*) Fix deck slab reinforcement.
(*d*) Pour deck slab.
(*e*) Cure deck slab.
(*f*) Fix soffit and side shuttering for cantilever footwalks.
(*g*) Fix precast kerb units.
(*h*) Fix cantilever reinforcement.
(*j*) Pour cantilever slabs.
(*k*) Cure cantilever slabs.
(*l*) Place wearing surface to deck slab.
(*m*) Place wearing surface to cantilever slabs.
(*n*) Fix handrails.
(*p*) Strike soffit formwork to deck slab and make good.
(*q*) Strike soffit and side formwork to cantilever slabs and make good.

Having decided upon the jobs or activities that have to be performed, the next step in the planning of any project is to ascertain the sequence of these activities; which must be done first, which cannot be started until others have been finished, and so on. This inter-relationship of jobs is a most important feature of any operation, and it is as well to express one's thoughts clearly and logically in the form of a table. This has been done in the first three columns of Table 1; column (2) describes each activity, column (1) allots a serial letter to each of these activities, and column (3) shows the inter-relationship or interdependence of all the activities in the project.

TABLE I

Job Table—Construction of an RC beam and slab bridge

Activity Serial Letter (1)	Activity Description (2)	Activity Inter-relationship (3)	Labour (4)	Plant (5)	Other Restrictions (6)	Duration (Days) (7)
A	Launch main pre-cast beams.	Starts before all else.	6 lab	10-ton crane	—	1
B	Fix soffit shuttering for deck slab.	Follows Job A.	3 C & J 3 lab	—	—	3
C	Fix deck slab reinforcemeent.	Follows Job B.	2 steel fixer 2 lab	—	Supply steel reinforcement	1
D	Pour concrete deck slab.	Follows Job C.	8 lab (incl mixer)	14/10 mixer vibrator compressor	—	1
E	Cure deck slab.	Follows Job D. Finishes before Job P can start.	—	—	—	7
F	Fix soffit and side shuttering for cantilever footwalks.	Follows Job B. Is concurrent with Jobs C & G.	3 C & J 3 lab	—	—	4
G	Fix precast kerbs.	Follows Job B. Is concurrent with Jobs C & F. Finishes before Job J begins.	5 lab (incl mixer)	14/10 mixer	Supply pre-cast kerbs	1
H	Fix cantilever reinforcement	Follows Jobs F & C.	2 steel fixer 2 lab	—	Supply steel reinforcement	1
J	Pour cantilever slab.	Follows Jobs H & D.	8 lab (incl mixer)	14/10 mixer vibrator compressor	—	1
K	Cure cantilever slab.	Follows Job J. Finishes before Job Q can start.	—	—	—	7
L	Place wearing surface to deck slab.	Starts 3 days after start of Job E.	3 lab	—	Supply of bitmacadam	1
M	Place wearing surface to cantilever slab.	Starts 3 days after start of Job K. Follows Job L.	3 lab	—	Supply of bitmacadam	1
N	Fix handrails.	Follows 3 days after start of Job K.	4 lab	—	Supply of handrails	1
P	Strike soffit formwork to deck slab and make good.	Follows Job E.	1 C & J 2 lab	—	—	2
Q	Strike soffit formwork to cantilever slab and make good.	Follows Job K.	1 C & J 2 lab	—	—	2

For instance, it is obvious that the soffit shuttering for the *in situ* concrete deck slab cannot be fixed before the precast concrete beams are in position. Therefore, referring to the Table, Job B must follow Job A. Similarly, the deck slab reinforcement cannot be fixed until the soffit shuttering is completed, and so it is logical that Job C should follow Job B.

Now if each activity is denoted by an arrow, the whole logical sequence of construction of the bridge can be illustrated by means of the arrow diagram shown in Figure 1.

The reader will note that the logic of the operation (as defined by the activity inter-relationship in Table 1) has only been achieved in the arrow diagram by the use of dotted, or "dummy", arrows and by the use of several, or "multiple", arrows for certain activities. It is worth while to discuss these two diagram expediencies in more detail.

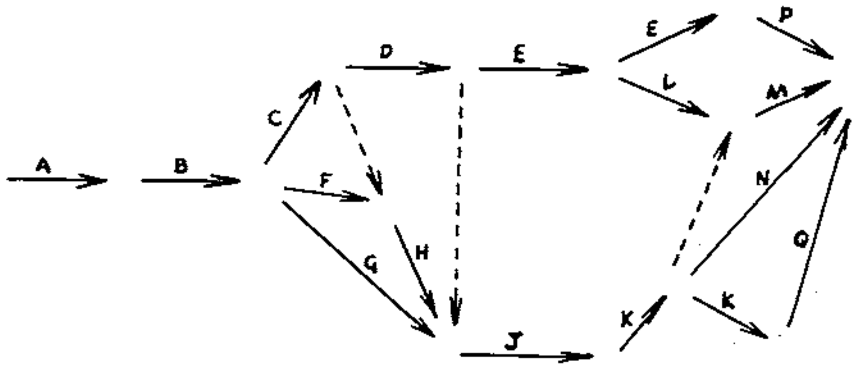


Fig. 1. Basic Arrow diagram.

Firstly, dummy arrows are used either to maintain the logical sequence of activities throughout the project or to enable each individual activity arrow to be uniquely defined, should two or more run between the same points. By way of example, the dummy arrow between Jobs C and H (Fig 1) indicates that Job H (fixing reinforcement in the cantilever slabs) not only cannot start until Job F (shuttering cantilevers) is finished, but is also dependent on the finish of Job C (fixing reinforcement in the main deck). This dummy, therefore, has no other significance in this instance than to maintain the sequence logic of the various activities.

Secondly, multiple arrows are used when it is necessary to split up an activity into two or more arrows, in order that the logical sequence of construction can be maintained. For example, the wearing surface can be placed on the main concrete slab (Job L) after the concrete has attained a certain minimum strength, whereas the soffit shuttering to the main slab cannot be struck (Job P) until the concrete has reached a much higher strength. Hence Job E (curing the deck slab concrete) must be split up into two arrows.

There are other examples of the use of dummy and multiple arrows in Fig 1 which are left to the reader to identify.

Events, Restraints, and Durations

At this stage it is necessary to discuss further refinements that must be made to the arrow diagram before project planning can be continued.

Since certain activities depend on the completion of others before they can proceed, clearly the beginning and end of an activity is as important as the activity itself. The start or finish of an activity is, therefore, known as an "event", and all events are numbered serially from the beginning to the end of the project (usually in such a way that the tail of an arrow always bears a number smaller than that at its head). Fig 2 shows event numbers added to the previous arrow diagram.

Another useful addition to the arrow diagram is the inclusion of information which may affect the start of a subsequent activity. For instance, referring once again to the example, it would be impossible to fix the steel in the deck slab or cantilever footwalks until the reinforcement had arrived on site; similarly, it would not be possible to spread the bitumen macadam wearing surface unless it also had been delivered. Such important provisos

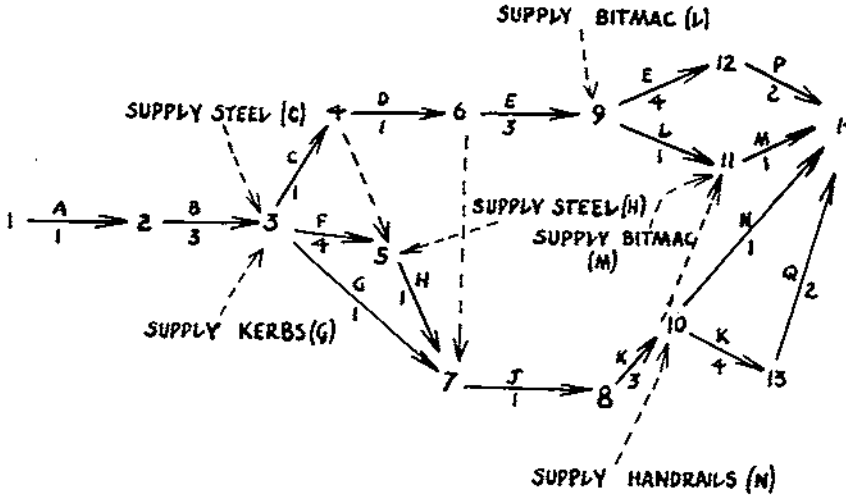


Fig. 2. Arrow diagram showing event numbers, durations, and restraints.

to the start of certain activities are known as "restraints", and are depicted by dotted arrows leading into the diagram at the appropriate event. Several such restraints are shown in Fig 2.

The next step in planning is to decide on the duration of each activity within the project and to add this information to the arrow diagram. Each individual duration is inextricably bound up with the size of the labour force, amount of plant, and nature of equipment used, and it is normal to assess the time taken for a particular activity using an economical gang and/or a recognized item of plant for the task. The assessment of duration is, of course, a matter of experience or recourse to recorded planning data. It should be remembered that whatever method of planning is used, the accuracy of the final plan can only be of the same order as the accuracy of estimated individual timings. However, it is worth pointing out that the Critical Path Method lends itself to adjustment more readily than any other method of planning, should this become necessary in the light of subsequent progress on site.

Economic labour and plant requirements, together with durations (in the same units throughout) have been entered against the appropriate activities in column (4), (5), and (7) of Table 1 for the particular bridge construction project under consideration. The durations have also been added to the arrow diagram in Fig 2, beneath the centres of the arrows to which they refer.

Event Timings

To determine the length of time from the beginning of the project up to a particular event (ie, to the end of a particular activity) is simply a matter of adding up the durations of activities leading up to that event. If there is more than one activity path, then clearly the earliest time at which the event can take place will be the sum of the durations in the longest activity path leading up to it. This is known as the "Earliest Event Time", and is marked on the diagram in a small square against the event to which it refers (see Fig 3).

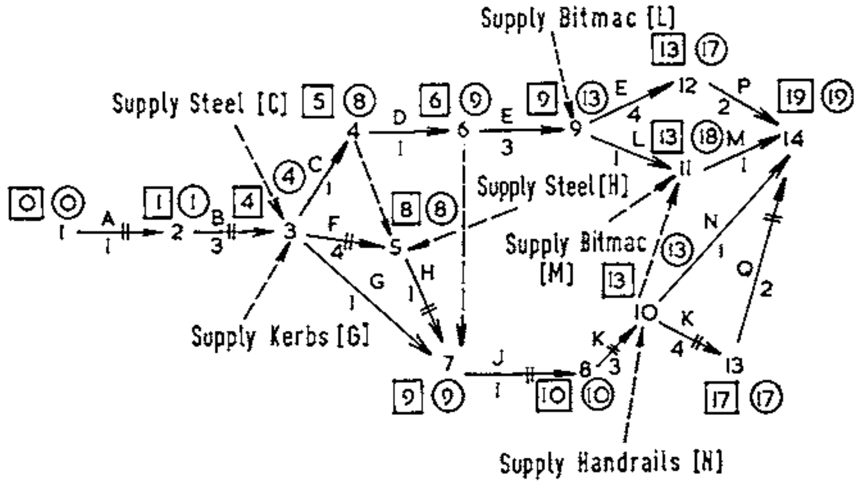


Fig 3. Complete arrow diagram showing event timings and the critical path.

In Fig 3 it can be seen that the longest path up to Event 3 is 1 day (Job A) + 3 days (Job B) = 4 days. Event 5 can be reached by two paths—through Events 1, 2, 3, 4, and 5, or through Events 1, 2, 3, and 5. The latter path is the longer (ie, 1 + 3 + 4 = 8 days), and so the Earliest Event Time for Event 5 is 8 days. Carrying on through the diagram it is evident, therefore, that the earliest time by which the whole project can be completed is 19 days after the start of work. This is known as the Earliest Event Time of the "Finish Event".

Conversely, the latest time at which a given event can occur without prolonging the project as a whole is determined by working back from the "Finish Event" along the longest activity path to the "Start Event". The "Latest Event Time" of the Finish Event must, of course, be the same as its Earliest Event Time, if no pointless delay is to be incurred. Therefore, the Latest Event Time of, say, Event 10 must be the longer of the two paths—Events 14 to 10, or Events 14, 13, to 10. The latter is the longer (ie, 2 + 4 = 6 days), and so the Latest Event Time for Event 10 is 13 days, and is marked in a small circle against the event to which it refers. Working back through the diagram in this manner, the reader may verify the Latest Event Times for the remaining events.

The Critical Path

Having calculated the event times throughout the arrow diagram it will be seen that some activity arrows bear the same Earliest and Latest Event Times at the head, and also the same Earliest and Latest Event Times at the tail, and that the difference between these is equal to the activity duration. Clearly these activities or jobs are critical inasmuch as any delay in completing them will result in a delay of all subsequent activities. There will always be one (or more) continuous path of such activities running through the arrow diagram. This is called the "Critical Path"—critical because any delay in the completion of one or more activities on it must inevitably delay the project as a whole.

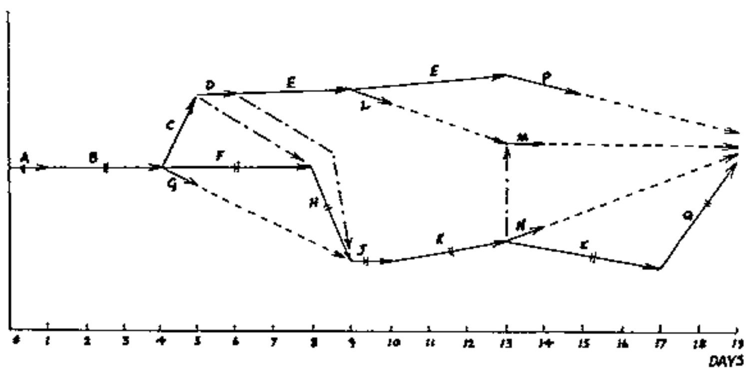
This concept of the Critical Path is a valuable planning aid since it directs the attentions of management to those jobs which are vital to the completion of the project on time. In no other planning technique are the critical jobs emphasized in such a clear and graphic manner.

The Critical Path in the arrow diagram at Fig 3 runs through Events 1, 2, 3, 5, 7, 8, 10, 13, and 14, and is accentuated by marking each activity on it with two hatched lines.

Float

Conversely, it is obvious that activities not on the Critical Path have spare time, or "float", associated with them. For instance, referring to Fig 3, Job C takes 1 day to complete but can occur at any time between day 4 and day 8, without affecting preceding or succeeding jobs. There is, therefore, a total of 3 days float for this activity.

Various types of float exist, each capable of mathematical definition and each with its own significance, but it is not intended to discuss these in this article. It is sufficient to say that the existence of float can play a most important part in planning, since it enables the planner to achieve economy throughout the project and provides the means whereby manpower and equipment can be redirected to more critical jobs, should this become necessary.



LABOUR	6	3	10	11	3	2	11	NIL	9	2	NIL	2
C & J	NIL	3	3				NIL		1		NIL	1
STEELFIXER	NIL		2	NIL		2	NIL					
10 TON CRANE	1	NIL										
14/10 MIXER	NIL		1	1	NIL		1	NIL				
COMPRESSOR & VIBRATORS	NIL			1	NIL		1	NIL				

Fig 4. Arrow diagram to a time base—showing free float (with Labour and Plant Table).

Scheduling

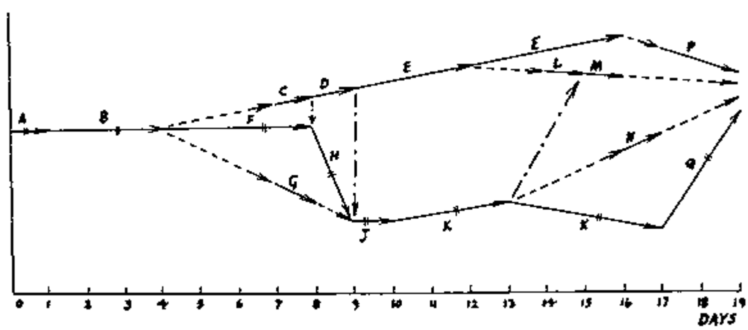
So far, although each activity has been given a duration, no time scale has been introduced to the arrow diagram. One of the ways of doing this is to draw the arrows of such a length that the horizontal components of them represent time. This has been done in Fig 4 for the example; jobs which are not critical, and have float associated with them, being shown as if starting at their earliest time. Thus Job G, of 1 day's duration, is shown to take place from day 4 to day 5 and its float of 4 days is shown by a dashed line to day 9.

The dot-dash lines are the dummies shown on the original arrow diagram, denoting job inter-relationships.

Labour, Plant, and Equipment Levelling

Having reduced the arrow diagram to a time base it is now possible to add up the labour, tradesmen, and plant requirements on any one day simply by adding up the requirements of each activity occurring on that day. This information, it will be remembered, was already recorded in columns (4) and (5) of Table 1, when compiling the economic durations of individual activities. This total requirement is recorded below the Time Schedule in the form of a table, as shown in Fig 4.

In its present form, however, this "Works Programme" shows a most uneconomical use of manpower and equipment. Clearly a more level use of resources must be achieved if the project is to run efficiently. This can be done by moving certain activities within their float period until a more even employment of manpower and/or equipment (whichever is the particular criterion) is achieved.



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<tr><td>COMPRESSOR & VIBRATORS</td><td colspan="4">NIL</td><td>1</td><td>1</td><td colspan="5">NIL</td></tr>
</table>

Fig 5. Revised arrow diagram to a time base (with manpower and plant levelled).

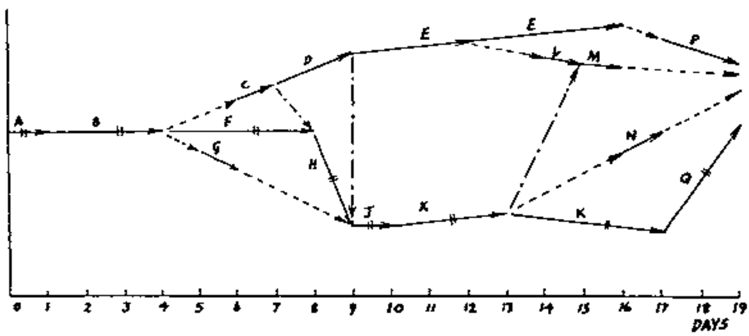
Such a solution is given at Fig 5, where it will be seen that the labour ceiling is now 10 men rather than 11. Tradesmen requirements have been grouped together rather than used haphazardly throughout the project, and plant used for specific periods only, so that it can be freed at all other times for work elsewhere.

This, then, is the final Works Programme for the task provided that:—

(*a*) The required amount of labour, tradesmen, and plant is made available.

(*b*) The length of time taken for the project is acceptable to the commander.

If either of these provisos is not met, still further adjustment to the Time Schedule must be made. For instance, if we assume that a maximum labour force of 8 men only can be supplied then clearly a reduction in the number of men used on the eighth and ninth days must be made (see Fig 5). Cutting down the labour force on Jobs F or H will inevitably increase the time taken by these activities, and since they are on the Critical Path the length of the whole project will be increased. Obviously this should be avoided if possible, and so the labour reduction must be effected in Jobs C or G and in Job D. Such a solution is shown in Fig 6, the increased length of these activities being taken up in their float without affecting the overall length of the project.



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<tr><td>STEELFIXER</td><td colspan="6">NIL</td><td>2</td><td>NIL</td><td>2</td><td colspan="10">NIL</td></tr>
<tr><td>10 TON CRANE</td><td>1</td><td colspan="18">NIL</td></tr>
<tr><td>14/10 MIXER</td><td colspan="5">NIL</td><td>1</td><td>NIL</td><td colspan="2">1</td><td>1</td><td colspan="9">NIL</td></tr>
<tr><td>COMPRESSOR & VIBRATORS</td><td colspan="9">NIL</td><td>1</td><td colspan="9">NIL</td></tr>
</table>

Fig 6. Works programme (assuming a maximum labour force of eight men).

If, on the other hand, the Commander had directed that the bridge must be constructed in eighteen days, instead of the estimated nineteen days, then it would be necessary to shorten certain activities by increasing the manpower or plant used on them. Since the total length of the project is governed by the longest activity path through it (which is, of course, the Critical Path) it is only necessary to consider activities on this path, when trying to reduce the length of time of the project. However, it is possible that they may be so much reduced that the float of certain non-critical activities becomes zero, with the result that they, in turn, become critical and may have to be shortened or "crashed".

Programming and Progressing

As has already been stated, the final modified arrow diagram drawn to a time base can be used as a Works Programme. Its main advantages over the traditional Bar or Gantt Chart are that it shows which jobs are critical, shows the amount of free time, or float, in non-critical activities, and illustrates the inter-relationship of activities throughout the project. It therefore forms a clear and simple visual aid for briefing, issuing of orders, and hand-over of duties.

In addition, it constitutes a very simple and efficient Progress Chart. Progress reports, merely listing activities and quoting their percentage completion, can quickly be applied to the arrow diagram, their effect on the progress assessed by the supervisor, and remedial action taken to expedite any critical activities falling behind schedule.

Conclusion

The main advantages of the Critical Path Method of planning and organization of work have already been mentioned within the text of this article, and need not be repeated here. Its value when applied to engineering construction and maintenance tasks is almost self-evident, but it may not be so apparent that the technique can also be applied to many engineer training and operational problems.

In this context, it is interesting to note that in early 1963 the method was used successfully by the Field Engineering School, RSME, in conjunction with Science in General Management (SIGMA) Ltd. to study the possibility of reduction of construction time for the HFB. The method may also have great potential in its possible application to tactical and logistical problems of a general military nature.

Perhaps the most telling argument in its favour is that, in the few short years of its existence, it has been accepted almost universally in research, industry, and engineering, as an invaluable aid to planning, scheduling and supervision of major projects and operations. If this is not a conclusive argument for its acceptance, at least it is a measure of the inadequacy of previous planning methods.

Army Reactors

By MAJOR J. D. ISAAC, RE, BSc(ENG), AMIMECHE, MINUCE

IN his articles in the September, 19161[1] and March, 1962[2] *Journals*, Major Hiscock described the small power reactors being developed, particularly in the USA. He mentioned the role of the US Corps of Engineers who are responsible for the "Army Nuclear Power Program" (ANPP) and who are developing land based nuclear power systems for all three military services in conjunction with the US Atomic Energy Commission (AEC).

With the advent of nuclear power, an energy revolution has taken place. The US Corps of Engineers are in the forefront of the technical struggle to adapt this novel source of power for military use and the ANPP aims to provide the military services with nuclear power plants which can further their mission operationally, logistically or economically.

In this article the writer brings the reader up-to-date on the ANPP and its reactors and touches on second generation systems which are now being mentioned in the technical press. An attempt has also been made briefly to compare these military reactors with the conventional means of power generation now used in the British Army. Finally some mention is made of possible advances in the reactor field and their effect on military reactors.

THE ARMY NUCLEAR POWER PROGRAMME

The ANPP can be reviewed by considering the probable task of each type of reactor system. These systems will reduce the Army's logistic POL load which, if aircraft fuel is excluded, is used in three main ways.

(*a*) Generation of electricity in fixed installations.
(*b*) Generation of electricity in mobile installations.
(*c*) Vehicles.

Army reactors were first developed to supply "station power" in fixed installations for areas of high fossil fuel costs. The Army Package Power Reactor, a pressurized water system driving a steam turbine to produce electricity, meets this requirement. The problem of mobile nuclear reactors was then tackled and two types are now being developed.

Finally, studies are being carried out to consider how nuclear energy can supplement or replace the POL used in vehicles. A vehicle mounted reactor has been considered but the cost and complexity of the system together with the problems of weight and armoured volume would seem to weigh heavily against such a solution at present. Further studies have resulted in the concept of the Nuclear Energy Depot powered by the Military Compact Reactor.

Thus there is a reactor system, either in operation or being developed, for station and mobile power and also for powering an energy storage depot for vehicles in the field. These are discussed in more detail below.

THE PACKAGE REACTOR

Five pressurized water reactors (PWRs) are now operational. Three are true package reactors capable of some degree of relocation and take some two to three months to instal. Two (SM-1 and SM-1A) are package type reactors built into permanent installations. Some details are given below:—

	Site	Net Output	Date Critical	Remarks
SM-1	Fort Belvoir	1850 KW(e)	April '57	Used for research and training.
SM-1 (A)	Fort Greely, Alaska	1,650 KW(e) + 38 million Btu/hr of steam.	Mar '62	Provides "base" power and heating for U.S. Army Cold Weather and Mountain School.
PM-2 (A)	Camp Century, Greenland	1,500 KW(e) + 1 million Btu/hr. of steam.	Oct '60	W.O.I James' Article in the Dec '61 *RE Journal* refers.
PM-1	US Air Force Radar Station at Sundance, Wyoming	1,000 KW(e) + space heating	Feb '62	Airlifted to site in sixteen C130 aircraft loads
PM-3 (A)	Naval Air Facility Base at McMurdo Sound, Antarctica	1,500 KW(e) + space heating	Mar '62	Operating 77 days after packages arrived on site.

Latest reports state that PM-2 (A) is to be moved from its present site "as requirements at the camp have fallen below the reactor's maximum capacity. The military authorities are seeking a new location for it". The reactor is still operating and will not be refuelled until installed at its new site.[3] This will be the first time a package reactor has been relocated and the operation will be watched with interest. Meanwhile PM-3 (A) was shut down on 9 September, 1963, while implications of corrosion on a removed control rod drive are being studied.[4]

In the meantime second generation package reactors are being planned. Colonel Robert B. Burlin, Chief of the AEC's (Atomic Energy Commission) Army Reactor Branch has repeatedly told the Joint Committee on Atomic Energy that "the biggest problem facing the controversial military reactor programme is economic—making units for remote sites cheap enough that the armed services will insist on buying them".[5] The AEC has now invited firms to submit design studies for a second generation military portable reactor. The principal design objective set by AEC is a 50 per cent reduction in the installed cost of portable power plants for military use. It has given as a yardstick $2.5 to $3.5 million for installed cost of a plant at an above ground bedrock US site 1,000 miles from the factory. Design guide-lines call for: electrical output of 1 MW(e), 60 cycle, 4,160 volts at 80 per cent power factor; 20-year plant life; skid-mounting of packages no larger than 8 × 8 × 30 ft and a maximum weight of 30,000 lb per package.[6]

There have been many conflicting reports on the cost of the present generation of package reactors. The figures quoted for the second generation reactors should provide a firm basis for future economic assessments at any likely package reactor site. Fuel oil might then have to cost about 5*s* or 6*s* per imperial gallon at site for such a reactor to be economic. This assumes an 80 per cent load factor, no interest charges and the plant installed and operated by sappers. Normal fuel oil prices are in the order of 1*s* per gallon but in remote bases these are very much higher. Thus, if small power stations are required in remote bases overseas, the package reactor may be economic. If it is, we as sappers may be required to instal and operate it.

For permanent bases where more power is required, large static reactors, which would meet these power demands, begin to compete economically with fossil fuels. It has been suggested that pressurized water reactors with an output of 10MW(e) might achieve production cost parity with fossil-fuelled stations where fuel oil costs were in the region of 1*s* to 1*s* 3*d* per imperial gallon.[7] Now in Gibraltar the cost of fuel oil is about 1*s* per gallon and the installed generating capacity for the three Services is in the order of 10 MW(e). In a similar new inter-service base overseas, the best logistic and economic solution for supplying the station's power might be a 10 MW(e) reactor providing the base load, with standby diesel alternators for "peak lopping". The US Corps of Engineers are responsible for the development of nuclear power systems for all three military services other than for naval vessel propulsion or air and space applications. The Corps must be ready to accept this sort of responsibility if and when power stations for inter-service bases are being considered.

Mobile Reactors

The economic advantages of the larger reactor are confirmed by the fact that the ANPP is now building a 10 MW(e) mobile system. This is the MH-1, a pressurized water reactor, which is being mounted in a converted de-mothballed Liberty Ship. This floating power station will be towed to any seaboard disaster area to provide immediate power. It is due to be completed in 1965. Such a system, moored in any new British base, could provide the base load as discussed in the previous paragraph.

At the other end of the scale, the low-powered ML-1 has been under test since September 1962. A description of this reactor was given in Major Hiscock's articles.[1, 2] It can be carried by rail, air, barge or tank transporter and develop power some 12 hrs after arrival on site. It is the smallest and hottest reactor to produce electric power. During trials a small gas leak has developed but this is being put right. A fuel element of the type used in this reactor has now operated with a coolant temperature of 1200°F for 10,000 hrs, the design life of the core.[8] Comparable gas coolant temperatures in British reactors are 750°F at Calder Hall and 1000°F for the Advanced Gas Cooled Reactor at Windscale.

Studies have also been made on designs for advanced, mobile, gas-cooled nuclear power plants. The system which was considered most promising is the high density moderated reactor (HDMR). This uses yttrium hydride as a moderator. The HDMR reactor would be more reliable, more easily maintained and more mobile than the ML-1.[9]

The ML-1's weight and size are of the same order as diesel alternator sets of the same output. It is probably slightly heavier and more bulky than many diesel sets but it is tailored to fit into aircraft and onto a semi-trailer. A major disadvantage of the present system however is that a total of some 3,000 gallons of purified water is needed for moderating the neutrons and for shielding. This volume of fuel would run a 300 kW diesel set for five or six days and the present ML-1 would seem to offer few advantages over the diesel generator for the enormous costs involved. One such reactor might cost £1 million, ie, orders of magnitude greater than the price of fossil fuelled equivalents.

However, before dismissing the small mobile reactor out of hand, the second generation mobile reactors should be considered and compared with the alternatives available. Second generation reactors will not need water and will be more mobile than the ML-1. The demands for mobile power will have increased. Tactical SSGW sites, SAGW sites, workshops and formation headquarters may each require hundreds of kilowatts of power. Even today reliable sources quote power demands of this order for a Corps Headquarters during a cold spell. The alternatives to a 300 kW reactor could be twelve 27½ KVA diesel alternator sets, or a single 300 kW(e) diesel alternator. Nearly 2 tons of fuel would be required each day. If a light-weight gas turbine were used, the daily fuel requirement might be 3 or 4 tons. A simple reliable mobile reactor would offer many advantages and this whole concept should not be written off because of the cost and complexity of the ML-1. It is a prototype, the first truly mobile reactor and a major technical achievement. Its success technically could lead to the development of further small mobile reactors and the Military Compact Reactor.

The Nuclear Energy Depot and the Military Compact Reactor

The Nuclear Energy Depot would be a mobile self-contained refuelling point powered by a reactor. The reactor's power would be used to generate synthetic fuels from indigenous materials or to recharge heavy duty batteries. This system could be used for refuelling military ground vehicles and also mobile equipment and installations.

The power source for the system would be the Military Compact Reactor (MCR). This is described as "an extremely mobile light-weight compact power plant with an output of 3 MW(e) having a high-temperature liquid-metal-cooled reactor coupled to a power conversion system".[10] All other details of the reactor are classified includng dimensions and weight. The completion date for the prototype has been quoted as late 1967.[11] Later reports state that the MCR programme "calls for the construction of two epithermal, lithium cooled, prototypes at a total cost of $50 million to AEC and $16 million to the Army".[12]

It is too early yet to say whether this is a practical concept during the next decade. Much time and money will have to be spent before a working system is achieved and even then such a system might not be suitable for our needs in the British Army. If the project is successful, however, it will be of great importance in combat development planning for the future. Developments in this R & D programme must be watched so that technical breakthroughs are recognized and acted upon.

At the present time a strong challenge on the necessity for the MCR has been made in a JCAE (Joint Committee on Atomic Energy) sub-committee.[13] Queries have also been raised "as to how widespread will be the applications for the ML-1".[14] The Department of Defence is, therefore, currently surveying the three Services needs for portable and mobile reactors. It intends to produce a "White Paper" evaluation of military reactor projects which is due to be completed in February 1964.[15]

Future Technological Advances

The Joint Chiefs of Staff in the USA established the requirement for the development of Army nuclear power plants in 1953. The first ten years of the ANPP have been ones of great technical achievement. Probable future technological advances may include:—

Photo 1. A REACTOR PACKAGE IS LOADED. One entire laboratory building—part of the PM-1 portable nuclear power plant built by The Martin Company under AEC contract—is loaded aboard a C-130 in Baltimore.

Army Reactions 1

Photo 2. PM-1's CORE IS ASSEMBLED. The fuel load weighs 1,500 lb and continuous full power operation is possible for two years. Two million gallons of fuel oil would have to be burned to release the electrical energy obtainable from a single

Army Reactions 2

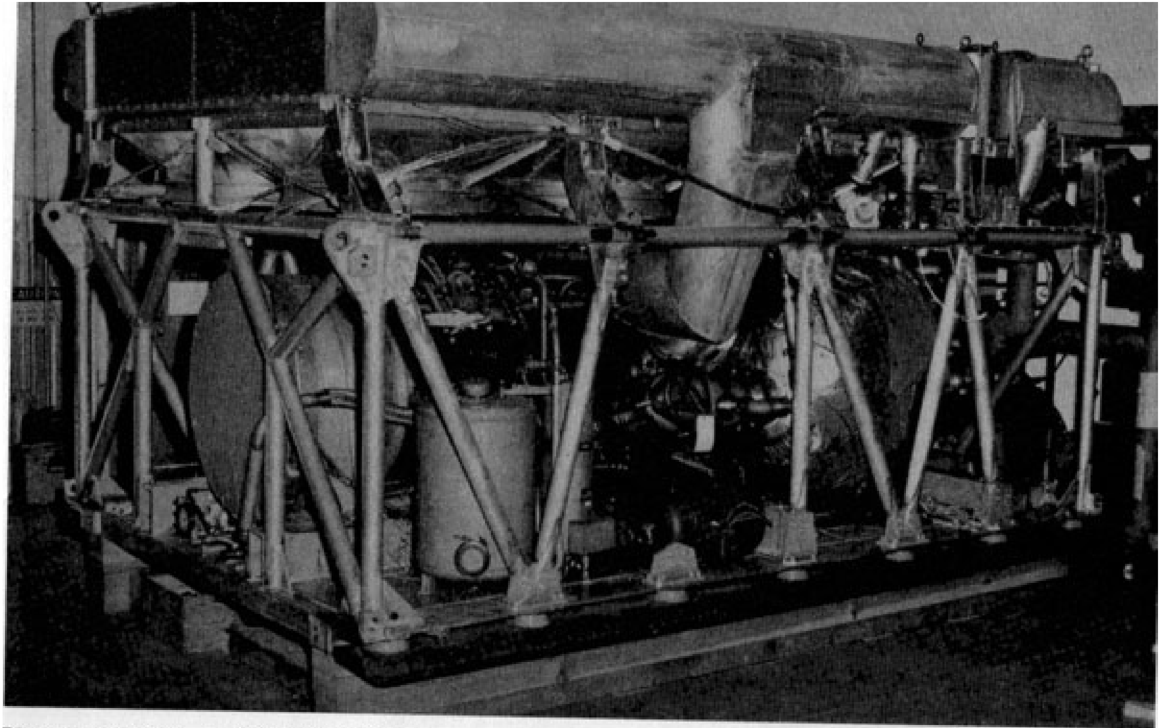

Photo 3. THE ML-1's POWER CONVERSION SKID. This includes Turbine-Compressor Set, recuperator, precooler, alternator and electrical switchgear.

Photo 4. The ML-1's Reactor on a Semi-trailer.

Army Reactions 4

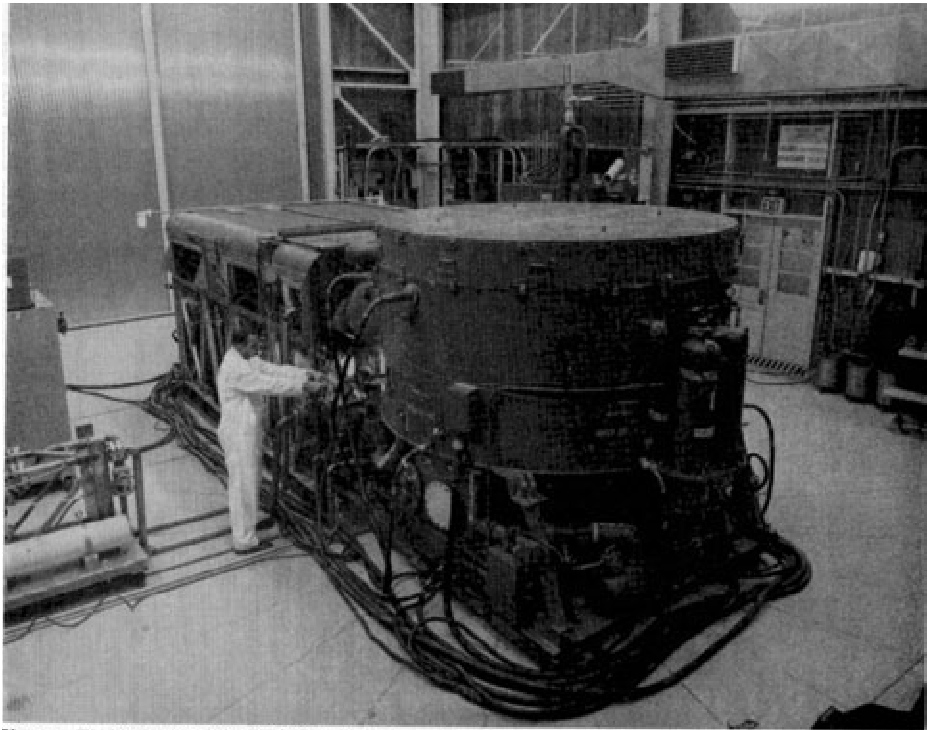

Photo 5. THE ML-1 POWER PLANT. This photograph shows the reactor and power conversion skid coupled together. The control cab (which can be carried on a 3-ton truck) is not shown.

(*a*) *More power from existing reactor cores.* It has been estimated that PM-1's output of 1,000 kW(e) could be increased to 3,000–5,000 kW(e) by making some modifications to the existing design.[16] A design study has also been carried out for a 1,000 kW(e) version of the ML-1.[17] Such reactors would have improved power to weight ratios and the cost per kilowatt of electricity would fall. At present the output of most reactors is enough to meet the demand at the site. As demands increase in the future there will be development potential available in the existing cores to meet this requirement.

(*b*) *The direct conversion of reactor heat to electricity.* Present thermodynamic power conversion systems are bulky, costly and require considerable maintenance. Furthermore, as reactors become smaller, these conversion systems become a major factor affecting the size and weight of the plant. There is a major research effort both in the USA and at Harwell to develop the principle of direct conversion of nuclear fission energy into electrical energy. Thermionic reactor diodes, theremoelectric devices and MHD (magneto-hydro-dynamic) conversion systems are all being studied.

(*c*) *Improved safety and simplified control systems.* Reactors, at present, are hardly "soldier-proof" and the consequences of mal-operation can be disastrous. The only fatal reactor accident in the USA was the nuclear explosion which occurred in SL-1 (a small boiling water reactor intended for Service use). The crew of three men, all of the US Forces, were killed. The direct cause of the accident was stated "to have been the manual withdrawal by one or more of the maintenance crew of the central control rod blade from the SL-1 core considerably beyond the limit specified in the maintenance procedure. . . . There is insufficient evidence to establish the actual reason or motive for such abnormal withdrawal".[17]

At present, complex control and safety systems are an essential feature of any reactor. These must be "fail safe"; that is, if a system component breaks down, the reactor is shut down. This is preferable to having no protection against a possible dangerous condition but it does mean that the reliability of the power supply is dependent on the reliability of the various "black boxes" associated with the control and safety systems.

In the proposed hydride moderated system it is possible for a reactor core to be designed to go subcritical before burnout temperatures are reached. This effect is achieved by a large prompt negative temperature coefficient; that is, as the fuel becomes hotter, the reactivity falls. As the hydride is mixed intimately with the fuel, this response is "prompt". This "built in" safety would mean that the reactor system would be inherently stable and would require conventional controls only, a major advance for military reactors.

Conclusions

It has been shown that, economically, static reactors of 10 MW(e) output may be suitable for providing power at inter-service bases. In remote sites package reactors are already economic because of the high fossil fuel costs. As reactor technology develops, package reactors will become cheaper and therefore economic in larger areas of the world. Small mobile reactors are not designed with cost as the major criterion and are many times more expensive than diesel alternators or gas turbines.

Logistically the reactor has great advantages. Its refuelling cycle is in terms of years rather than days and in a military role, as there is so much energy available, the efficiency of the power conversion equipment can be very low provided that this equipment is simple, light and robust.

At present reactors are costly and complex and only in very remote sites do they offer outstanding advantages. However, nuclear energy is a fast developing subject. Even if the fact is accepted that the Americans give a wide interpretation to "defence" and carry out many R & D projects under this heading which would be developed by civil firms or establishments in this country, it has now been demonstrated that mobile and package reactors are practical and have a military future in a developed form. Having considered the achievements of the ANPP in the first ten years of work on military reactors, it would be most unwise to write off the possible use of military reactors by this country during the 1970s.

The UKAEA are now beginning to devote an increasing amount of time to smaller reactors. They must be made aware of probable military needs in the 1970s. It is unlikely that the demand for specialized military reactors such as the ML-1 would be great enough in this country to pay for development costs. It might be cheaper and quicker to buy from the USA. However, in the package and static reactor field where logistic and economic considerations merge, a small British reactor might have both civil and military applications. The Corps must appreciate both the potential and the limitations of nuclear power in the military field, analyse likely power requirements for the future British Army and inter-service bases and then play a major part in the development of military reactors in this country.

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The East Peckham Bomb

By Lieut-Colonel C. A. A. Crouch, RE

On the 28 August 1961 we received a report by telephone from a Mr Gardiner, the owner of Crowhurst Farm, East Peckham, near Tonbridge. He said he intended to put new agricultural drains in an orchard, using a Howard trench digger. As this caused a lot of vibration, would we please remove the UXB which dropped there during the war.

We weren't quite as surprised as you might expect. Just previously a UXB had blown up spontaneously on a farm in Derbyshire, and the incident had received some publicity. We were pretty sure that there were a fair number of UXBs about in the country which farmers and land-owners had not had followed up; with good reason, too, as we would be the first to admit that we do make a mess, and a deep shaft, if it comes to that, often results in a splendid growth of weeds some 400 square yards around the site.

The East Peckham area, like many country districts in the Home Counties in particular, has quite a history of bombs and UXBs. The early incidents were not always thoroughly documented. We found three old reports, studded with question marks, though none of them tied up with Crowhurst Farm. Still, it was possible.

The next day, 29 August, Captain Thompson, the Troop Commander concerned, visited Crowhurst Farm, and met Mr Dolding, the bailiff. Luckily for us Mr Dolding had lived at the farm for thirty years, so we were able to get first-hand information (often this isn't possible). Mr Dolding said that early in the war two bombs were dropped on the farm, only one of which exploded (he was told by the ARP that this was a 1,000-lb bomb). The following morning he found a hole, 6 ft in diameter and 4 ft deep in the centre, in a hop field, and in the hole part of a ring of metal, about 2-ft diameter, of triangular section, and painted blue. He showed Captain Thompson the approximate position on the ground—but in the course of time the depression had disappeared and the hops had been replaced by an orchard, so naturally he couldn't be exact.

All this was quite encouraging, for from the size of the hole it could be the splash crater of a fair-sized UXB, and the metal ring could be the kopf-ring of a Hermann (a 1,000-kg German bomb)—a device attached round the nose supposed to prevent deep penetration, and, like the bomb, painted sky blue (Hermanns were carried externally). So too was a visit to the village pub, for though mine host was a comparatively recent arrival some of his patrons remembered the bomb(s) dropping, and were able to give their own versions. After a couple of pints Captain Thompson might well have supposed that an absolute bombardment of bombs had fallen on the farm in deadly silence, producing a sort of lunar landscape of enormous splash craters.

On 6 September Sergeant Hartshorn and his squad, or gang, arrived. All our gangs have their own individual characteristics. Some like digs, with a sandwich lunch on the site. Others like to camp, and eat at a near-by café. This particular gang is a civilian one, mainly Germans, and they moved into an outbuilding loaned by the farmer, and Nofz, the driver, took up his usual role of cook-housekeeper. They were to remain there, on and off, for about six months.

They followed the usual routine. First, surface location using the ERA bomb locator. They covered 2,130 sq yds in the first week, without result. Hardly surprising, as the ERA will only pick up a big bomb down to about 10 or at most 15 ft, but well worth trying—bombs sometimes jink up towards the surface again. Then they started jetting. This is a very damp occupation—in theory you rotate the vertical pipe while water under pressure squirts out through holes in the nose, pushing the earth out of the way and allowing the pipe to subside gently into the ground while the exuded water is absorbed by the earth. Of course it isn't like this at all. The pipe runs into a bit of rock or stone, the operators bounce up and down on the handles, the hose connection to the pipe falls off on your head, and the site soon becomes a quagmire. A good supply of water is required for this game, and in this case it had to be pumped from a source 700 yards away. By 28 November fifty boreholes at 9-ft spacing, had been sunk to a depth of 30 ft, and the ERA bomb locator lowered down each. Nothing.

At this stage the scene of operations was moved to another part of the orchard. I'm not sure whether this was because Mr Dolding had second thoughts, or whether Captain Thompson or Sergeant Hartshorn had a hunch. Anyway, the gang started their routine all over again—with immediate results. The surface location gave some interesting readings, and on digging a quantity of old tins was exposed. Optimistically we hoped that these had been thrown into the splash crater, perhaps by hop-pickers, and buried. Next, jetting again. At the first attempt the pipe went down very easily—down the entry-hole of the bomb? But there was no reading on the bomb locator when it was lowered down the jetting pipe, nor on the two next occasions, and we wondered if perhaps the bomb was deeper than 30 ft —the limit of the jetting pipes on this site. So we started Phase Three.

A Boyles boring rig was brought to the site, and a triangular pattern of 50-foot bore-holes was started. The Boyles is a sizeable contraption, trailer-mounted, and, since it is a wet rig, it has a tank mounted on the trailer forward of the mast. It is not easy to manoeuvre, particularly in mud. By now, too, it was winter. Short days, night frosts and cold hands slowed up the work. Two consecutive reports indicate the difficulties: 28 December—"Borehole 57 to 35 ft"; 29 December (a Friday)—"Borehole 57 to 40 ft—failure of primer pump to start, heavy rain, and very hard drilling caused delays, and stopped drilling early to allow time for frost precautions to be taken for the week-end."

All this time the bomb locator, when lowered down each borehole, 2 ft at a time, had remained passively disinterested. But on Borehole 58 it gave a positive reading at about 28 ft. Borehole 59 gave better readings, and Borehole 60 better still. This was on 23 January. All that remained now was to site the shaft, dig down and dispose of the bomb—if it was a bomb.

Our standard timber shaft is 9 ft by 8 ft. A Hermann (we were sure it was a Hermann—the readings, the kopfring, the fact that only two bombs were dropped all indicated this)—a Hermann is 6 ft 3 in long without its tail, and over 2 ft in diameter. Now there is nothing more tiresome than digging a 30-ft shaft and not finding the bomb wholly within it. You can't fill it in and start again; timber shafts depend on earth pressure to keep their shape.

One is faced with the tricky operation of striking off a heading—and as these are normally rather less than 5 ft by 4 ft one is pretty cramped when eventually one comes to the bomb. So siting the shaft is very important. By transcribing the bomb locator readings for the three boreholes to graph paper, and doing a bit of mumbo-jumbo with half-maximum readings and stray constants, you can, in theory, "place" the bomb. But it requires experience, flair, and perhaps a bit of luck, to site the shaft correctly for a large bomb.

By 28 January the stores were on site, including a 19RB, and shafting began. Heavy blue clay made digging hard work. On 13 March we had our first sight of the bomb at 27 ft—it was a Hermann, and it was centrally placed in the shaft, with the nose slightly above the tail. The pace hotted up. Extra men and lighting equipment were sent to the site, to work round the clock, for once a bomb is exposed we like to get the dangerous part over quickly. The shaft started flooding, and we had to keep the pumps going. Strong ammonia fumes emanated from the tail area. We fixed 15 March as D-Day.

Meanwhile a good deal of planning was going on. With the police we arranged evacuation of the village and road closures. With PR we made arrangements for the Press. Both BBC and Southern Television wanted to be "in". And the J. Arthur Rank organization was to film the operation for one of their "Look at Life" series. All this worked out pretty well in the event. What was really taxing us was how to deal with the bomb!

The problems were these. As regards the fuze, Hermanns have only one fuze pocket, fortunately. It was very probable that the fuze would be of the normal impact type, but it was possible that it might be a 17 clockwork fuze (with an anti-withdrawal device?), or an anti-handling fuze with a trembler switch, or even a rare battery-operated fuze. As regards the bomb filling, Hermanns have cast explosive in the nose, and powder filling towards the tail; where the two explosives meet a third explosive is formed by chemical reaction, very sensitive to heat, so it is not possible to steam out a Hermann. The best one can do is to wash out as much of the powder filling as one can. Finally, it is unwise to move a bomb which has cracks in its case, as there is a danger that explosive may be pinched in the cracks and be set off—and we thought that the case must be cracked to account for the ammonia fumes.

In this case we, or rather Major Hough, the Field Engineer, decided that if it was a normal impact fuze the best thing to do would be to take it out, if he could. This is a reasonably safe course of action, the main hazard being the accidental detonation of the sensitive picrics around the gaine; this is minimized by introducing easing oil into the fuze pocket, and by a steady pair of hands. Of course, sometimes the locking ring on the fuze won't budge, or the fuze pocket has been distorted, or the picrics have crystallized out and the whole lot is jammed solid, and this is bad luck. If the bomb case was cracked he would try to take off the base-plate and remove as much of the filling as he could. Then, depending on circumstances, get the bomb out of the shaft and away, or blow it up *in situ*.

If it was a 17 fuze, the clockwork fuze which often had an anti-withdrawal device behind it, the best that could be done would be to fix a clock-stopper (an enormous electro-magnet), and carry on as if there were no fuze. As experience has shown that 17 fuzes have a tendency to stop with only a few seconds (up to 20) of their life to tick away, they are never very pleasant things to play with. Incidentally, I should say at this stage than an electrical stethoscope had already been placed in contact with the bomb at the site, and a 24-hr watch instituted just in case.

If it was a battery-operated fuze, we could freeze the bomb (and thereby lower the EMF of the battery). This would fix the fuze, and we could then carry on as if it was an impact fuze. Finally, if it was an anti-handling fuze, we could resign our commissions.

The 15 March was a fine day, Major Hough and Captain Thompson went down the shaft. The bomb was sitting at the bottom, in a pool of muddy water. They removed the extension cap to reveal the head of the fuze. It was a 28—an impact fuze. The locking ring turned easily after a good soaking in easing oil. Using the Stevens Stopper, they filled the fuze pocket with easing oil. After the statutory cigarette on the surface, back down the shaft, off with the locking-ring, and out with the fuze. Couldn't be better. The time was 0945 hrs.

Next the bomb was completely uncovered. The fumes were very bad, and air was pumped down the shaft. Then we had our second bonus—the base-plate was already off, presumably torn off during the bomb's journey; this would account for the ammonia fumes. The bomb was checked for cracks and pinches, but none were seen. The 19RB lifted the bomb to the surface, and work started on washing out the powder filling. It was very solid, and less than half could be removed. As a thorough check showed no cracks at all in the bomb casing, our now impotent Hermann was very gently lifted into a 3-tonner, and escorted to Lydd Ranges, where it was disposed of by 1700 hrs, together with the fuze as the gaine was corroded to it. The next morning there was 12 ft of water in the shaft, so it was as well we had acted quickly. All that remained to be done was to back-fill the shaft and withdraw the timbers, and this was completed on 27 March.

It was tragic irony that, at the same time as Major Hough was successfully removing the fuze, thirty miles away at Lympne we had one man killed and another wounded by a pipe mine.

Outward Bound Adventure Training July/August 1963

By Lieutenant R. M. Stancombe, RE

There is much ignorance over the purpose and character of an Outward Bound Course. This becomes very obvious when talking to boys newly arrived for one of the Courses. Several boys imagine that their next four weeks, twenty-six days to be exact, at the school are to be a holiday. Other lads think that they are just to be taught skills of mountaineering or canoeing, and some of the finer points of camping. There are even those chaps that arrive expecting a full battle P.T. course.

When I first heard of Outward Bound I had a vague picture in my mind which consisted of a mixture of the above ideas. The whole idea of instructing at an Outward Bound School came from an Officer (a Gunner) who had done several courses the previous year. He had enjoyed it so much and was so obviously enthused by the whole thing that I began to show some interest myself. I found it difficult to believe how someone like myself could be of any value at all to such an institution, where I understood all instructors were brilliant mountaineers, expert swimmers and canoeists and generally behaved like monkeys in treetops. But I was very wrong. Although I had never climbed before in my life (my knees went weak when more than my own height off the ground) and only had some paltry experience of canoeing, I was apparently to be of immense value.

This gunner friend of mine was so impetuous that I found myself volunteering for not one, but two Courses at the school near Ashburton in Devonshire.

All Outward Bound Schools proper are controlled by the Outward Bound Trust. Several schools are now in operation in Wales, the Highlands of Scotland and in Devon. The Devon School, at Holne near the ancient market town of Ashburton, is the youngest Boys' School having been started up five years ago. Up until April of this year the School catered for girls as well as boys, the Courses alternating. Perhaps this was why my Gunner friend enjoyed his stay so much?

The School now runs approximately one course a month and caters mainly for boys between the ages of 16 and 19. The type of student attending varies considerably. Schoolboys come from all schools from Eton to Southmead Secondary Modern and many Apprentices from Industry. Police cadets all do an Outward Bound course at one of the schools before graduating and there is always a selection of interesting characters, Americans, Dutchmen, and even boys from Borstal institution. The fee per course is forty pounds per boy and is usually paid by his sponsor who, incidentally, requires a full report on the boy's character at the conclusion of the month's activity.

The aim of the Courses are to encourage boys to be good and useful citizens. They will have the opportunity of living with other boys of their own age group for almost a month. Some lads will never have had this opportunity before. The boys are faced with challenges, individually and collectively, and are able to surmount the potentially dangerous activities put before them. Each lad will get his chance to lead his group and in this way can develop his leadership qualities—for many of them this being the first occasion that they will have been given this opportunity. During the days at the school the boys learn to laugh at their own mistakes and, if they are themselves competent, to encourage those who may be in difficulty. The boy is given the opportunity to be public spirited and he tries to be guided by the motto of Outward Bound—to serve, to strive and not to yield.

Soon after arriving at the School, set in a beautiful park on the banks of the River Dart, I realized that my job during the ensuing courses was to be a Patrol Instructor. There were ninety-six boys on the Summer Courses and they were divided into eight patrols of twelve boys apiece. Each patrol was named after an eminent Devonshire gentleman, Grenville, Hawkins, Drake, Raleigh and others.

As patrol instructor I met my twelve boys as they were disgorged from the coaches which transported them all from Newton Abbot station. They were a rough looking crowd being almost all apprentices from all parts of England. I must have given them a pretty fearful impression of the place as I was very unsure of myself and not absolutely sure what was expected of me. However, things improved, and we succeeded in getting through all the laborious, but necessary, joining instructions, i.e. collecting camping gear, seeing the School Doctor, sorting out financial arrangements and seeing the Warden.

At the beginning of the Course each boy sees the Warden, a retired Colonel, and is asked if he will sign a pledge that during the next twenty-six days he will not drink alcohol or smoke and will adhere to the training conditions, generally. He must co-operate with his instructors and also partake of a dip in the River each morning at 6.30 a.m. At the conclusion of the Course he is asked whether he has been true to his word and if so is given one of the coveted badges. The whole system is based on mutual trust and no one gains by dishonesty. This is pointed out to the boys.

The first few days of every course are taken in getting to know the boys and also in getting them really fit. They will not be able to enjoy the expeditions later on in the Course unless they are supremely fit, so the training is fairly tough and there is no let-up.

In between periods of instruction on map-reading, first-aid, knotting and camping, all given by the patrol instructor, the boys are taken on steeplechase runs, given an opportunity to climb ropes and trees and each day put through a strenuous outdoor circuit training course designed to develop team spirit as well as personal fitness.

Many boys have had little or no previous experience of climbing or outdoor activities in general and much time and patience is expended in attaining certain standards in ropework and climbing. The fact that a particular boy may be far better than the others at any activity does not gain him tremendous recognition whilst on one of these courses. It is the boy who finds the activities extremely difficult but through his own determination alone conquers his fear and surmounts the obstacles. He is the lad that receives real praise. A boy of outstanding skill will not be ignored but encouraged to help those others who are finding things less easy.

This hard training is very necessary as the boys have the chance to take part in more potentially dangerous activities later on which require that they should be physically fit and adept in the basic skills. For example, the High Ropes course which is done during the last week, requires that boys should climb around on ropes up to fifty feet off the ground, doing a free slide from the treetops and traversing the river, some forty feet above it along two ropes and finally on one rope. This is to mention only a few of the sections of the course but it must become obvious that certain time must be spent on a Low Ropes course in order that the boys may learn the correct way to climb up ropes, lock themselves on with feet only, slide on a single horizontal or sloping rope and the like.

Morale is pretty low after the first week as the lads are exceedingly stiff and a number of them have a plentiful supply of blisters and minor abrasions.

However, from now on the more interesting activities are undertaken. A day's rock-climbing up on the 60-ft high Hay Tor, teaching all the rudiments of the art, is followed by a 25-mile trek across the moor to the Dewerstone Rock where climbs of up to 200 ft are attempted. During these actual climbing periods I hand over to a qualified instructor and join in on the end.

Each night the boys camp out and split up into smaller groups to walk back across the moor. By now their map reading, and especially compass work, is highly developed or if not, they simply get lost and arrive back hours

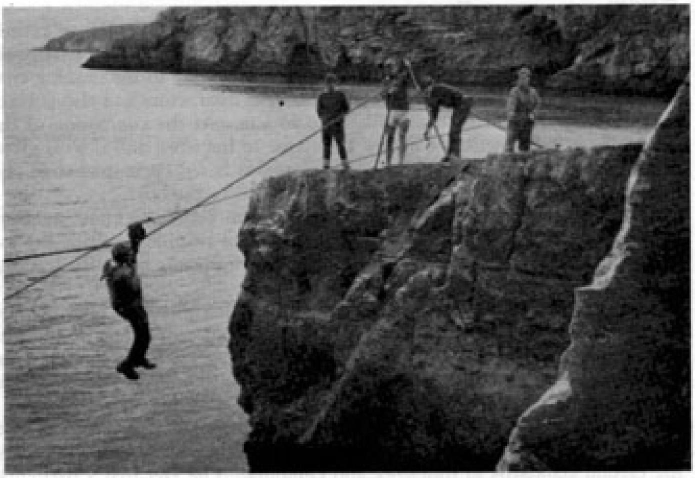


Photo 1. Rescue operations from a "wreck" on the Devon coast.

Photo 2. Cliff rescue over Berry Head.

Outward bound, adventure training, July,August 1963 1 & 2

late. As instructor I keep pretty firm control on their movements and always know in what part of the moor they are to be found at any moment.

Two days are spent down potholes which give plenty of scope for imagination and adventure. Candles are used and the boys are asked to do some pretty hair-raising squeezes which certainly sort out the men from the boys, so to speak. Many patrols get lost down the meandering passages and caverns but even if a trifle late, they always find their way out in the end. The whole thing seems fearfully dangerous at first but after a while one realizes that it is, in fact, difficult to stray too far away.

When back at the School in the evenings, and not out camping, time is devoted to discussion and a public speaking contest between the patrols is held. This is very good for the boys as they organize their own programme with the minimum of guidance from the instructor. Some of the boys produce very amusing items.

After spending a morning practising canoeing on the river near the School and being taught how to form a raft and to right a capsized craft, the boys go on a canoeing expedition down one of the Devon rivers. The boys are driven in a Land Rover plus canoe trailer, myself or another instructor driving, across the moor to Calstock on the River Tamar. This is the most hazardous part of the journey for the instructor as propelling a Land Rover plus twelve boys and seven canoes along the tortuous Devon lanes is no simple matter. Stopping on a 1 in 4 hill in a stream of traffic is certainly enough of a "Character forming" situation for the driver! Twelve ebullient, cheering boys in the back do not help matters.

However, once safely launched at Calstock the journey begins and after four hours hard canoeing against the tide, the camp site is reached. An early start the following morning to catch the outgoing tide and then downstream under the new Tamar Bridge, dwarfing the old railway bridge, past the Reserve Fleet at anchor and then through Devonport Dockyard. Into the Sound with Plymouth Hoe on the port bank and out on to the mile-long breakwater for a quick bite to eat. A quick look at wind and tide and then a hard paddle out to sea and round the coast to the next river. Several boys get cramp and are very "seasick" during the "voyage" but they combat this and team spirit carries them through. They have a tremendous sense of achievement when lying in the sun at the end of the journey and tracing the 30-mile route on the map. Life jackets and buoyancy are used meticulously but there is still an element of danger, especially as the boys build the canoes themselves!

During short periods back at the school Athletics periods are allotted and boys try to attain standards that they can use for the Duke of Edinburgh's Award Scheme. Other activities at the School do not qualify for this scheme.

On Sundays the boys are transported to their own particular place of worship and afternoons are taken up with initiative tests as well as preparing for the following (team) day's expedition.

A most enjoyable and worthwhile period is spent staying in the H.M. Coastguard Lighthouse at Berry Head. The boys sleep in hammocks in the age-old fort and do an hour each with the coastguard during the night. During the daytime the basic skills of Cliff Rescue are taught and boys climb down over the 200-ft high cliff to be rescued by their friends using various different methods. Great fun is had by all, scrambling around the rocks and caves at the bottom, and a bosun's chair rescue is carried out.

Photo 3. Climbing instructions at Haytor rocks.

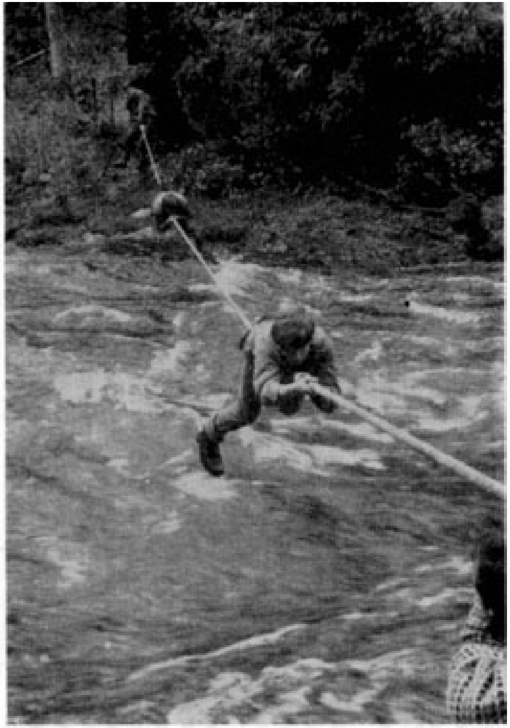


Photo 4. A patrol crossing the river Dart the difficult way.

Outward bound, adventure training, July,August 1963 3,4

The only shame is that there is rarely a real rescue for the boys to perform, but perhaps one should not hope for one.

The Course winds up with a three-day final Scheme during which the boys are dropped by coach 90 miles from the School and make their ways back, picking up clues as they go. This usually entails crossing two of the three moors, Dartmoor, Bodmin, and Exmoor and the boys really feel a sense of achievement when they arrive back at the School in their groups of four.

A final day doing the crosscountry course and you would imagine the boys would be too exhausted to do anything else. But this is far from the truth, and after the presentation of badges by the Warden on the last evening they put on a concert which is always hilarious fun. A good course will result in the instructors putting on a turn which always goes down well with the boys.

As will become clear after reading the above account of some of the main activities at the Devon School, a wonderful spirit is attained by the boys towards the climax of the Course. Few boys go away having failed to enjoy themselves and they will all admit that they have learnt a tremendous amount about themselves and about people in general. They covet their badges and the exceptional boy who wins a Warden's Badge, for outstanding service to others, is there for all to see.

Thus, the Courses go on, all over the country, in fact, worldwide. In winter as well the schools function and strive to produce the same atmosphere of friendship and challenge.

Even after instructing for two courses I realize the immense value of Outward Bound. There are many criticisms of such an idea but having taken part in this exceptional way of life one realizes the immense dedication on the part of the instructors, especially the permament instructors who work the whole year round. A temporary instructor may only attend for several courses but the permanent may stay at a school for years. This is a full-time job, working seven days a week and with the possibility of occasionally as much as a week between Courses. More often Courses are separated by a few days.

This is very dedicated work but tremendously rewarding, providing the instructor has a broad sense of humour. Understandably, there is a shortage of permament instructors and so temporary instructors are always welcomed to fill in the gaps.

The Army runs its own school which does tremendous work, but it is very interesting to see how the civilian schools are run and I feel much can be learnt by officers spending a few courses at such a school. The main drawback is obtaining at least a month to do this, but the Adventure Training period whilst at the RMCS is as good a time as any.

The officer, due to his training as a soldier, is able to be of great value to Outward Bound and can also gain much from the experience, having a much clearer impression of the excellent motto—to serve, to strive and not to yield.

Dhekelia, Cyprus

DEDICATION OF THE RE WINDOW IN THE GARRISON CHURCH OF ST GEORGE

By CAPTAIN P. J. WALSH, RE

ON the final evacuation of British troops from the Canal Zone in 1956 there was no permanent Anglican Church for use by the Army in the Eastern Mediterranean. Plans were, therefore, made for the construction of a Garrison Church at Dhekelia, Cyprus, and it was proposed that a number of items that had been salvaged from St Georges Church, Moascar, should be included in the structure. The new building was finally completed and dedicated by the Chaplain General to the Forces on 11 March 1962.

Amongst the items salvaged from Egypt had been a number of stained glass windows, depicting the badges and emblems of various Corps and Regiments. Most of these windows were too small for the new structure, and the Royal Engineers, amongst others, were invited to contribute towards the cost of windows to go in the new church. The Corps Committee made a generous grant, and the architect was able to go ahead with the production of designs, incorporating the RE window from Moascar. The design finally accepted showed the venerable figure of Bishop Gundulph, one-time Bishop of Rochester and almost the Patron Saint of the Corps, with a King George VI RE cap badge above him, the latter being the part of the RE window evacuated from Egypt.

The construction of the window took a long time, but it was finally installed in the church in May 1963. Even then, all was not well, because the window had somehow been reduced in size during design and manufacture, and was too small for the frame. But willing work by the Cyprus Park Squadron and the District Works Officer ensured that this mistake was rectified, and the finished product, as can be seen from the photograph, is worthy of the Corps.

A special service was held on Sunday 16 June 1963 to dedicate the windows. The service was conducted by the Rev T. O. Sturdy, CF, assisted by the Rev W. Jamieson, MBE, CF. The GOC Cyprus District Major-General P. G. F. Young, CBE, was present. There was a very large congregation for the occasion and many of the guests and their families were entertained to coffee in the RE Officers' and Sergeants' Messes after the service. A Royal Signals window was also dedicated, and the joint service helped to cement the bonds between our two Corps.

Dhekelia, Cyprus - Window

Early Chatham Defences

This article was submitted to the Royal Engineers Historical Society by

MAJOR H. JOHNSON

IN the year 1779 the whole of England was on the alert to meet an expected French invasion, the united fleets of France and Spain being temporarily masters of the English Channel. Armies were assembled in Essex, Sussex and Kent to throw back the expected invader should he get a foothold, the press gangs were on the prowl to produce "imprest" men for both the Army and the Navy, earthworks were being constructed along the rivers' edges and the Navy were siting floating batteries in the estuary of the Thames.

The Right Honourable General Lord Amherst, after whom Fort Amherst at Chatham is named, was the Master General of the Ordnance and Adjutant-General at Whitehall—Major-General Calcroft was in command of His Majesty's Forces at Chatham—and Lieut-Colonel Hugh Debbieg was (to give him his full title) "Chief Engineer upon the Staff in Great Britain". His office was within the Chatham Lines and it is from the original file letters, written in copperplate handwriting on watermarked paper, beautifully bound, that I have obtained my facts.

Hugh Debbieg was a most colourful personality. In 1742, at the age of 11, he enlisted in the Artillery as a "Matross", the next in rank below "Gunner" and one who acted as a Gunner's mate. He later passed through the RMA Woolwich and was commissioned into the Corps of Engineers (not Royal until 1787). He served as General Wolfe's AQMG during the capture of Quebec in 1759; it is said that the General died in his arms on the heights of Abraham. During his chequered career he was twice court-martialled and convicted of insubordination to the Master General of the Ordnance. Nevertheless he rose to the rank of General.

It is interesting to note that in 1779 the Chief Engineer constructed and operated the first Gravesend Ferry, carried out the major part of the earthwork within Chatham Lines and at other points on the south coast, built a hospital within the Lines, modified ships' holds for the "safe" conveyance of deserters and impressed men to reinforce overseas units, carried out a feud over forage allowance with General Calcroft, dealt with the civilian population regarding the provision of adequate roads in the Dockyard area, and carried out a whole host of minor activities, yet the total number of letters, written and received between "15 Febry 1779 ½ past 10 o'clock at night" and 14 September 1779, amount to only 128 double pages! It serves to make one wonder whether or not the invention of the typewriter has been of any great service to the Army.

In early 1779 the staff of the Chief Engineer consisted of Captain Charles Shipley (later to become Major-General Sir Charles Shipley, Kt)—stationed at Gravesend and fully occupied building the Gravesend ferry—and Honourable Lieutenant Chetwynd, Lieutenant Farnham Close, Lieutenant John Wright, Lieutenant Nathaniel Bland and Lieutenant Wm Brigstock stationed at Chatham. Later in the year Thomas Smart was granted his commission as Practitioner Engineer and proceeded to Rye to supervise the building of the fortification in that area.

Although it is not clearly shown on the files, it would appear that the Gravesend Ferry project was the idea of Captain Charles Shipley. It was anticipated that the main body of the French invading force would land at a position on either the Kent or the Essex coast and all available troops were dispersed over this area. The difficulty lay in concentrating the troops at the point of the French landing once that position was known. The only road route between Kent and Essex lay through London, a long and arduous march. Shipley's plan was to have about twenty large barges concentrated at Gravesend. The barges were to be operated on the captive ferry system and for this purpose quantities of cables, each 1,440 fathoms in length, were ordered. The barges were strengthened to carry the various heavy field pieces and Shipley gave an estimate that a whole division could be transported across the river during daylight hours. This allowed the Army Commander to split his force into two halves, the half on the southern side of the Thames being concentrated in the Chatham area, and that on the north side in the Colchester area. By using the ferry he could rapidly concentrate his force no matter which side of the estuary the French landed.

Shipley was greatly worried by the fact that his trained civilian boat crews would be snatched up by the press gangs and he eventually persuaded the Office of the Board of Ordnance to issue the crew with certificates which could be produced to the press gangs should any of his staff be caught in the net! The press gangs at this period must have been most active as there are dozens of letters on the files ordering the release of "imprest men" who had been proved to be apprentices bound to various masters. The onus for applying for release would seem to have rested with the "master" and not with the "apprentice".

One result of the building of the ferry was a petition to the Chief Engineer from shopkeepers on the quayside at Gravesend. They asked for sixpence per day compensation for losss of trade due to customers having to climb over the large coils of cable laid on the pathways in front of their shops. Debbieg's reply, addressed to the Mayor of Gravesend, refused the demand for compensation and accused the citizens of a grave lack of public spirit!

Shipley's orders regarding the prevention of shipping interfering with the operation of the ferry, no doubt echoing Debbieg's forthright attitude, were couched in no uncertain terms. They read:

Gravesend, August 25th, 1779.

INSTRUCTIONS for Mr Green relative to the stopping of Shipping etc, whilst the Barges are Manoeuvring this day.

You will take care to be well above or below the Communications according to the different Times of Tide, if the Barges work on the Ebb tide, you will cruise off Mr Webbers, or in the Northfleet Hope. If on the Flood in the Hope.

You will speak to all Vessels, and require them immediately to come to an Anchor, acquainting them with the Hawsers being stretched across the River.

You will have a Serjeant and Twenty Men with their Arms and Ammunition in the Sailing Boat with you, who will have Orders to follow your directions. Therefore should Vessels persist in making their way after you have hailed them, you must immediately order half of the people to Fire with Ball amongst the Rigging etc. Should they not immediately attend to that, the Rear Rank will also Fire amongst their Sails and Rigging. Should not this still have the desired Effect, You will directly man the Eight Oard Boat, and take in as many of the Party as it will hold, go on Board and cut the Anchor from the Bow and let it go with all her Sails Standing.

The Sloop will at the same time run up as close as possible and the remainder of the Party remain on the Deck, ready to give you every assistance in their Power. You may further acquaint the Masters and Pilots, that should they by their rashness be the Means of the Hawsers being cut, and thereby obstruct His Majesty's Service, they may lay it to the Account of their own Obstinacy.

CHARLES SHIPLEY

Mr Joseph Green, Cockswain of the Chief Engineer's Boat.

Other engineering tasks were the building of earthwork defences on the Lines at Chatham, and at the Heights of Pleydon near the town of Rye.

Debbieg's report on the Heights of Pleydon concluded with:

"Taking it therefore for granted that enclosing the Church will take the preference here follows:—

An estimate of the Materials that will be required to be prepared beforehand as also of the time in which with a given number of men the said Redoubt may be compleated. The parapet of which will be five feet in thickness at the Top. The Ditch 30 ft wide at the Top and 12 at Bottom, and a Gracis in front of, and surrounding the whole Work of 42 feet in breadth and 3 feet high on the Crest, which makes the Ditch 11 feet in Depth.

Fraize	(2500 Oak Palisades	of 9 ft long at 1s 6d	....	£185	0s	0d
	500 ,,	of 12 ft long at 2s 0d	....	£ 50	0s	0d
Fascines	1000 Fascines	of 16 ft long at 1s 3d	....	£ 62	10s	0d
	1000 Do	of 12 ft long at 1s 0d	....	£ 50	0s	0d
	1500 Do	of 9 ft long at 9d	....	£ 57	10s	0d
	2000 Do	of 6 ft long at 6d	....	£ 50	0s	0d
Pickets	16500 Pickets $4\frac{1}{2}$ feet long, $1\frac{1}{2}$ in dia @ $1\frac{1}{2}$d		....	£103	2s	6d
		Cost of Material	....	£558	2s	6d

Excavation Earth { 6943 yards of Solid Digging which is imagined 500 men well employed would throw up in Ten Days.

Chatham Lines, 6th July 1779".

Debbieg's duties also included a certain responsibility toward the positioning of the cannon as is shown by this extract from his letter to Lord Amherst:—

"In these circumstances (tho' the whole Lines are nearly in as good a State of Defence as when I begun to reform them) Major General Calcroft thinks, and I entirely agree with him, that the Redoubt should be finished as soon as possible, which, with your Lordships approbation, I mean to do, and to mount some of the Cannon that were formerly upon the Lines herein, and to order 100 of Ball and 100 rounds of Grape Shot, with Powder in Proportion, to be issued and lodged in the Magazine in readyness for Service in case of an Urgent necessity".

The Chief Engineer of those days had to face all the problems and set-backs which are today still only too frequent! On 9 March 1779 he received the following letter:—

"Sir,

I must trouble you to send over two Subaltern Officers to compose a Garrison Court Martial which will be held at this place, tomorrow morning at 11 o'clock.

I am, Sir,

Your Most Obedient and Most Humble Servant,

Tho Dade—

Fort Major"

To which he replied with the usual Sapper cast iron excuse!

"I have received the favor of your letter. . . . Beside that your Demand is more sudden than usual upon such occasion, as near a Thousand Men with their Officers are under Orders for immediate Embarkation. I cannot spare you the Officers you demand, and I think you should apply to the Shropshire Regiment of Militia at Gravesend and Dartford.

I am, Sir,

Your Most Obedient Humble Servant

Hugh Debbieg"

Debbieg was called upon "to answer a suit at Law for not paying for a large quantity of gravel taken last summer out of the Gravel Pits at Chadwell". To which he replied "(The cost) of One shilling a cartload is unjustifyable and Impertinent . . . and the honour of an Officer ought not to be sported with by such a Man as you. I shall appear in the prosecution cloathed with the Innocence which will exculpate me and shew your client in the light he deserves to appear to all the World."

The final outcome of the suit was not recorded.

Queries over travelling claims, even in these early days, were not uncommon as is shewn by the letter sent to Debbeig from the Office of Board of Ordnance on 20 April 1779:—

"Sir

Having laid before the Board your request of 21st ultimo to be allowed Fifteen Shillings a day as Compensation for Travelling Charges and Extraordinary Expenses in complying with the several Orders and executing the several Works committed to your care.

They command me to acquaint you that they wish you would deliver an Account of Travelling Charges for their consideration, and Guidance in settling the same.

I am, Sir,

Your Most Obedient and Humble Servant,

John Boddington"

The Chief Engineer replies rather huffily to this:—

"My Lord and Gentlemen,

In reply to your Commands of the 20th past signifying that you wish me to lay before you an Account of my Travelling Charges for your consideration and guidance in settling the same I am to inform you that I have kept no account whatever of those extra Expenses, and if I had, I should have begged your leave to have declined making a bill, esteeming it infinitely more honorable for me to have such a stated allowance as you may think proper to grant, than to make *a Charge* to which, as yet, I am a perfect stranger."

On the 1st day June 1779 the claim for Travelling expenses of Fifteen shillings per day was allowed by Principal Offices of His Majesty's Board of Ordnance!

It was, however, labour problems which troubled Debbieg most. He was frequently advertising for civilian labour and extracts from a typical public notice are shown here.

"Five Hundred copies of this were printed by Mr FISHER of Chatham and distributed at Church Doors round the Country."

"Chief Engineer's Office,
Chatham Lines. 9th March 1779.

"This is to give notice that a number of Labouring Men are wanted for the Kings Works, particularly such as are used in digging of Ditches, making of Turf Banks and working in Earth according to given slopes.

All able-bodied Men of the above description willing to be employed on the said Work, and also to engage themselves under a certain penalty not to quit the same till they shall be discharged may apply to Mr PARK, Clerk of the Cheque at the Office upon the Lines, and will meet with all due encouragement.

Hugh Debbieg
Lt Col and Chief Engineer".

If the "labouring men" worked the same hours as the Troops employed on the same work they no doubt needed "all due encouragement" as the order for the day of 20 March 1779 said:—

"After the 25th instant the Troops of the Working Party are to parade at half past five in the morning, and the Drum is to beat for them to leave off Work at Eleven in the forenoon. To parade again at One in the afternoon and Work till Six in the Evening."

Hugh Debbieg Lt Col

Despite the Chief Engineer's efforts the Regiments of the Line sent him less and less numbers in their working parties until Debbieg sent the following letter to General Amherst:—

Chatham, 30th July 1779.

"My Lord,

The Board having been pleased to Order the Cutting Tools demanded in my letter of the 22nd past has, I presume, been principally owing to your Lordship seeing the propriety thereof.

The several excusions I have been lately able to make thro Kent and part of Sussex has proved a source of Pleasure and Instruction in which I have long wished to gratify myself and could not fail to raise thoughts that urged me to demand those tools, and your Lordships will not be surprised if in some measure I should have gone so far as to conceive very extensive Ideas of their use in almost all cases, none of which I need to suggest to your Lordship. Yet I must take the liberty of mentioning how very advantageous to the Service (in my humble opinion) it would be, if a Corps of Artificers was to be selected from the Army. The present Establishment of Pioneers to each Regiment will prove in no case sufficient or equal to the purpose of advancing an Army through such country as this.

The great attention of the Antients to this particular was wonderful, and the highest point of perfection in the Roman Legion was that when it made Detachments, tho' ever so small, they carried with them a just Proportion of the Component Parts of its excellent System—Artificers of all Denominations.

Modern Armys differ from those of the Antients scarcely in nothing but the Arms in use; in all other points we cannot imitate them too exactly. I am sensible the Subject is not new to your Lordship, and if it did not strike me as a thing absolutely necessary for the good of His Majesty's Service, particularly at this time, I should not have troubled your Lordship thereon.

It is a most essential part of a Soldier's duty, I allow, to be as expert as possible at covering themselves with Earth Works; but then there is also a necessity for a Band of Leading Men capable of instructing others and of conducting Works with more regularity than has been usually done where I have yet been upon Service, as also with greater dispatch.

I will not presume to point out to your Lordship the means of establishing such a Corps, nor how far two Men per Company would go towards making it numerous enough for the purpose, from the Militia alone, but I will venture to say that had such a Body of Men been constantly here, these Lines would have been nearly compleated; and you know what state they are in at present.

I regret exceedingly that my Duty at Rye prevented me from having the honor of meeting you here, because I wish to explain some things to your Lordship which I find you are not duly informed of, as well as to exhibit a Machine I have made that I believe may be rendered highly useful in particular cases; it is a moveable Cheval de Frize.

I beg your Lordship to believe me,
My Lord,
Your Lordships,
Most Obedient and Faithful Humble Servant,
Hugh Debbieg"

The reply to this was:—

Whitehall 11th August 1779

"Sir,

I have received the favor of your letter of the 30th past. Your idea about forming a Corps of Artificers from the Army is a very good one, as far as that such a Corps would be very desirable, but at a time when it is a material subject of consideration to increase the Army by every possible means, the forming of such a Corps cannot be thought of. In the case of any Service happening within this country the general business of the Pioneers must be done by the able bodied men among the Peasants of the Country.

I am Sir,
Your Most Obedient Humble Servant,
Amherst".

Although Companies of Soldier Artificers were raised at Gibraltar in 1772, primarily for work on the defences of the Rock, it was not until 1787 that the Corps of Royal Military Artificers was raised for duties at home and in certain overseas garrisons other than Gibraltar. The Soldier Artificers of Gibraltar were eventually absorbed into the Corps of Royal Military Artificers in 1797.

It is fascinating to think that these files may well have lain unopened for over 180 years, and that by opening them now, we are able to obtain details of the day-to-day working of the Chief Engineer's Office in those far off days. The fullest details are given, even down to the names of the crews who manned the various barges on the Tilbury Ferry, and the names of the leading Chatham citizens who petitioned Debbieg for an improvement of the roads in the Dockyard area. His feud with General Calcroft over the provision of fodder for the Chief Engineer's horses makes interesting and amusing reading, and may well be the subject of a later article.

Annual Corps Dinner

By Brigadier A. T. J. Bell, OBE

(Late Engineer-in-Chief, Australian Military Forces)

For very many years it has been the custom of the Royal Australian Engineers to hold an annual Corps Dinner in each Command, and elsewhere, on a date as close as possible to 18 June, the anniversary of the Battle of Waterloo. The dinner has been known in Australia as the RAE "Waterloo Dinner".

Although there is no doubt that the reason for so doing was originally well understood, over the passage of years it has become forgotten. Consequently many members of the Royal Australian Engineers, and other distinguished guest speakers, often strove valiantly on such occasions to explain that the Royal Engineers played such a notable part in the famous battle that the Royal Australian Engineers had good reason for dining together on its anniversary date. Much individual research was done on the subject.

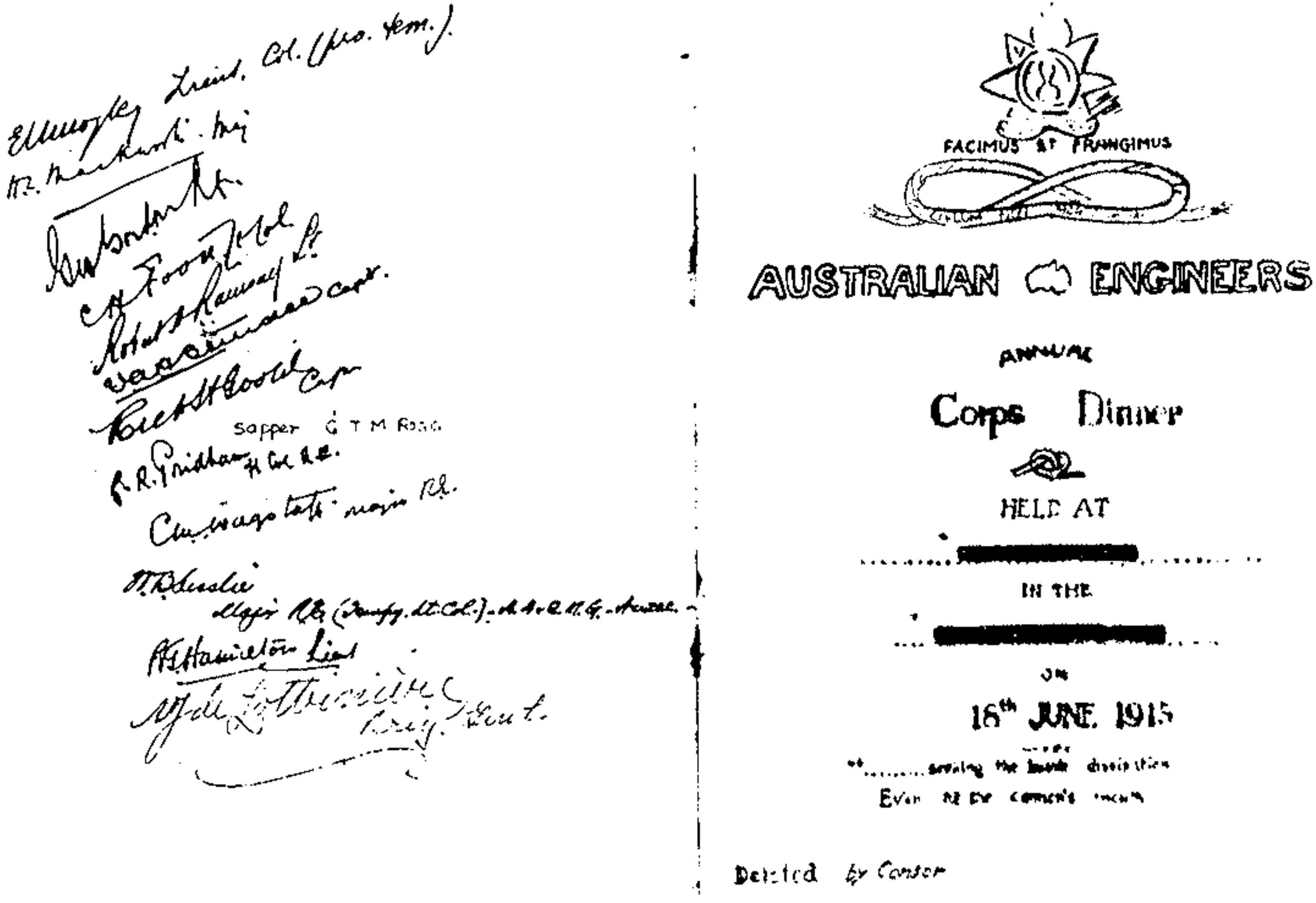
In 1962 Brigadier W. C. D. Veale, CBE, MC, DCM, VD, then Representative Colonel Commandant RAE, when proposing the annual toast to the Corps of Royal Australian Engineers at the Central Command dinner, informed those present of the origin of the custom. Broadly it appears to have been as follows:—

On 18 June 1915, the hundredth anniversary of Waterloo, the Mediterranean Expeditionary Force, including the Australian and New Zealand Army Corps (ANZAC), the 29th British Division and a French division were struggling grimly to expand the beachhead on the Gallipoli Peninsula. No doubt to provide some lighter relief, it was decided to hold a dinner in the Chief Engineer's Mess of the ANZAC Corps to celebrate the Battle of Waterloo. It may be that there were other similar functions held elsewhere. A reproduction of a signed Menu card for that occasion accompanies this article. The Menu was drawn by Sapper Gilbert T. M. Roach, a South Australian artist of high repute. It records what might be regarded as a multi-course meal; in fact it consisted of bully-beef and biscuits. Of the officers signing the Menu five were Australian, five were from the Home Country and two were Canadians commissioned from The Royal Military College, Kingston, into the Royal Engineers. Details of the officers are as follows:—

Major (temporary Lieut-Colonel) E. N. Mozley, RE, Professor of Military Engineering, Royal Military College, Kingston, Canada, 1904–1909, Housing Commissioner for South Western Counties of England under Ministry of Health 1919–1921. Major H. L. Mackworth, DSO, Signal Company, RE, later Colonel, awarded CMG 1918, transferred to Royal Signals 1920, Chief Signal Officer, British Troops Egypt 1924–1927. Lieutenant G. M. Gordon, RE, retired with rank of Captain, 1920. Lieut-Colonel C. H. Foot, AA & QMG Branch, AIF, later Brigadier-General, CB, CMG. Lieutenant Robert A. Ramsay, Automobile Corps, Australian Imperial Forces, later became Major. Captain (Adjutant) V. A. H. Sturdee, RAE, later Lieut-General Sir Vernon Sturdee, CB, CBE, DSO, Chief of the General Staff, Australian Military Forces. Lieutenant (honorary Captain) R. H. Goold, RAE, later Major. Major (temporary Lieut-Colonel) G. R. Pridham, RE, later Colonel, CBE, DSO, Chief Engineer, British Troops Egypt 1925–1927, President RE Board 1927–1929. Major C. M. Wagstaff, RE, later Major-General, CB, CMG, CIE, DSO, in 1916 GSO II 5th Australian Division—1917 Head of British Mission at HQ USA Expeditionary Force in France, Commander, Nowshera Brigade on NW Frontier of India, Commandant, Royal Military Academy, Woolwich, 1930. Lieutenant R. G. Hamilton, Signal Company, RAE, later Lieut-Colonel, MC. Major (temporary Lieut-Colonel) W. B. Lesslie, RE, later Brigadier-General, CB, CMG. Born in Canada 1868, educated at the Royal Military College, Kingston, AA & QMG ANZAC Corps, and Military Landing Officer at the Gallipoli Landings, became Chief Engineer II ANZAC Corps. In January 1917 took over command of the 1st Australian Infantry Brigade in France and in June 1918 he was given command of the 190th Brigade 63rd (Royal Naval) Division. Head of Military Mission sent to Mished—commanded the Royal Bombay Sappers and Miners. Finally commanded 155 (East Scottish) Infantry Brigade (TA). Brigadier-General (later Major-General) The Hon A. C. Joly de Lotbinière, CB, CSI, CIE, RE. Born in Canada 1862, educated Royal Military College, Kingston. Served in India before the First World War. Designed and constructed the Canvery Hydro Electric scheme, the first hydro-electric transmission power scheme in the East and, at that time, the longest power transmission line in the world, Chief Engineer, Kashmir State Public Works 1906, Chief Engineer and Secretary PWD Bengal, and Member of Legislative Council 1911, Chief Engineer, ANZAC Corps 1914–1918. Chief Engineer, Eastern Command 1918–1919.

For the Corps of Royal Australian Engineers, Reunion Dinners, following a custom initiated during the Gallipoli Campaign, are especially appropriate since that was the first occasion on which a formed body of Australian Engineers served outside Australia. Indeed, because this was the first campaign in which an Australian Force of divisional size saw active service, the Australian Nation observes Anzac Day, the anniversary of the landing at Gallipoli on 25 April 1915, as a Day of Remembrance for the fallen of all wars in which Australians have participated. These include the China, Sudan, Boer Wars, both World Wars, Korea and Malaya.

In some ways the cessation of the need for speakers at RAE Waterloo Dinners to endeavour to explain the existence of a major connexion between the Royal Engineers and the famous battle is a loss. Many involved and ingenious speeches have been made on the subject. Late in the evening frequently they have sounded most convincing.


FACIMUS ET FRANGIMUS
AUSTRALIAN ENGINEERS
ANNUAL
Corps Dinner
HELD AT
[redacted]
IN THE
[redacted]
ON
16th JUNE 1915
Deleted by Censor
Sapper G T M Ross

MENU

Wine list to starboard

Hors de Combat

Consommé d'Autriche (a)
Potage Allemande (a)

Huitres au Naturel (b)
("The sea hath its Pearls")

Poisson

Saumon en fer Blanc
Poissons d'Avril (25me)
("'Tis all one", says the Sapper")

Piéce de Resistance Fort

Dinde (tres Roti)
Bœuf Geleé d'Australie

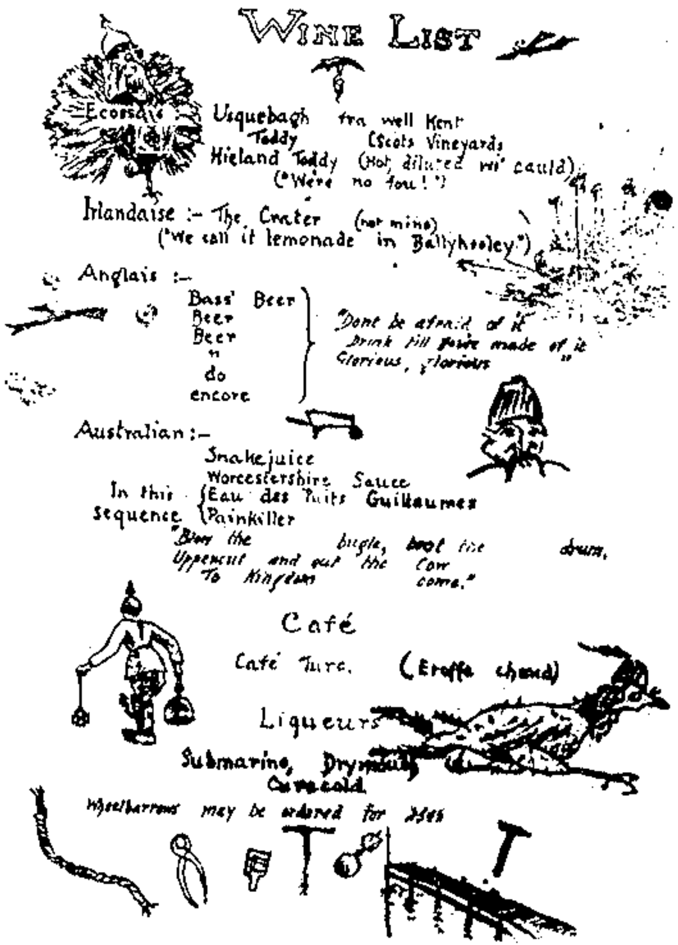
Ponch Romaine (c)
a la Bersaglieri
("All the excitement of war and only 25 per cent of the danger")

Charlotte Russe

Bombes Sapeurs
Torpilles Genie
Obus Varies

Bomb - Bomb - bumb - Bey

(a) More in it than ever
(b) Very much on the shell
(c) Demain, demain, toujours demain.



WINE LIST

Ecossais

Usquebagh fra well Kent
Toddy (Scots Vineyards)
Hieland Toddy (Hot, diluted wi' cauld)
("We're no fou!")

Irlandaise :- The Crater (not mine)
("We call it lemonade in Ballyhooley")

Anglais :-

Bass' Beer
Beer
Beer
"
do
encore

"Don't be afraid of it
Drink till you're made of it
Glorious, glorious"

Australian :-

Snakejuice
Worcestershire Sauce

In this sequence
Eau des Puits Guillaumes
Painkiller

"Blow the bugle, beat the drum,
Uppercut and out the Kingdom Come."

Café

Café Turc. (Etoffe chaud)

Liqueurs

Submarine, Drymouth
Curacold

Wheelbarrows may be ordered for

The King's German Legion

In May 1803, due to Napoleon's persistent flouting of the terms of the Treaty of Amiens signed two years earlier, Great Britain and other continental powers declared war against France.

To increase the officer strength of the Royal Engineers a King's German Legion was raised in 1804. In all thirteen officers were commissioned. They were examined as to their professional qualifications by the Professors of the Royal Military Academy, Woolwich. On commissioning they were placed under orders of the senior Royal Engineer officer at the stations to which they were posted. They received the same rates of pay and allowances as Royal Engineer officers and were assimilated into the Corps.

After being employed on the construction of anti-invasion fortifications and Martello Towers along the South Coast, a few gained their first active service experience at Copenhagen in 1807. Subsequently two served throughout the Peninsular War 1808–1814, taking part in the sieges of Badajos and Cuidad Rodrigo; others served in the ill-fated Walcharen Expedition of 1809, in the Mediterranean and in Canada and wherever else the fortune of war took them. After Napoleon's final defeat at the Battle of Waterloo, 18 June 1815, the Legion was disbanded on 16 December 1815. The officers were repatriated to Hanover where they received a gratuity and were placed on half-pay. Captains Frederick de Gangreben and John Luttermann, however, who were serving in Canada and in Genoa respectively, were not repatriated to Germany until July 1816.

To commemorate this eleven-years' incorporation of German military engineers into the Corps of Royal Engineers Brigadier-General Möller-Döling, Chief of Engineers, German Army presented a water colour picture of an officer of the King's German Legion to the Royal School of Military Engineering when he visited Chatham in December 1963 together with Colonel Langenstrass, Commandant of the German Engineer School. A reproduction of the picture accompanies this article.

Hannover ~ Ingenieur-Offizier 1808
» The King's German Legion «

Correspondence

Colonel A. J. Kerry, OBE, late RCE,
The Old Town House,
Park Street,
Woodstock, Oxford.
23 December 1963.

The Editor,
RE Journal.

TUNNELLING IN GIBRALTAR

Dear Sir,

This is probably an unnecessary letter but I think that one or two points in the historical part of Major Lauder's article, "Tunnelling in Gibraltar", published in the December 1963 *Journal*, could do with a little expansion so far as the Canadian participation is concerned.

The first detachment (4 officers and 99 ORs, together with 217 cases of special equipment) from 1 Cdn Tun Coy arrived in Gibraltar on 26 November 1940. The last details from this group only returned to England on 7 October 1941. These men were nearly all diamond drillers.

2 Cdn Tun Coy (some 225–250 all ranks) was then formed and sent to Gibraltar, arriving on 10 March 1941. This unit consisted mainly of hard-rock miners, again a trade not very common in the UK. It returned to the UK on 25 December 1942.

The detail of work done by these men is rather lengthy for this letter—it will all appear in Vol II of the *RCE Corps History* in due course—so I shall only note here that the rate of work rose to about 4 tons per man per shift. With regard to the record of 180 ft quoted in the footnote, this was apparently a 6 ft × 6 ft tunnel made by a gang of 70 men frm 180 Tun Coy RE in one working week, estimated at 20 cu ft per man per day. Shortly before this, in mid-March 1942, a section of 30 men from 2 Cdn Tun Coy had put in 152 ft of 8 ft × 8 ft tunnel in the same time, about 50 cu ft per man per day. All ranks who served in the Rock were given the "Gibraltar Key".

A further small detachment (1 + 26) from 1 Cdn Tun Coy was at Gibraltar from 27 January 1942 to 19 February 1943. This may be the one referred to by Major Lauder. They were "hydraulic" specialists, sent to wash down the scree and boulders at the foot of the North face of the Rock so that it could be broken up and used as fill on the runway extension.

Yours faithfully,

(Sgd) A. J. Kerry.

Brigadier A. J. le G. Jacob, MBE Brigadier E (Q Services)
The War Office,
Whitehall, London SW1
7 January 1964

The Editor,
RE Journal.

THE UNCONVENTIONAL SAPPER

Dear Sir,

Lieut-Colonel Wilson has given me great pleasure with the arguments expressed in his article in the December 1963 issue of the *Journal* in favour of training for Cold War tasks but perhaps the light should shine even more clearly on the way ahead.

(*a*) Cold war is the Army's top priority with only the proviso that its deployment should be such as to enhance the deterrent.

(*b*) Because one is fighting in a primitive country does not mean one should use primitive methods of engineering, on the contary one is inevitably outnumbered and the main advantage possessed is the knowledge of the latest engineering techniques which conserve manpower. Therefore, it is not just a few specially trained units that are wanted but the brains of the whole Corps behind each unit that has the great opportunity to prove itself in "peace".

I would like to take this chance to add a few more aspects of this realistic training for war.

(*c*) RE Intelligence. Some of us were lucky enough to be given assignments before the last war, which were strictly behind the curtain. (This certainly turned me from an undergraduate into a military engineer.)

(*d*) Planning of such operations as Lieut-Colonel Wilson envisages is one of the best forms of training for the Corps—meticulous attention to detail and imagination saves lives.

(*e*) The Corps is desperately conventional when it comes to equipment, and quite forgets its tremendous workshop production capacity.

If you want something in the middle of nowhere make it yourselves. It is the skill to utilize any old junk that you find that must be rediscovered. Of course get it in by air or water if you can: if necessary build yourselves a sledge or an ACV and drag it in.

Yours faithfully,
(Sgd) A. J. le G. Jacob.

Colonel R. C. Gabriel,
Headquarters,
1 Transportation Group RE
Beavers Lane Camp,
Hounslow, Middlesex.
9 January 1964.

The Editor,
RE Journal.

THE CORPS IN A CHANGING WORLD

Dear Sir,

May I be permitted to make a few comments on Lieut-Colonel McCutcheon's interesting and certainly very provocative article in your December number. These are on the Transportation paragraphs, the contents of which indicate to me a "Suez Complex" in the author's mind (referring of course to the Musketeer operation mainly in the Port Said area).

Inland Water Transport

What rot! How about the operations now in progress in Borneo? The much despised inland water transport shares with helicopters the distinction of being the only way to reach certain areas and personnel of a Port Squadron RE are doing a fine job there with their RPLs and other craft. Nor are they "alongside RASC water transport units".

IWT units as such of course do not exist now, for Lighterage ones have taken their place. RE personnel of these carry out important work at many places overseas besides the Far East including Cyprus and Aden. At the latter, for instance, would the writer really care for our Corps to surrender the job of operating the Unifiote Raft Set there? The inference is that he would like the Royal Navy or an Inter-Service Transportation Corps to take this on (and perhaps other rafting too! Why ever not? Lighterage after all is only a means of crossing a particular water gap).

Port Operating

The first sentence is far too sweeping, and in it the word "never" is wrong in my opinion; "seldom" would be preferable. Although in general I support the idea that unloading a ship is largely "field works afloat" and much of it can be improvized, it is not entirely so, particularly when awkward or superheavy lifts are involved. Admittedly these are not frequently met, but in any case their handling is not something all senior NCOs and some officers of our corps can master on a short course of training. I am well aware that on several occasions non-specialist units have been used with considerable success but under Transportation supervision or the equivalent. Loading a ship however (at a mounting base for instance) undoubtedly calls for much more skill and experience.

I cannot agree that port operating is a logical commitment for the Royal Navy, and am reasonably certain that they do not either!

With the introduction of LSL's and other roll-on-off shipping, port operating techniques are obviously going to change. Already an increasing number of ocean-going ships are fitted with electric cranes instead of derricks; is it "logical" for the Royal Navy to operate them? Surely not.

Railway Transport

In general war there are certain tasks in north-west Europe outside the scope of the host nation responsibility, while in some other parts of the world in any sort of war the host nation may physically be unable to carry out some of the necessary tasks *within the time-scale required.* Even a few specialists could make a very measurable impact and dividends would I feel be clearly perceptible.

The assertions about likely requirements for cold and limited war operations are not true. Suez (Op Musketeer) posed an unusual and very simple railway problem and there were sizeable engineer forces in the field that included of course a large proportion of NS men some of whom would have railway experience. As regards the training, British Railways have declined to give it and in any case military techniques are not identical with those employed every day on British Railways. We might as well get all rafting taught by the Woolwich Free Ferry authorities!

I agree with him, however, that RE manpower is possibly being used somewhat uneconomically for these tasks and would therefore urge some reorganization to give the maximum flexibility and interchangeability between RE units. Let the "Wind of Change" blow but do not let Transportation be swept away in the gale! (It has probably happened already!)

Yours faithfully,

(Sgd) R. C. Gabriel.

Memoirs

MAJOR-GENERAL A. V. ANDERSON, CB, CMG, MBE

Alexander Vass Anderson was born on 17 November 1895, the son of Lieut-Colonel Alexander Vass Anderson of Stonehaven in Scotland. He was educated at Stonehaven and the RMA Woolwich, and commissioned in the Royal Engineers in August 1914.

After a shortened course at Chatham he was posted in May 1915 to France, joining 14 Signal Company RE. He was promoted to Temporary Captain in February 1916, was mentioned in despatches a year later and transferred to 19 Corps Signal Company early in 1917. At the end of 1918 he left France to serve at the Signal Service Training Centre and in September 1919 he returned to Chatham to complete his courses at the SME.

Early in 1921 he was posted to India and joined the 2nd QVO (Madras) Sappers and Miners at Bangalore in which Corps he was to carve out a most distinguished career. Soon after joining his unit trouble broke out on the Malabar Coast where the Moplahs rebelled against British authority, and in August 1921 one platoon of 9 Field Company left Bangalore with an expeditionary force sent to the Malabar Coast for operations against the rebels. The remainder of the Company followed in October under the command of Captain Anderson. The company greatly distinguished itself and after its return to Bangalore in January 1922 the GOC Madras District issued the following Order of the Day: "Please convey my thanks to Captain Anderson and all ranks of No 9 Field Company for their services in Malabar. If it were possible for me to form a higher opinion of the efficiency of the Madras Sappers and Miners than I already hold, the work of this Company would have had that effect. They have worthily upheld the reputation of the Corps." For his services Anderson was awarded the MBE.

Anderson remained with 9 Field Company until March 1924 when he was made Adjutant at Bangalore, and he held that coveted appointment until he was given command of 12 Field Company at the end of 1927. A year later his unit was posted to Mandalay where he spent two years before passing into the Staff College, Camberley. After graduating from there he returned to Bangalore as Superintendent of Instruction. For a few months in 1933 he officiated in a GSO 2 appointment at Army Headquarters, Simla, and in February 1934 he was made DAAG at Army Headquarters. In the summer of 1937 he officiated as AAG (Mobilization and Recruiting) and in October 1937 he was appointed Commandant of the QVO Madras Sappers and Miners at Bangalore, soon after his promotion to Lieut-Colonel, a worthy reward for his long and outstanding service with the Madras Sappers.

Soon after the outbreak of the Second World War he was promoted Colonel and became AQMG, North West Frontier Expeditionary Force (India) for a few weeks before returning to the UK to become AQMG Home Forces. In October 1940 he was appointed Colonel i/c Administration, Home Forces and then in April 1942, on becoming a Brigadier, he was made DA and QMG Home Forces. In December 1942 he was sent to Washington, DC as DQMG British Army Staff in the USA with the rank of Major-General. He left that appointment in Agust 1944 for employment at the War Office. In

Major-General AV Anderson CB CMG MBE

1945 he was MGA, Western Command and in 1946 became Director of Civil Affairs at the War Office. He retired in June 1949.

For his war services he was created CB in 1945. He was also made a Commander Legion of Merit USA and he received the Dutch decoration of Orange and Nassau. In 1949 he was created CMG for his work in Civil Affairs.

He married twice, firstly in 1918 Estelle Bell, only daughter of George Gasson Esq, of Queenstown and East London, South Africa; they had four sons. His second marriage in 1935 was to Aileen Elizabeth, daughter of Stanley Stevenson Esq of Edinburgh and widow of Major T. J. Barnes, sometime 64th Pioneers; there was one daughter.

After retirement Major-General Anderson lived in Jersey. He was almost an invalid for many years and he died on 17 October 1963, aged 67 years.

Many tributes have been paid to him by former officers who served with him in the QVO Madras Sappers and Miners; among them are the following:

"I still have vivid memories of the zeal and enthusiasm with which AVA played rugger in Madras in the 'twenties' for the Army against the Planters and his tremendous energy and good company after the game".

"I joined at Bangalore when Andy was Adjutant and not only then, but also during his later terms as Superintendent of Instruction and as Commandant, I received always the greatest help and encouragement from him. One could so readily take one's problems to Andy and be sure not only of a patient and a serious hearing but also of a solution which one entirely agreed with and felt no resentment at nor inclination to argue over. In official, as well as in personal, relations one was immediately struck by Andy's grasp of the problem and knowledge of the subject and the infinite patience with which he reviewed every aspect of it that was puzzling you and you left with the contentment of mind that goes with a difficulty overcome and a clear course seen ahead."

A former Adjutant writes:

"Andy took over command of the QVO Madras Sappers and Miners in October 1937 from an outstanding Commandant, Edward Bradney. As is often the case, the prospect of a new CO was viewed with slight apprehension, but we need not have worried. His quiet authority, his calm competence and his obvious fairness soon won him the respect and loyalty which had so recently been shown in such large measure to his predecessor. He was a master of detail and yet he had vision. Like Bradney, he had a remarkably clear brain, and a flair for recognizing the essentials of any problem. He was hospitable and kindly, but somewhat reserved. It, therefore, took time for the respect and liking one felt for him to become real affection. One could not wish for a better CO."

Other tributes were:—

"I thought he had all the makings of a first class staff officer. I remember on one occasion I asked him to draft a letter to AHQ in connexion with the Madras Sappers 150th Anniversary, he was then S of I. He produced a really first class draft—a small matter I suppose but it made a great impression on me at the time, there is no doubt that he was a very able man indeed."

"I remember Andy as very efficient, and very helpful and kind, both as Adjutant and as Commandant. It undoubtedly fell to him to have the Madras Sapper Mobilization Schemes in working order for 1939; I can remember him telling us just pre-1939 that our Unit Mob Schemes had ceased to be 'academic exercises' and had become realities which would undoubtedly have to be put into effect some day. I also recollect his doing a long recruiting tour during his Adjutancy, whereby he must have increased his knowledge and understanding of the Madras Sapper."

BRIGADIER C. L. B. DUKE, CB, MC*

Cecil Leonard Basil (Bulger) Duke was born on 27 November 1896, the son of Lieut-Colonel A. L. Duke, IMS, of Arbroath, Scotland. He was educated at Edinburgh Academy and the RMA Woolwich and commissioned into the Corps on 22 April 1915.

After completing a War-time Course at Chatham he was posted to the Western Front on 7 October 1915, shortly before his nineteenth birthday. He joined 70th Field Company and whilst serving with that unit he was twice wounded and awarded the MC. In March 1918 he became Adjutant to the CRE 51st Division. The following month the Germans launched their last great offensive. On 12 April German Forces broke through the centre of the 51st Division front. A composite force of about 1,700 strong, made up of reinforcements, machine gunners, Canadian Railway Units and two Gas Companies RE, were placed under command of the CRE with the title "Fleming's Force". This force took over the defence of the village of Robecq which was then at the apex of the German salient on the River Lys. For gallantry in that action Duke received a bar to his MC.

In January 1919 he returned home to complete a Supplementary Course at Chatham at the conclusion of which he was posted to India where he was to spend the next seven years. In 1922 he was given command of the 4th Field Company, KGO Bengal Sappers and Miners and he held that appointment until 1928. During that time his Company was engaged on road and bridge building in Waziristan and the construction of training camps near Peshawar.

On returning home Duke served in the Depot Battation at Chatham until being selected as Adjutant of the Training Battalion RE in January 1930. A year later he passed into the Staff College, Camberley. After graduating from there he served for a short while in a Works Appointment as DCRE Edinburgh before returning in 1934 to the Bengal Sappers and Miners at Roorkee as Superintendent of Instruction where he spent the next two years. His first staff appointment was as DAQMG at Meerut District. In July 1938—then a brevet lieut-colonel—he became Commandant of the Bengal Sappers and Miners Training Battalion at Roorkee. The following year he attended the Senior Officers' School at Belgaun and returned home on leave at the end of the course.

Duke was in the United Kingdom on leave on the outbreak of the Second World War, and he was appointed AA and QMG of 61st Division, a second-line Territorial Division commanded by Major-General Carton de Wiart. When the latter was sent to Norway Duke joined him. In his book *Happy Odyssey* General Carton de Wiart wrote: "One addition to my staff had given me the greatest pleasure, an officer who had been my AA and QMG in the 61st Division, Colonel C. L. Duke. With his unfailing energy and

Brigadier CLB Duke CB MC

knowledge he managed to put a lot of order into chaos, and if I were asked who was the best officer I had ever had under me, I should answer Bulger Duke. After Norway I helped him to get a command of an Infantry Brigade; he was captured at Singapore and all his energies wasted for five years in a Jap prison."

In October 1940 he was made a Brigadier and given command of 53rd Infantry Brigade. After a period of training at home his brigade was embarked for the Far East and after an eleven-week voyage in a crowded troopship landed at Singapore at a time when the Japanese were advancing rapidly southward through the Malay Peninsula. Three days after landing the Brigade was ordered to move to Ayer Hitan which was reached on 17 January 1942. The troops were unacclimatized, soft from their long sea voyage and inexperienced in jungle fighting. Communications were poor and information about the enemy and our own forces was scanty and often inaccurate. Duke's brigade suffered heavy casualties in the Bickit Pelandok defile which, after being lost, could not be recaptured. As part of a hastily organized "West Force" the brigade retreated, and on 26 January, Duke's column was caught by a Japanese ambush north of Rengit and badly mauled. By 8 February 53rd and 28th Brigades occupied defensive positions between Sungei Seleter and the Causeway leading to Singapore. On 12 February Duke's brigade successfully repulsed a Japanese attack knocking out three Japanese tanks, but the following day the brigade was withdrawn to the perimeter defences. On 15 February 1942 Singapore capitulated. Then followed a period of long, gruesome and gruelling years as prisoner of war in Japanese hands.

After a period of leave following his release from captivity in July 1945 Duke was appointed as an AQMG at the War Office, and in June 1946 he was given another Brigadiers' appointment as BGS Burma Command, to be followed by that of Commander, South Malaya Sub-District.

On returning home once more he was made BGS at Eastern Command and a year later he was appointed Commander Mombassa Sub-Area where the vast Mackinnon Road construction works were being carried out. He was awarded the CB in 1951. He retired in August 1952 and settled in Kenya near Thomson's Falls.

He never married. He died in Kenya on 4 November 1962.

Bulger Duke was renowned for his boundless energy. On the playing field, on training and on the field of battle he always gave his utmost. He was a splendid Sapper officer, an ideal Bengal Sapper and Miner and a great commander of men. He inspired enthusiasm. Serving with, or under, him could never be dull. If he had not had the misfortune to be made a prisoner at Singapore, he must surely have made his mark as a great commander in the field.

W.L.D.V. writes:—

The earliest recollection of some of Bulger Duke's school friends is of an aggressive stocky forward, whose red hair showed up strongly against the white scrum cap which he always wore. Seventeen years later as Adjutant at Chatham he was still fit enough to play rugger as hard as he worked.

Throughout his life, however, Bulger's heart was in the India he knew and liked so much. On arrival in 1922 his first posting was to the Pathan Field Company of the Bengal Sappers and Miners and mutual trust and admiration of officer and men grew rapidly. His early short leaves were often spent in the old North West Frontier Provinces near the villages from which his recruits came, and he became known to and respected by old and young. His grasp of detail was immense, and the complicated ramifications of tribal and village quarrels were plain sailing for him. His popularity with his Pathan soldiers was probably because they knew that he stood absolutely no nonsense from them, and although he was impetuous he was very fair at all times and never went too far.

In later life he several times said how much he regretted returning to England in 1929, but in 1934 he returned to India and Roorkee. Wherever he went he left his mark, and Chief Instructor of Fieldworks was not to be an exception. In spite of the financial difficulties of the 'thirties he managed to have built from training resources a bridging pit combined with a swimming pool, which were badly needed and which were still used in 1947. Another of his major works in this period was the writing in roman-urdu of a loose-leaf pocket-book on field engineering for use of Indian NCOs—it was so useful that few British officers failed to have it with them always. It was periodically brought up to date and was in constant demand throughout World War II by all units of the RIE. To Bulger's immense amusement, when he visited the Pakistan Engineers in 1954, he found that a modern and greatly revised edition was still in daily use.

During his period as DAQMG of Meerut District in Dehra Dun in the mid-thirities he lived with the 2nd Gurkhas, and from his delight in their glorious Mess garden began his love of flowers and shrubs which was to be one of his major interests in later life. Fly fishing for small mahseer in the Song river, and for heavier fish in the Ganges, also became his relaxations from very heavy staff duties. There his organizing ability and driving energy were soon felt by all, and problems which had pended for years were solved to everyone's, or nearly everyone's, satisfaction.

In July 1938 he returned to command the Training Battalion in Roorkee and during that cold weather he also commanded the Bengal Sappers and Miners during the absence of the Commandant on prolonged sick leave. By now it was clear that war was inevitable, and Bulger prepared in careful detail an expansion plan which later proved invaluable and saved many mistakes which would have been inevitable without his wise forethought. Life for Bulger was, however, never all work and no play and he found time for shooting at weekends and golf on many evenings. The Roorkee Golf Course took on a new lease of life with small pumps at every "brown" to convert them to "greens". The duck, partridge and jungle fowl were also harried by Bulger, whose large American convertible was made to go everywhere or stick fast in the attempt. Improvements to the Mess garden and the planting of flowering trees and shrubs along the Cantonment roads also bore witness to Bulger's enthusiams. It was indeed a sad day when his final posting orders to England arrived.

His earlier war experiences were described in an enthralling letter (unfortunately now lost) which was received towards the end of 1940. In it he gave a racey account of his experiences in Norway on General Carton de Wiart's staff and described his final arrival in England in the third destroyer he had boarded, the first two having gone down. The General's own book shows how highly he thought of Bulger.

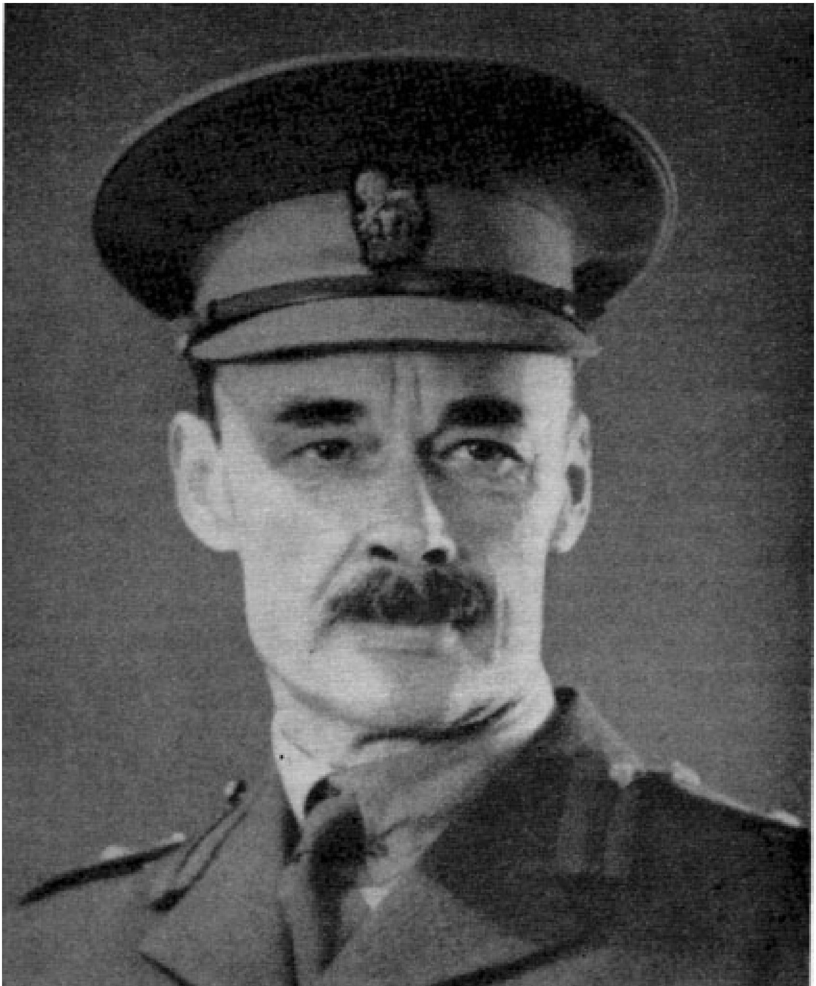
In 1954 Bulger flew from retirement in Kenya to Pakistan to be present at the first Reunion of the Pakistan Engineers in Risalpur. Here he met again many old Roorkee friends, and was greeted with delight by pensioned and serving officers. In order to meet the many Pathans who had not been able to come to the Reunion, he went after it was over to the larger villages and his popularity was a joy to see. It certainly repaid him for the long journey from Kenya. Energetic as always, he then demanded to be taken to visit the recruiting areas in the Punjab in addition to as many units as he could find time to visit. These meetings were universally popular and in later trips to Pakistan it was always about Duke that enquiries were made of the writer. His whereabouts, health, and the date of his next visit were enquired into with genuine interest and affection. His sudden death is mourned in many villages and homes far from Kenya and Scotland.

COLONEL M. EVERETT, DSO

Maxwell Everett was commissioned into the Corps on 20 December 1906 from the Royal Military Academy, Woolwich where he was awarded the Sword of Honour.

He was posted to India in 1909 after completing his Young Officer training at Chatham and he served there in a number of works appointments up to the outbreak of the First World War.

He was on leave in England when war was declared and in November 1914 he joined 20th Field Company, 3rd (later Royal) Bombay Sappers and Miners which formed part of the Indian Expeditionary Force sent in to France. He later joined 21st Field Company, Bombay Sappers and Miners and accompanied the unit when it left the Western Front for the Middle East towards the end of 1915. The Company then joined Lieut-General Sir George Gorringe's Tigris Corps and took part in the abortive effort to relieve General Townsend's forces besieged in Kut el Amara. After the surrender of Kut in April 1916, Everett assumed command of 21st Field Company with the acting rank of major. His Company was employed mostly on water-supply duties in General Maude's subsequent advance on Baghdad. In April 1918 the 3rd Indian Division, of which the 21st Field Company formed a part, was moved to Egypt to take part in General Allenby's Palestine offensive. The plan was to advance on two axis—one on the East side of the Jordan Valley and the other along the coastal plain of Palestine and Syria. The 3rd Indian Division was equipped on a pack-transport basis and crossed the mountains of Samaria in order to cut off retreating Turkish forces. Damascus fell in early October 1918 and mounted and motorized troops reached Aleppo, 120 miles distant, on 26 October. The Turks then sought an Armistice which became effective on 31 October 1918. In this five weeks' campaign the Egyptian Expeditionary Force, at a cost of just under 6,000 casualties, destroyed the Turkish Armies in the Levant and took over 75,000 prisoners. The Sappers' contribution to this victory in maintaining the mobility of Allenby's troops and supplying the enormous quantities of water



Colonel M Everett DSO

required each day by his mounted formations was vital. For his wartime services Everett was awarded the DSO in 1917, mentioned in despatches in 1916, 1917, and 1918 and made a brevet major in June 1918. He was also awarded the Medal of Solidaridad and the Order of the White Eagle.

Everett stayed with his Field Company in the Middle East for almost two years after the cessation of hostilities and it was not until the end of 1920 that the unit was repatriated to India. After a short stay at Kirkee the Company was moved to the North West Frontier and Everett remained in command until 1923 when he was made CRE of the Makin Column engaged in punitive operations against the Mohands in Waziristan. At the conclusion of these operations he entered the Staff College, Quetta, from where he graduated in 1924.

On returning to England he was employed for a short while as Divisional Officer, North Wales before being selected to attend the Royal Naval Staff College, Greenwich. From there he was posted to Sierra Leone as Brigade Major and after a two-year tour of duty he returned to England to become DCRE West Hampshire. He then held the appointment of Brigade Major SME from March 1929 until September 1931.

He returned once again to India after completing his tour at Chatham and, having served for a short while as Garrison Engineer at Poona, he was appointed Superintendent of Instruction to the Royal Bombay Sappers and Miners at Kirkee. In December 1932 he became Commandant at Kirkee and held that appointment until his promotion to Colonel in March 1935. During his time as Commandant an attempt on his life was made by a Lance Nike because of a grievance which he and other Jat Sikhs had over accepting Nazbi (low caste) Sikhs from the disbanded Sikh Pioneers into the Royal Bombay Sappers and Miners. A bullet intended for Everett struck R. L. Thompson at close range who, quite miraculously, escaped with his life.

On promotion to Colonel, Everett reverted to the home establishment and in January 1936 he was sent to Baghdad as a Senior Instructor at the Staff School for the Iraq Army. The following year he became Inspector of Army Training in Iraq and he held that appointment until his retirement in January 1939.

On the outbreak of the Second World War he was recalled for service as GSO I 50th (Northumbrian) Division with which formation he served in North West Europe and returned to the United Kingdom by way of the beaches of Dunkirk. He was invalided out of the service in July 1940 but he returned in a non-combatant role first as a Senior Umpire to V Corps and then as Chief Umpire at VIII Corps Headquarters. He finally retired in 1942 and became Regional Officer at 6 Regional Headquarters, Civil Defence. After the war he went to live near Newbury where he worked two acres of garden and was Church Warden at the local church. In 1954 he moved to Church Stretton, where, due to failing health, he was unable to take part in local activities. He died on 17 October 1963, aged 76 years.

In April 1928 he married Violet Philbrick of Clare House School, Beckenham, who survives him. They had two daughters. The elder became a 2nd officer in the WRNS and married a Naval Commander, the younger became a trained nurse and married an Irish farmer living near Belfast—they have three young children.

LIEUT-COLONEL LLEWELYN EVANS, CMG, DSO

LLEWELYN EVANS left a broad and deep mark where he worked, of lasting value to his country, and died, little known, at his home in Wiltshire on December 16.

It was he who, as a captain of Royal Engineers at Aldershot in the first decade of the century, developed wireless telegraphy in the Army from an experiment in applied science, of which the principles were but half revealed, into a practicable means of communication in the field, and launched it on its course from its first faltering steps to its present confident stride. He brought to the task an unusual combination of theoretical knowledge, practical ability and imagination. He lived partly in the academic world of science, while, like any other regimental officer, his first duty was to his commander and the men and horses under his care. All this he compassed in his easy, competent way. From Aldershot he was sent to India, where he set up a country-wide chain of wireless stations, for internal security, an unheard-of development in those days, and did preparatory work for the future Empire wireless chain.

It was here, as a pioneer of military wireless communication, that lay his first great service. His second was of even wider significance, for after the 1914–18 War it was mainly his advice and influence, and his clear vision of future needs, that led to the creation of a Signals branch at the War Office under the Director of Staff Duties, which later grew into a General Staff Directorate of Signals in its own right. Here he was able to lay the foundations for the future organization of Signals in the armies of Empire and Commonwealth, their relations with commanders and staffs, and their status as a combatant corps.

The milestones of his life are briefly summed up. His father was the Rev H. J. Evans. He was born in June 1879, educated at Charterhouse and the Royal Military Academy, Woolwich, and commissioned into the Royal Engineers in June 1898. He fought in the South African War from 1900 to 1902 and throughout the Great War in France, where he gained the DSO, the CMG, and a brevet lieutenant-colonelcy. He retired in 1920 and was recalled to the active list on the staff of the Inspector of Signals in the Second World War.

In 1920 he married Margaret, daughter of Lieut-General Sir Arthur Sloggett, and there are four sons of the marriage. For long years he served on the board of Creeds.

He had style. He was tall, rangy and powerful, with dark Mephistophelian good looks and a sardonic humour, which concealed great kindness. He was an accomplished and bold horseman, an able yachtsman, a widely read man, and a water colour artist of rare amateur quality. All in all, he was the distinguished product of a great period.

(Reprinted from *The Times* of 3 January 1964, RC-T)

Book Reviews

THE SWORD-BEARERS

By Correlli Barnett

(Published by Messrs Eyre & Spottiswoode, 1963. Price 35*s*)

In *The Sword-bearers* Mr Correlli Barnett, like other young historians, has focused on the First World War. Fascinated by the influence of military leaders, he gives us most readable vignettes of Moltke the younger, Jellicoe, Petain and Ludendorf, and describes the impact which each of them produced. In the preface of the book he says that he finds it moving "to study these men locked in struggle with events greater than themselves", which puts one in mind of Tolstoi's philosophy in *War and Peace* that a surge of tremendous events is conditioned by forces quite other than the strivings of mere leaders. Events certainly swept away first Moltke and later Ludendorf, whilst Petain was only just able to withstand them. If Jellicoe had lost the battle of Jutland, fate would inevitably have removed him from the scene also. As it fell out, however, he became First Sea Lord and was in office at the time of the unconditional surrender of most of the German Navy. *A propos* of Jutland, Mr Barnett for his part exaggerates too much when he declares, also in the preface, that "Jellicoe had the chance of transforming the war by destroying the German High Sea [*sic*] Fleet". With greater excellence of warship and gun design, the Grand Fleet might have suffered less and destroyed more than it did. But on that fateful afternoon and evening of 31 May 1916, in fitful conditions of sunshine and mist, with the rival fleets, now hotly engaged, now moving leagues apart and changing course round the compass almost with the speed of railway trains, it was idle to expect a British victory of annihilation as was possible in the days of sail. A large percentage of the German warships were bound to escape. When emerging from the mist, Jellicoe's superbly handled ships finally opened fire on the German van about half past six in the evening, Scheer recognized at once that flight was his only refuge and as darkness fell made tracks for Wilhelmshaven. Although the result of Jutland disappointed Britain and her allies, the experience of Scheer and his gallant men during the battle convinced them that the sorely battered German fleet had no future at sea. Nor had it. Mr Barnett, however, considers that if the Navy had been in better shape Jutland could well have been a second Trafalgar. In support of this highly debatable thesis, he declares on page 184 that in 1900 arrogance and ignorance of monstrous dimensions had reduced the Navy to "a decadence hardly matched in any force of modern times, except perhaps by the French Imperial Army of 1870". Such breathtaking nonsense ill becomes a young writer, who claims to be a reputable historian. One might say, just as absurdly, that the Federals were of decadent stock because they did not destroy General Lee's army after winning the battle of Gettysburg or that the decadence of the Roman legions was the prime cause of their defeat at Cannae.

On the same page we read that, also in 1900, "officers were too often recruited by nepotism or influence" a form of co-optation "which induced the characteristics of professional inbreeding to the extent of a Goyaesque fantasy". He also deplores on page 186 "the tragedy that the British aristocracy was flexible and intelligent enough to preserve itself by recruiting from commerce and industry". Since my own brother joined the Navy in 1904 and served in it unaided by influence until his death as a Commodore in the last war, chapter and verse about the alleged element of nepotism would remove doubts and banish surprise. It is also disturbing to find Mr Barnett bewailing the flexibility and intelligence of an integral part of Britain's social structure, which it would have been most difficult to extirpate except by a violent revolution in the manner of Lenin or Hitler. Actually the "hierarchy of birth and class" not only preserved itself, as it always had done, by recruiting able commoners, but also arranged by stringent examination and interview that the Navy got magnificent officers from every source available. Fisher, Jellicoe, and Beatty, who joined the Service at the tender ages of 13, 14, and 12 respectively, came from the middle piece of the British people. They owed nothing to favour in getting ahead of the ruck of their contemporaries in the race for promotion.

It seems as if Mr Barnett is hagridden by the idea of decadence and social disintegration spreading, without respect for frontiers, all over Europe. In his passion he fails to observe that Britain, in spite of the alleged handicaps of tradition, weathered the vicissitudes of 1914–18 far better than the other countries of the Continent and that in 1939–45 her military leaders, far from being decadent, developed a professional skill in the ordering of sea, land and air forces, which conduced much to Britain's victories, as well as to the cementing of the Grand Alliance with the USA.

An old adage, from which during a long life I have often profited, says that a man must beware of failings which are constantly on his lips lest, unbeknownst, they are also his own. Mr Barnett might ponder on it, whenever in his zeal he finds himself becoming contemptuous of the foibles and weaknesses of humanity, since contempt is as evil as jealousy and should find no place in the make-up of a good historian.

The other essays show off the author's talent to better advantage since failure on the other side of the Channel can be borne with more equanimity. In the one about Moltke, the description of the confusion in the German direction of the war is brilliant. In the armoury of weapons for once, no special mention highlights the dominance of the machine-gun, whilst cartridges are quaintly described as bullets. Joffre, alas, is crude, an intellectual pigmy and apt to be thinking unduly of his next meal, all of which is rather hard on the winner of the battle of the Marne. For all that, Joffre had the determination and the rough eloquence which marked him as a generalissimo of far finer clay than his hapless successor of 1939. The study of Petain who, with a touch of genius, nursed back the French Army from mutiny to discipline is perhaps the best of the four. How he lacked the continuing ferocity of a true Fabius Maximus is well portrayed. A curiosity about Ludendorf, who first tumbled to the highly successful tactic of attacking the "soft spot" is that when in 1918 he had to tackle strategy, he made no strategic use of his new idea but attacked the better of the two armies which confronted him. The German intelligence system seems to have missed the serious mutiny in the French Army almost entirely, which was fortunate for the Allies. Like the "Desert Generals" this book is eminently readable but frequently exasperating.

B.T.W.

WARFARE IN THE ENEMY'S REAR

By Otto Heilbrunn

(Published by George Allen and Unwin Ltd. Price 30*s*)

Dr Heilbrunn has probably undertaken more research on irregular warfare than any other civilian in this country.

In his *Partisan Warfare* published in 1962, he undertook a theoretical study of guerilla and anti-guerilla warfare during and since the Second World War.

In this new book Dr Heilbrunn begins with a survey of war in the enemy's rear since the beginning of the nineteenth century and he rightly concludes that operations in depth, which were almost totally absent in the First World War, have come to stay. He goes on to study unconventional forces. In this category he includes not only Partisans, but Regular Army units, which are specially organized, equipped and trained for what have hitherto been regarded as abnormal tasks. He then deals with what are nowadays regarded as conventional forces which are capable of operating in great depth; regular Airborne troops, Commandos and the contribution of the RAF.

There follows an important examination of the scope and control of operations conducted in different degrees in depth and the inter-relationship there should be between activities on the main battlefront and all other subsidiary activities in the enemy's rear. He examines enemy operations behind our own main battlefront and finally touches on the possible roles of forces acting in the enemy's rear in nuclear warfare.

Dr Heilbrunn has obviously undertaken a stupendous amount of careful reading on this subject. He has assembled a mass of valuable facts and made a number of useful deductions. Unfortunately, his facts are often marshalled illogically; and, as in *Partisan Warfare*, he tends to over-theorize. His writing is often weak; so much so that it is sometimes misleading.

For example, Dr Heilbrunn states (vide page 22) that "on the whole, Clausewitz has added little to the theory of partisan warfare. . . ." He presumably means that since Clausewitz wrote his masterpieces on war over a century ago, little has been added to the theory of this type of warfare.

Tito's partisans fought large-scale engagements in the far rear (*vide* page 28), primarily not in an attempt to conform to any clear pattern of operations which the Allies wanted from them, but for a number of other reasons. These were mainly political and the fact that, in Yugoslavia, there was a large expanse of terrain which was suitable for partisan operations. If the wishes of the Western Allies had not coincided with Tito's political aims at that time, nothing would have induced him or his partisans to act in accordance with their requirements. Not until we reach page 110 of his book, does Dr. Heilbrunn rightly state that one of the factors, on which depends the type of contribution which guerillas may make, is the suitability of the area in which they operate; and (*vide* page 124) that "a belligerent, who wants to employ partisans in a foreign country to form a movement or influence and unify existing movements, will by and large have to accept the movement, including its structure, as he finds it".

On page 202, Dr Heilbrunn reminds us that in the Second World War, airborne forces were generally under-employed in the role for which they were primarily designed. But he omits the two main reasons, firstly, that the number of aircraft available was strictly limited and they were often required for other tasks considered to be of higher priority; and secondly, because of the considerable amount of time it takes to mount an airborne operation on any large scale, in the often fast-moving warfare of the Second World War the opportunity of using airborne forces had sometimes passed before they could be launched.

Apart from such points of detail and weakness in presentation, his only major omission is to deal with operations designed to mislead the enemy, as one of the possible primary roles of forces acting in the enemy's rear. Although in no less than three places he mentions by name Colonel Dudley Clarke in connexion with the use of Commandos, he omits all reference to "deception", in which type of warfare Colonel Dudley Clarke became such an expert during the Second World War. Moreover he describes elsewhere the main role of the Greek partisans as that of harassing the enemy. This was not always so. Immediately prior to the invasion of Sicily, the Greek partisans successfully executed a valuable series of carefully planned and timed operations specifically designed to mislead the enemy into thinking that Greece rather than Sicily was about to be invaded by the Allies. As a result two German Divisions were initially sent from Yugoslavia to Greece rather than to reinforce Sicily.

Lieut-General Hackett's comprehensive and brilliantly presented foreword makes Dr Heilbrunn's work appear amateurish. At the same time it greatly improves the overall value of the book by putting it into correct prospective. As General Hackett says, "it is high time we had a systematic approach to forms of warfare more closely characteristic of the time we live in than almost any others". It cannot be said that this book fully achieves such a purpose. But it goes a long way towards doing so.

E.C.W.M.

MILITANT DON

By Donald Portway

(Published by Robert Hale Ltd. Price 21*s*)

Colonel Donald Portway is an accomplished writer. This new book of his reminiscences is full of interest, humour and humanity. Every Sapper Officer who has been to Cambridge will enjoy reading it. There is, moreover, something of value to be learnt from his exceptionally full life by a far wider field of readers, civilian as well as military, who are concerned with the education, selection and training of men for positions of responsibility and service.

The author describes himself as "a man of little importance", but adds that "history is surely as much concerned with the lives of everyday men and women as with those of the eminent". His description of himself is, of course, over-modest as is shown by the exceptional diversity of his achievements. These include a classical scholarship at Felsted School, fourteen years of famous Proctorship at Cambridge University, "Blues" for swimming and boxing, instructor at Dartmouth, a commander of Royal Engineer troops in both world wars, Master of St Catherine's College, a civilian member of the RE Advisory Board, a member of UNESCO in Korea and Nepal and, at the age of 70, Professor of Mechanical Engineering at Khartoum University.

We read and hear much these days about the Engineering profession not being given the recognition and status it merits. Few men have done more to put that right. Donald Portway was the first Engineer ever to be appointed Master of a College at Cambridge.

Many of us will remember the dubious qualities of some of our teachers at Cambridge. As an undergraduate, I particularly recall one who, at the beginning of every lecture period, with virtually no preliminary remarks, picked up a piece of chalk and started writing on the blackboard. He wrote furiously first on one board and then the other, returning to the previous board and, after obliterating everything on it, continued thus without a check until the end of the lecture period, whilst we did our best to take down in our note books, all that he was writing. On the occasions when he did allow the last few minutes for any questions, most of us were too busy, struggling to catch up with our own transcriptions, to take in the full import of the "lecture", leave alone to ask any intelligent questions. Not until our weekly sessions with our "tutor" were the sailient points unravelled. Colonel Portway has never been a person who holds his punches and I am glad to read his criticism of the selectors of University teachers for sometimes having given too much attention to research rather than teaching ability.

Nowadays I spend a lot of time each spring interviewing undergraduates from many different universities, towards the end of their period of academic studies. Although the Cambridge undergraduates of today undoubtedly have less time for extra-mural studies, hobbies and healthy recreation than their predecessors of thirty years ago, they still fare much better in this respect than undergraduates from the newer and smaller universities, where many often appear to have practically no spare time to devote to the all-important broader aspects of their education. Colonel Portway has something to say on this and on the broader role of Engineers in our national life. ". . . The world is looking more and more to Engineers to provide the means of making life more satisfying, for increasing leisure and the pursuits that leisure brings. We Engineers will be unworthy of ourselves if we do nothing to meet this challenge, and the answer is education—and that includes something more than mere technology. There is a need in young Engineers for more imagination and often for more initiative . . ."

There can be few men who have contributed more varied service to their country and to the education of its young men, in particular its young Engineers, than Donald Portway. If his reminiscences had been published before General Horrocks' *A Full*

Life, such a title would have been more appropriate than *Militant Don*. For although he sometimes appeared to be militant, he never lost his sense of proportion and he was always intensely human. His reminiscences have the air of an armchair chat with an Engineer for whom the Corps has warm affection and gratitude.

E.C.W.M.

THE ORDNANCE SURVEY ANNUAL REPORT, 1962–3

(Published by HMSO. Price 7*s*)

At the end of the Second World War the Ordnance Survey was faced with the huge task of carrying out new surveys at the 1/1250 scale of all major towns and at the 6-in scale of all mountain and moorland areas, and recasting on the National grid and revising the 1/2500 scale plans of the remainder of the country. In addition, the retriangulation and relevelling had to be dealt with.

The 1962–3 Report shows the progress made towards the completion of those tasks. The end of the 1/1250 scale programme is in sight, but the 6-in and 1/2500 scale programmes are unlikely to be completed before the early nineteen-eighties. The retriangulation, however, was completed in 1962 and the publication of *The History of the Retriangulation*, which records this important task, is awaited.

It is of particular interest to see that the Ordnance Survey is making increasing use of air survey, not only for the new 1/1250 and 6-in scale surveys but also for the revision of the 1/2500 scale areas. In this field, and in its report on Research and Development, the Survey shows its awareness of modern trends and techniques.

The Report is set out in separate sections each dealing with such subjects as surveying, map-production and research. The sections state concisely the progress made in each field, the text being well illustrated by Appendices and plates.

This is an interesting statement of progress by a government department in which many Sapper Officers have served, and are still serving.

C.W.F.

EXPLOSIVE WORKING OF METALS

By John S. Rinehart

Professor of Mining Engineering, Colorado School of Mines, and

John Pearson

Senior Research Scientist, Michelson Laboratory, US Naval Ordnance Test Station

(Published by Pergamon Press Ltd. Price £5)

Explosives have been used for working metals for some time, and operations such as forming, cutting and welding can now be performed by means of explosives.

The book is divided into two parts. The theoretical aspects of the various operations are covered in Part I, and their practical applications are dealt with in complementary chapters in Part II. It would have been easier to follow had the theory and practice for each type of operation been grouped together. However, all the operations are very fully covered.

Two complementary introductory chapters, covering the theory of explosives and their practical handling, are of particular interest to Sapper officers. The remainder of the book, on account of the specialized nature of the subject, is likely to be of academic interest only.

The book is very well produced, illustrated, documented and indexed. P.C.B.

SHORTER TECHNOLOGICAL DICTIONARY

Polish/English—English/Polish

Edited by S. Czerni and M. Skrzynska

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 70*s*)

This dictionary has been compiled to meet the needs of engineers and others whose work entails the use of Polish/English technical terminology. It contains a selection of over 10,000 general technological and professional terms, including the fundamental terminology of pure sciences and economics. The English/Polish section, which is laid out in strict alphabetical order, includes the pronunciations of the English terms in the International Phonetic Alphabet. A list of phonetic symbols is given, also a summary of the abbreviations used.

Typical of the terms and their extensions are the references to *fuel* and *thermal*:—

Fuel, fuel filling column, fuel gauge, fuel injection pump, fuel jet, fuel level gauge, fuel oil, fuel pump, fuel systems, fuel tank.

Thermal, thermal air currents, thermal capacity, thermal coefficient of expansion, thermal conduction, thermal conductivity, thermal conductor, thermal electric power station, thermal energy, thermal equivalent of work, thermal expansion, thermal gradient, thermal insulation, thermal transmission, thermal treatment.

The dictionary is pocket size with a stiff cover. The text is easy to read and the general standard of production is very good. F.T.S.

ADAPTIVE CONTROL SYSTEMS

Edited by Felix P. Caruthers and Harold Levenstein

(Senior Members, Long Island Institute of Radio Engineers, New York)

(Published by the Symposium Publications Division of Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 80*s*)

By virtue of his organisms man has the ability to adapt himself to extremes of environmental and other varying conditions without undue loss of efficiency. At the same time he has certain limitations of which proneness to fatigue and lack of memory capacity are typical.

As a result of the tremendous scientific advances that have been made since World War II we are entering an age of ergomatics and automation, and strenuous efforts are being made to produce control systems which contain scientific equivalents to, and improvements on, the physiological characteristics of man. Into this field of endeavour comes the adaptive control system which may be defined as, a control system with its specified performance varying within a tolerance band while operating over a wide range of environmental conditions or being driven by a wide range of control input functions. If one studies the generic block diagram of an adaptive control system one finds three essential elements: the means for performance measurement, a means for translating this into a quantitative figure of merit, and a closed-loop control of system parameters to achieve an optimum as given by the figure of merit.

This book consists essentially of the Papers and Discussions of the Long Island Institute of Radio Engineers Symposium of 1960, and each provide a separate chapter of the book. Broadly speaking the chapters are grouped as follows: Definition of Problem; Analytical Techniques; Adaptive Systems Theory I; Adaptive Systems Theory II; Applications; Panel Discussion.

In all some fourteen Papers are presented and together they cover the present range of adaptive control systems, the principles on which they work, their limitations, and the ideas which are being followed up for future development by scientists and engineers of international repute. The Papers are extremely advanced and obviously only suitable for study by those specializing in this branch of science.

The book, which is well illustrated with explanatory diagrams and charts, is excellently printed on good paper and well bound. F.T.S.

A COURSE OF MATHEMATICAL ANALYSIS—PART I

By A. F. Bermant

Translated from the Russian by D. E. Brown and edited by I. D. Sneddon, Simson Professor of Mathematics, University of Glasgow

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

A review of Part II of this Course of Mathematical Analysis was published in the December 1963 *Journal* of the Institution.

This book, Part I, is a modified version of the original 1950 edition, and the author has incorporated a number of amendents which have been suggested by some users of the earlier edition who adopted the latter as a text-book for students at higher technical schools. In effect, therefore, the text has already been subjected to "teacher trials" and only contains matter which is applicable to the syllabi of appropriate mathematical courses.

Mr Bermant has included an introductory chapter which roughly traces the growth of the science of mathematics and its application, plus the personal achievements of a number of leading Russian mathematicians that should serve as a stimulant to the able to persevere into the text proper.

The nine chapters cover: functions; limits; derivatives and differentials; the differential calculus; methods of evaluating definite integrals; improper integrals; application of the integral; and series.

Each chapter begins with the concept or basic definition and then proceeds, in a concise manner, to explore and explain the subject matter to the level required for higher technical training, illustrating the text with worked examples and mathematical curves.

The book contains some 500 pages and is excellently printed and produced.

F.T.S.

PROBLEMS IN THE DESIGN AND DEVELOPMENT OF 750 MW TURBO-GENERATORS

By V. P. Anempodistov, E. G. Kasharskii and I. D. Urusov

(Electromechanics Institute, USSR Academy of Sciences)

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

Hitherto the planned rate of economic development within the USSR has been dictated by a lack of electrical generating capacity and the Russian engineers are working hard to rectify this deficiency.

In 1958 the total electric output of the USSR power stations was 233 milliard KW hr, but the planned output for 1965 is 500–520, and the Russians hope to achieve this tremendous increase by providing a number of additional coal-burning power stations, these being preferred to hydro-electric stations which require a greater capital outlay.

The new stations, and their generating units, will be much larger in capacity in order to reduce capital investment and operational costs. Those stations recently completed have been provided with sets of 200 and 300 MW output, but the Electromechanics Institute have carried out a great deal of research on the design of sets of even greater capacity.

This book, Volume 18 of the International Series of Monographs on Electronics and Instrumentation published by Pergamon Press Ltd, summarizes the main lines of research that have been followed to produce a single shaft generator of 750 MW, a capacity which greatly exceeds that of the current USA (Westinghouse) project which aims at 325 MW.

A section of the book is devoted to the problem of designing an efficient unit cooling system, especially for the windings, thus permitting a greater current density.

In this respect it is interesting to note that part of the text covers the ideas submitted by several USSR factories, who have co-operated with the Electromechanics Institute, to modify the currently used air, hydrogen, transformer oil- and water-cooling systems.

The chief mechanical factors limiting the dimensions of turbo-generators are the diameter and length of the rotor, and a section of the book is devoted to a theoretical analysis which aims to state the prospects for further increases in rotor diameters.

Other new problems of design are grouped and discussed in Chapter IV and include: stray losses; the interaction between main flux and leakage fluxes; mechanical strength and running stability.

The book also gives a possible technical specification for a turbo-generator of 750 MW output which could be raised later to 1,000 MW, supplemented by a summary of the scientific and technical problems which have yet to be solved before it can become a practical proposition.

The book has been written at the highest professional level and is, therefore, only suitable for designers and manufacturers of heavy electrical-mechanical equipment, they will find plenty of interest in the 76 pages of this short treatise.

F.T.S.

THERMODYNAMIC ASSESSMENT OF ROCKET ENGINES

By B. A. Nikolayev

Translated from the Russian by W. E. Jones of UK Atomic Energy Authority and edited by B. P. Mullins, Senior Principal Scientific Officer, Ministry of Aviation, Farnborough

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 63*s*)

This book is Volume 4—Division VII: Aerodynamics—of the Publishers International Series of Monographs in Aeronautics and Astronautics.

It emphasizes that rocket engines are designed and tailor-made to suit a given set of circumstances, and that the primary aim in design is to determine, by calculation, the specific thrust that can be obtained from the combustion of the chosen fuel when the engine is functioning in its operating régime.

Most of the known methods of calculation in respect of the fuel and the chemical composition of the combustion products are complex and laborious, and this treatise expounds a reasonably accurate method of dynamical calculation of rocket engines that does not require the preliminary calculations of the composition of the combustion products. The method proposed is apparently acceptable for rocket engines using fuels consisting of carbon, hydrogen, nitrogen and oxygen.

The chapters of the book are devoted to: the thermodynamic parameters of undissociated and dissociated products of combustion; the method of thermodynamic assessment of liquid rocket engines; the calculation of the chemical composition of the combustion productions at high temperatures.

Included also are five tables of numerical data: Enthalpy of Gases I, kcal/mole; Chemical Equilibrium Constants; Entropy of Gases S, kcal/g-mol, deg C; Physico-Chemical Properties of Certain Combustibles; Physico-Chemical Properties of Certain Oxidants. These are followed by forty-two families of curves which are in support of the text. My criticism of the latter is that they do not carry a reference to the page of the text to which they are applicable. The standard of printing and general production is first-class.

To quote the Translation Editor: "This book should be of interest and use to rocket performance engineers and is sufficiently elementary to be read by students of jet propulsion science."

F.T.S.

DEVELOPMENT OF THE BLUE STREAK SATELLITE LAUNCHER

Edited by D. R. Samson

(Department of Mechanical and Aeronautical Engineering Hatfield College of Technology)

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 60*s*)

This book is Volume 16—Division IX: Symposia—of the Publishers International Series of Monographs in Aeronautics and Astronautics, and its contents are the *copyright* of the de Havilland Aircraft Company Ltd.

It consists essentially of the papers read at the second Space Engineering Symposium organized by the Mechanical and Aeronautical Engineering Dept at Hatfield College of Technology, Hertfordshire on 22 February 1963.

Apart from presenting to the reader a technical summary of the design and manufacture of the British first stage of the European satellite launching vehicle and the associated test and launching site facilities in this country and Australia, it serves to publicize the tremendous efforts which have been made by Britain to develop space research, and points out just what was discarded when the Blue Streak project was jettisoned.

The book presents the six papers read by de Havilland engineers to the Symposium, and includes a long list of selected reading references on allied subjects. The papers are:—

Performance of Blue Streak as effected by Engineering Requirements
Explaining how the performance of a multistage vehicle is evaluated and the necessary interaction which occurs with engineering design and environment, firstly from an ideal point of view and then as a practical analysis of its application to Blue Streak.

Design and Development of Blue Streak Autopilot
Describes the functions of the control system and the problems overcome in achieving these functions, both in the design and hardware stages; the development tests completed on the solo vehicle; and the proposed programme of testing on the multistage vehicle.

The Instrumentation of Blue Streak
The acquisition of data by means of the Blue Streak instrumentation system for design and development purposes from firing charges and flight-vehicles to assess overall vehicle and individual system performances, and for data required to enable pre-flight check-out and preparation sequences to be carried out.

Design and Development of the Blue Streak Structure
Reviews the design and developments which have led to the structure which exists today.

Blue Streak Propulsion and Pressurization Systems
In this paper the vehicle and ground systems are briefly described and a typical countdown is used as background for discussion of some of the major factors that effected design.

A Ballistic Vehicle Launching Site its Development and Operation
An appreciation of the building and development of launching sites and range facilities.

The book comprises 128 pages with a fair number of graphs, tables, and photographs of vehicle parts and launching sites. It is excellently printed and well bound.

Whilst of first interest to the specialist, the average technical layman will find plenty to understand and learn once he has familiarized himself with the space vocabulary used. A very good reference book for military engineers.

F.T.S.

Technical Notes

CIVIL ENGINEERING

Notes from *Civil Engineering and Public Works Review*, October 1963

WEST WATER RESERVOIR AND DAM. The reservoir will be formed by the construction of a rolled fill earthen dam 100 ft high, consisting mostly of boulder clay with an impervious rolled clay core. Below ground level there will be a concrete filled trench and waterbar with a grouted curtain below that. Devices for measuring pore water pressure will be provided, as will also a substantial filter drain into the rock toe. The overflow is to be of the side weir type; tests were made to decide the best form of energy dissipator, and the final choice is for a deflector bucket formed below invert level where the sloping channel reaches the stilling pool. The draw-off arrangements entail pipework in a sloping shaft leading to the outlet tunnel.

THREE LARGE NEW MARSHALLING YARDS. The modernization of the North Eastern Region of British Railways entails the scrapping of a large number of small obsolete marshalling yards; a few of the original yards are being modernized, and three completely new ones are being built. These latter yards, on Tyneside, Teeside, and at Healey Mills near Leeds, are much larger than earlier ones, being semi-automatic with humps and retarders for controlled gravity shunting and sorting of wagons. The new yards have been strategically sited to deal with the heavy industrial traffic in their areas. In addition to interesting facts and figures, this article lists many of the preliminary engineering works which had to be carried out before the main yard construction could be started.

THE STRENGTH OF ENCASED STEEL COLUMNS. Steel columns are encased in concrete to give protection against fire and corrosion, and at the same time to increase the load bearing capacity. Researches have shown that under heavy loads the stresses in the concrete and steel develop independently. Theoretical formulae are derived from first principles and simple design procedures are suggested; the latter do not comply with BS 449. A design table is given but its scope is limited and the thickness of casing shown is in some cases below the 2-in necessary to allow casing strength to be taken into account.

COFFER-DAMMING FOR THE JOHN DAY DAM. The construction of the John Day dam across the Columbia river is a gigantic project. Started in 1958, the construction of the 5,900 ft long dam will not be finished until after 1965. Diversion of the strong-flowing river is being accomplished in three stages by building large coffer-dams; these have rock filled dykes running out into the river and connected at the outer ends by curved sections built up from steel piled cells filled with drained gravel. Bags of cement, placed by divers were piled against the inside walls of the cells to prevent loss of fill and to reduce leakage. Figures are given of the pumping effort required to dewater the first cofferdam, and there are some good photos and a general layout plan.

A HEAVY DUTY TRUCKING ROAD. This is a description of the design principles and construction of a 3¼ mile road built to take heavy iron ore trucks to and from a quarry. The road is in reinforced concrete construction, with a 12-in slab on top of 4-in of a dry lean mix. The complete project included two concrete bridges, two culverts and a cattle creep, all of which are described. The work was done as a package deal after selective tendering.

STRUCTURAL ASPECTS OF STONEWARE PIPELINES. Carrying on from last month, this covers the importance of correct backfilling of pipe trenches and suggests some new ways in which pipes could be improved.

Filled Mixes of Resorcinol-Resin Glues for Laminated Timber Joints. This is a report on some experiments to determine the strength of glued timber joints. For some of them, fly ash was used as a filler, and it was found that this made the glue stiff to spread and reduced its setting time; the loss in strength was of the order of 10 per cent. In other tests laminates with butt and scarfed joints were loaded to destruction.

J.C.P.

Notes from *Civil Engineering and Public Works Review*, November 1963

Precast Concrete Shell Roof Construction. Describes an experimental concrete shell roof constructed of pre-cast slabs. With the economy of shell construction and the advantages of pre-cast construction this system has a promising future especially for industrial buildings.

Direct Solution of Common Pipe Flow Problems. This article is a summary of the formulae for pipe flow and gives the formulae in a number of forms in terms of non-dimensional parameters. By careful choice of parameter, it is possible to obtain a direct solution to pipe problems instead of labourious trial and error processes.

Shear Design of Flexible Water Bound Macadam Overlay over Badly Cracked Concrete Pavement. With heavy modern vehicles and higher traffic intensity, in many parts of the world, comparatively thin concrete road slabs have become badly cracked. This article suggests that an overlay of surface-dressed water-bound macadam is an efficient and cheap remedy. Design rules are developed for various degrees of cracking of the road slabs. While this article gives an interesting description of the action of cracked slabs under wheel loads, the case for a water-bound macadam overlay is not very convincing.

Engineering Geophysics for Land, Marine and River Site Exploration. Exploration by geophysical methods has long been quite common in mining and oil operations. In recent years seismic refraction and resistivity methods have been used increasingly for sub-surface exploration for dam sites, pipe lines, etc.

Geophysical methods are now being used for obtaining a continuous underwater profile. This article describes very briefly a method of underwater survey to a depth of 1,000 ft obtained at an average rate of 4 knots.

The Design and Construction of Marine Works from a Contractor's Point of View. In the construction of marine works, the contractor is more at the mercy of the elements than the contractor on land. In general, having to use either floating working platforms or extensive temporary works means that the contractor's plant costs are high. This article describes some of the difficulties of marine construction and emphasizes the need for close co-operation between the designer and the contractor. The design must be simple so that the contractor is not trying to cope with near impossible construction problems in severe weather conditions and the design and construction so matched that best use can be made of the available heavy plant.

Hamburg's Novel Quay Developments. This interesting article compares port development in Britain and certain continental ports. The author concludes that the development of many British ports has been, and still is, hampered by the original design based on impounded docks. With many European harbours based on tidal basins, progressive development has been possible and war damage repaired comparatively easily.

Underwater Cutting and Welding. Describes some of the problems of cutting and repairing underwater.

The article gives some useful tables of gas pressures, consumption etc for various operations and depths.

D.F.M.

THE MILITARY ENGINEER

September–October 1963

The Rock. Noradcoc, by John M. Norvell. The initials in the title stand for North American Air Defense Combat Operational Center. This will eventually be housed in "A huge cavern blasted deep within a Colorado mountain." The center will serve as the primary collection and evaluation center for data concerning unknown aircraft, missiles, or space vehicles which might bring destruction to North America. Huge electronically controlled display boards will make it possible to evaluate the tracking data instantaneously and to take appropriate defensive action. The work began in June 1961 and has continued on a three-shift basis ever since. The article describes the accommodation which is being provided and the engineering problems involved. The rock to be excavated is granite so the scale of the achievement already realized, and which is well indicated by excellent photographs, is impressive.

Natural Chlorides in the Arkansas—Red River Basins, by R. R. Debruin and John C. Ball. This is a description of how an unusual water supply and control problem has been tackled. The water in the Arkansas and Red River Basins is excessively high in mineral content, predominantly sodium chloride. The principal sources of the pollution are natural salt beds in the rocks of the catchment areas. The article goes into some detail of the various means employed to hold, or divert, the flow of heavily salt laden water.

Military Engineer Field Notes

Daylight Underwater Reconnaissance by Captain David R. Mabry, US Marine Corps. This is a description of the organization, training and operation Under Water Demolition teams whose duty is less demolition than reconnaissance. The method adopted provides a detailed survey of the bottom from about 500 yds from the waterline. It is difficult to see how this could be done in daylight off a defended beach. There are interesting photographs.

Seventh Army Expedient Bridge by Captain Jerome Hilmes, Corps of Engineers. This is a quickly constructed temporary Class 50 or a Class 60 (risk load) bridge made with components from the M4T6 bridge set. Sufficient description, with diagrams, is given for the method to be understood.

Army Engineers in the Space Program, by Colonel Joe A. Clema, Corps of Engineers. The Army Corps of Engineers provides support to be National Aeronautics and Space Administration (NASA) and the Air Force in their space projects. This support is in the fields of engineering, design and construction of facilities, and acquisition of real estate. In addition the Corps is engaged in nuclear power production, mapping, lunar construction study, and other special related fields. This article, which is illustrated, is a summary, with brief detailed descriptions of a number of projects which are in hand. Some of the projects have already been described in earlier numbers of *The Military Engineer*. The magnitude of the tasks involved is staggering. They include static engine tests stands on various sites. The largest is to cope with a 1,500,000 lb thrust. Research centers with the full complement of laboratories, administrative buildings and living quarters, and the launching facilities at Cape Canaveral for the progressive stages of the development of the space vehicles required for the moon flight.

A Graphical Pert Analog by Lieut David F. Sampsell, Civil Engineer Corps, US Navy. PERT stands for Performance Evaluation Review Technique, and it is a simple non-computer method of planning and co-ordinating the various activities which make up a task or project. The method does not differ very much from the old work table we were taught to prepare but it is embellished with many symbols and is more diagramatic. The article is a clear exposition of the way in which such a system can be used.

SUBMARINES THROUGH TWENTY CENTURIES by Captain J. E. Rehler and Lieut G. C. Bottger Civil Engineer Corps US Navy. This article is a resumé, well illustrated with photographs and diagrams of the history of the development of underwater craft from Alexander the Great's diving bell to the latest nuclear and diesel powered submarines under design for the US Navy.

COMPREHENSIVE SURVEY FOR REGIONAL PLANNING, by Brig-General Arthur H. Frye, Jun, Corps of Engineers. The rapid and continuing population expansion in the State of California has emphasized the necessity for Regional Planning of the development of water supply. Irrigation, flood control, transportation, navigation, housing, education, improved farming methods, forest and land resources conservation, and recreational facilities to name some of the subjects. This article describes the general problem and then goes into greater detail of the San Francisco Bay Study which is being carried out by the Army Corps of Engineers. Other government departments and specialists are helping but the co-ordination of the results is the responsibility of the Engineers. An example is given of the sort of information which would be made available to a manufacturer wishing to select a site for a new factory.

BRIDGE BATTLE OF ENGINEERS 1861 by Paul C. Ziemke. A brief illustrated article to interest transportation in particular. It describes the difficulties experienced by the Federal railway engineers in reopening the Nashville–Louisville Railway in face of the successful bridge demolition tactics of the Confederates. The first year 1861 is dealt with in detail but the author notes that for two more years the destruction and replacement of bridges continued but the bridge builders kept the trains running when most needed.

NOVEMBER–DECEMBER 1963

THE ENGLISH CHANNEL CROSSING, by John O. Bickel. A summary of the history of the past attempts to make a Channel Tunnel followed by a review of the various methods of providing a crossing which are under consideration at present. The article gives a clear, well illustrated account of the problems involved without committing itself to an opinion.

WATER RESOURCES PROGRAM MANAGEMENT, by Wendell E. Johnson. The US Army Engineers are engaged on a review of the water resources of the US on a nation-wide scale so that plans can be made for them to be developed to the greatest advantage. The survey covers wild-life preservation to navigation and coastal harbours. The article describes the organization for collecting the information and planning the projects to be carried out. For instance investigations by the Senate Select Water Resources Committee indicate that the amount of reservoir water storage capacity will have to be doubled in the 20-year period ending 1980. Planning such projects and many others requires the considerable organization which is described here.

ENGINEERS' ROLE IN COUNTERINSURGENCY, by Colonel L. L. Haseman, Corps of Engineers US Army. This is a development of the idea put forward by Colonel Clutterbuck in his article in the July–August number of the Magazine that the engineer troops can do a great deal by providing Services, defended villages, water supply, roads and so forth, to align the loyal population of a country in the toils of guerilla war on the side of the West. The examples of what can be done are taken from Vietnam and describe the work of the Vietnam Engineers.

PROGRESS IN SPACE 1963. A table giving details of all the successful launchings of satellites and space vehicles to 1 August 1963. Russian launchings are included as far as they are known.

TERRAIN RECONNAISSANCE WITH ELECTROMAGNETIC SENSORS, by Ernest B. Lipcomb. This article describes the laboratory work planned and in hand which is being carried out with the object of developing equipment mounted in an aircraft capable of perceiving, registering, and integrating terrain data from which the trafficability can be assessed. Much detail of the equipment in use and the methods being followed are given and there are many illustrations.

MH—IA Army Floating Nuclear Power Plant, by Captain Gerald W. Chase and Captain Joseph P. Franklin, Corps of Engineers US Army. The MH-1A is to provide a water-borne mobile source of reliable electric power for transient military operations without dependence on a continuous fuel supply. The article describes the first Army floating nuclear power plant to be built in some detail. Included is a table of measurements output, etc. The net output is 10,000 kW and the core life is one year at full power before reshuffle and partial replacement.

Radar at Arecibo, by Lieut-Colonel Mark C. Carrigan, Corps of Engineers US Army. This is a description of the construction of the Arebico Ionospheric Observatory the object of which is to study the earth's Ionosphere in depth. The radar is unique in that its reflector is the largest ever constructed—a spherical dish 1,000 ft in diameter and 160-ft deep-built on the slopes of a deep natural bowl in Puerto Rico. Electrical energy is transmitted to, and received from, the surface of the reflector by equipment mounted on a 500-ton platform suspended in the air 500 ft over the reflector by cables which are strung from three reinforced towers on the tops of surrounding hills.

Interesting details of construction are given and the whole is well illustrated.

The Road Engineer, by Lieut-Colonel Harley W. Ladd, Corps of Engineers US Army. In the July–August number there was a description of the ROAD Division, a very powerful armoured formation. This brief article gives details of the Divisional Engineers.

Coast Guard Off-shore Light Stations, by Lieut-Commander K. G. Wiman. US Coast Guard. There is a project in hand to replace, very quickly, most of the lightships round the coast of the US, with permanent structures mounted on piles. The author describes in this well illustrated article the design and method of construction

Destroy these Bulldozers, by Kenneth J. Deacon. A spirited account of an action in Luzon where armoured bulldozers supported by tanks were effective in overcoming Japanese strong points in caves and bunkers which were preventing the advance up a mountain track.

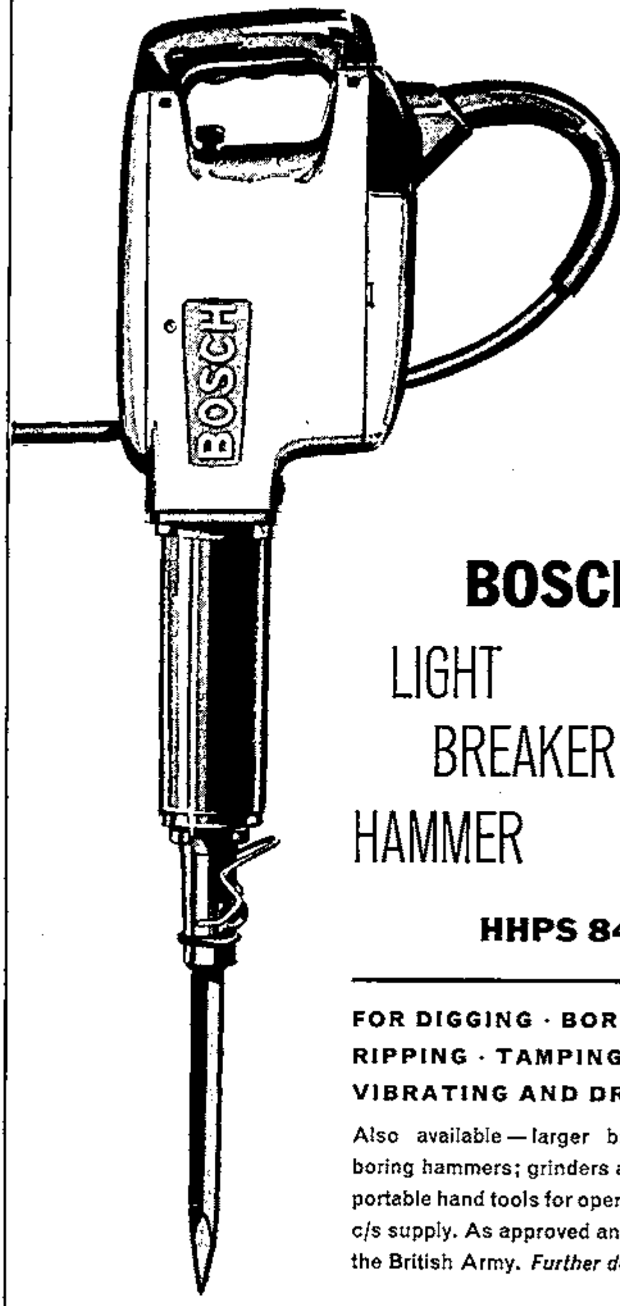
Laser Range Finder, by R. L. Quandt and C. R. Smith. A description of the development of a range finder of great accuracy using the Laser principle. The range finder is illustrated being used by a man in the kneeling position with a pack on his back. The various military applications of such an accurate range finder are obvious.

Modern Highways for Afghanistan. Lieut-Colonel C. M. Messall Corps of Engineers, US Army. It is strange to read of a motor road from Kabul to Kandahar but this is what this article is about.

Engineering Geology. Problems at Missile Sites. by 1st Lieutenant Valentine E. Zadnik. This article describes the geological problems encountered in selecting and constructing launching sites for Atlas Titan and Minuteman Missiles. These problems are not only associated with normal construction factors but also and decisively with the effect of air and ground shock produced by nuclear explosions against which the missiles and operation rooms, etc have to be protected.

The Gooney Bird Meets Critical Path, by Commander J. B. Adams, Civil Engineer Corps US Navy. Gooney birds are a species of Albatross which interfere seriously with the use of the airfield in Midway Island. In order to keep them away from the runway it was decided to pave the sandy areas next to the runway, which were popular with the Gooneys as nesting sites. The time allowed for the work was short and the interest of the article lies in the use made of the Critical Path Schedule in the organization and control of the work. There was an article on the Critical Path Schedule in the July–August 1963 number of the magazine.

J.S.W.S.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