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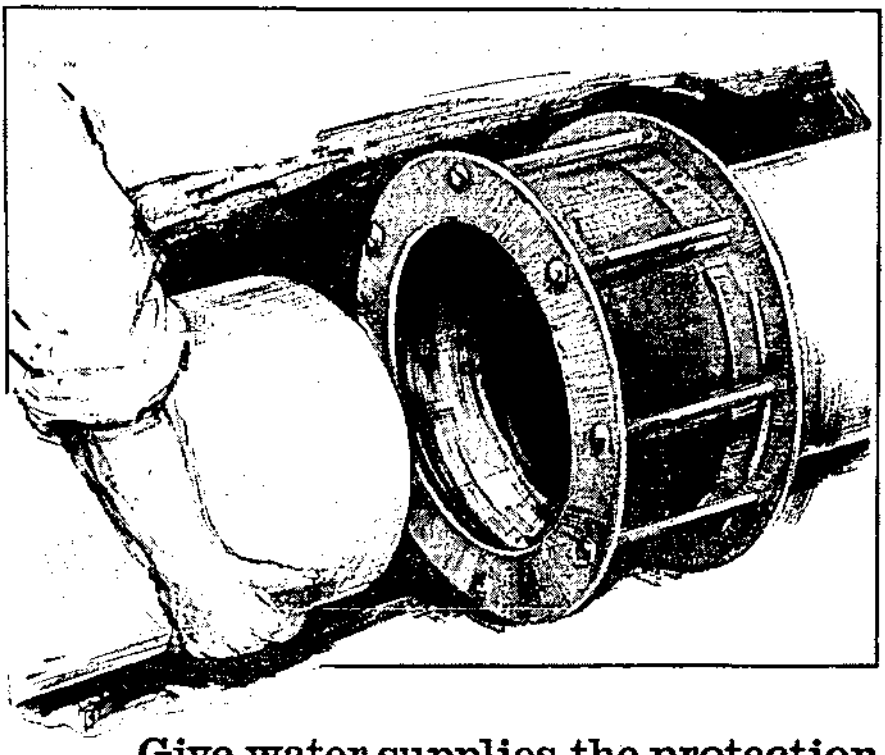

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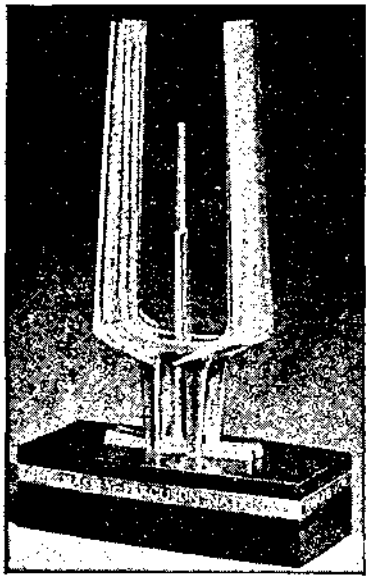

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VOL. LXXX

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SEPTEMBER, 1966

THE ENGINEER-IN-CHIEF'S ADDRESS TO THE ANNUAL GENERAL MEETING OF THE CORPS OF ROYAL ENGINEERS ON 22ND JUNE 1966

Introduction

Chief Royal Engineer and Gentlemen, during the past few years, the management of the Corps has been greatly handicapped by uncertainty as to its exact future role. The McLeod and Nye reorganizations, and the changes in Works Services responsibilities, with their resulting upheavals, have absorbed much of its time and effort.

Now at last we are in the happy position of knowing almost exactly what we have to do. I say almost because there are a few remaining fringe areas which have yet to be sorted out. But in the main the mists are clearing, our objectives are there, and we are in a position now to take a close look at our organization, trade structures and training, in order to attain them.

On the other hand there are still some uncertainties in the organization of the Army. The impact of the Defence Review on our order of battle is not yet clear, and in the UK, although the future of the Reserve Army has been virtually settled, the command structure has not, and this will affect our senior posts.

I will begin by discussing some major organizational and equipment matters which affect the whole Corps, before reporting on our activities around the world.

Organization

Resources. The most important decision affecting our future role has been the outcome of the Odling Committee, which has been investigating the future of the RE Resources Organization. It has been decided that the Corps shall retain its present responsibilities for the supply of engineering material.

Although we as engineers appreciate the importance of controlling all aspects of an engineering task, this is not always apparent to others, and I think you will agree that this result is quite an achievement on the part of those responsible for presenting the Corps' case. In fact, the investigation did us a great deal of good, apart from its outcome, because it made us take a very close and searching look at our own system. It has also, as a by-product, given us the opening to straighten out some of the tangles in the systems for the repair of plant and machinery, and the provision of spare parts. We are now in for a reorganization, which will involve the concentration of HQ ESE and 1 and 2 ESDs into Long Marston. The Defence Review and changes in the role of the Reserve Army are also likely to have an effect on the general structure of Command Engineer Stores Depots.

Military Engineer Services. Last year my predecessor told you that we had made progress in formulating our proposals for an organization to replace the Engineer Specialist Services Establishment, to include military works units. These were to be two CsRE (Construction) and three Specialist Teams (Construction). I can now tell you that our proposals have been accepted, and neither they, nor our intentions, have altered. Two Specialist Teams (Construction) are at present deployed on Works for the Army, as agencies of MPBW, in Borneo and in Aden. The third is likely to be employed in the

Persian Gulf in the near future. The formation and deployment of these three teams has placed a considerable strain on our resources of trained men in some trades. Because of these shortages, we have not yet been able to bring one CRE (Construction) in the United Kingdom up to strength, nor to form the second one, and we have had to leave unfilled some of our vacancies in MPBW.

Works Control. My predecessors have often referred, since 1959, to the inherent deficiencies in successive civilian works organizations, which hamper the works support they are able to give to the Army in conditions of war or emergency. In each case where such support has been required, the Royal Engineers have had to step in on an ad-hoc basis, usually as an agency of the civilian works organisation. This has entailed some difficulties of control, and limited the support available from the Army. However we hope soon to get it agreed that, where circumstances are such that only we can provide works support to the Army, the place in question will become a "Military Works Area". In such an Area, we will assume an independent responsibility in our own right for Works Services.

Airfield Construction. We have made a start in meeting our new commitments for airfield construction and other support for the RAF. 10 Fd Sqn (Airfds) has taken over airfield construction commitments in the Middle East and CRE Cyprus has taken over responsibility at Akrotiri. In January this year, 51 Fd Sqn (Airfds) took over from 5001 Sqn RAF in Singapore.

HQ RE (Airfds) has been established at Waterbeach with two field squadrons, of which 53 is committed to general support of the RAF in the UK, and 52 to the support of the Strategic Reserve. Both are carrying out, as part of their training, a number of normal civil engineering tasks, mostly for the RAF. On 11 March I attended a guest night at the RAF Station at Waterbeach to mark the winding up of the RAF Airfield Construction Branch, and the taking over of their duties by us. Although marked by some nostalgia on the part of the RAF and ACB, it was a friendly occasion, and the Air Member for Personnel was gracious enough to say in his speech that the RAF would rather the Royal Engineers took over this role than anyone else, as they sprang from us in 1912.

The station was officially handed over to RE Airfields on 16 May, and it is a great acquisition for the Corps. It makes a valuable testing ground for MEXE and the Ministry of Aviation for airfield criteria and construction techniques. It has excellent buildings and facilities, and its Mess should be useful to Sapper officers at Cambridge University.

The constant aim of our airfield units is to give the RAF even better service than they had before. Although they are necessarily far less specialized than the ACB were, all the reports I have had seem to show that they are achieving it.

The Reserve Army. A matter of greatest concern to us this year has been the reorganization of the Reserve Army. The financial and manpower limits laid down made it impossible for the Army to retain more than a fraction of the established strength of the existing TA and AER—in our case about one fifth. Unfortunately those units which have to be organized on a geographical basis to allow the necessary degree of training (that is to say Category I and IIa), are so few that they cannot anything like cover the whole country. As it is, the five regiments in this category are spread out to the limit of practicability. So most of the southern and eastern parts of England can only find a

place in the Category IIb, or "sponsored", type units, the equivalent of the old AER. These are themselves considerably reduced and consist mainly of specialist teams. However, we have managed to keep the Engineer Regiment of the AER, and I hope that some of the keener members of the TA units which are due to disappear on 1 April 1967 will be able to find a place in it, because I believe that in future it will have to consist almost entirely of men who are already trained soldiers, or who possess some special skill.

We do not figure at all in Category III, the Home Defence part of the reserve. The size of the force, and its budget, are so small that we could only have been allowed at the best, in each civil defence region, a tiny unit with no equipment and no money for training. Such units would not be viable, nor able to maintain their enthusiasm as engineers, and we have therefore opted out of this category altogether. However, some of our disbanding units are joining the force, as sub-units of other arms, and I have told them that if they wish to retain some RE insignia or title, this will have my support, although they will not be able to wear the cap badge.

I have written to all the Hon Colonels of the units whose fate has been decided to tell them of it, and to express the gratitude of the Corps for all the generous service of their units in the past. There are still one or two units whose future is not yet settled.

On 11 June I held as usual my Reserve Army Conference, the main object of which was to evolve a policy for the training of the new reserve. I was gratified to find how many of the COs of the disbanding units took the trouble to come and give me the benefit of their advice. They were uniformly helpful and constructive, and I was much encouraged.

Finally I am glad to report that that very distinguished body of men, the Engineer and Railway Staff Corps, are to continue unchanged, under the thin disguise of T & AVR Category IV. It makes no difference to their existing status and obligations and adds not a penny to their cost to the State of precisely nil. I know we shall continue to profit from their expert knowledge and advice.

It follows from what I have said that there will be a good deal of redundancy among senior regular officers and senior WOs, which is likely to be aggravated by whatever changes in the UK Command Structure may be decided upon.

Location of the E-in-C. The new staff system resulting from the Nye Report, whereby the engineer staff cells are under policy directors, is working reasonably well, but the location of the E-in-C's office at Chatham creates difficulties both for the staff cells and for me. In practice, either I or my Deputy have to be in London most of the time, in order to co-ordinate, but having no facilities there, it is an inefficient and time-wasting system. All I will say now is that this matter is again under consideration at the Ministry of Defence.

Equipment

General. The amount of new equipment coming into service lately gives little idea of the great variety of things which have been under development in the R & D Establishments during the past few years, and it is only recently that we have begun to feel the benefit of all this effort. The new range of bridging equipment shows great promise. The Medium Girder Bridge was shown in the last RE demonstration and has been under trial in BAOR, and

the Class 16 Airportable Bridge will reach units for trial during the coming year. Both these look like being winners and we hope will attract overseas customers. The new range of demolition stores have at last been accepted for service. Encouraging development of mats and membranes is going ahead at MEXE and in the coming year we hope to be looking for a site for the first membrane-covered strip. Much attention has been paid to aids to amphibians, and also to the problem of knocking down and reassembling larger items of plant for carriage by helicopter. We are attaching an RE officer from MEXE to Cambridge University for fundamental research into the physics of earth moving, which is a surprisingly neglected subject, but one of great importance to us.

I should like to refer here to the great value derived from Exercise "FORSDALE", an experimental POL installation set up at Little Aden to try various new equipments and techniques in tropical conditions. This has provided indispensible experience and lessons which will assist in the development of our new range of POL equipment.

Whenever I visit MEXE I come away much cheered by the wealth of new and very practical ideas being pursued, and I think this is due in a large measure to the extremely close contact they have always kept with us, the users.

In April, the 8th Quadripartite Engineer Conference was held at Fort Belvoir, Virginia, between ourselves, the United States, Australia and Canada, and resulted in a number of agreed requirements, which should lead to useful co-operation and sharing of effort in research, development, and production.

Plant Policy. For many years, the Army has had difficulty in managing its plant fleet efficiently, and we in the Corps have been plagued with fleets of a great variety of outworn and outdated equipment. The difficulty has always been to reconcile the financial and operational factors, which are so different to those of a civilian contractor.

Last year the DAEP's "C" Vehicle Review Team, which was mainly concerned with numbers and types of "C" vehicles, reported. The time was ripe for a completely fresh look at the whole subject of management of plant, including all engineer plant, not only "C" vehicles. In December 1965, the Army Department set up a Working Party for this purpose at my request headed by the Director of Fighting Vehicles and Engineer Equipment under the MGO. Many of the officers in the Corps, who have much knowledge and very strong, though often quite contradictory, views have been invited to give evidence. The passionate interest aroused by this subject among Sappers is well illustrated by the very large attendance at the Joint Meeting with the Institution of Mechanical Engineers on 9 February 1966, at which papers on the military requirement for plant were presented. The report is due next month, and we all hope will result in far more efficient and economical use of more modern and effective equipment.

As a result of this, and also of the Odling Committee report, we shall be having a close look at the trades needed to operate and repair our plant and machinery, and their bearing on the production of Clerks of Works (Mechanical). In the meantime, I hope for improved results from the introduction of the new "A" trade of Plant Operator Mechanic.

This will form part of a complete review of the trades structure of the Corps which is in hand.

Nuclear. We continue our close participation in the US Corps of Engineers Nuclear Programme. We have had successive officers on the Engineer Reactor Group Course at Fort Belvoir, and another enjoys the title of Visiting Assistant Professor of Nuclear Science at the University of Washington, Seattle.

Deployment in General

Before turning to activities in particular theatres, I will say straight away that the state of stretch of the Corps and the high incidence of unaccompanied emergency tours show no sign of decreasing. The main causes have been the extension of the airfield project in Thailand for longer than was expected, and the coming redeployment in the Middle East from Aden to the Persian Gulf.

Even before these increased commitments, the rate of rotation of units and individuals on unaccompanied emergency tours was at too high a level. For instance, much of the time three of the squadrons of the Strategic Reserve Support Echelon have been so committed—one in Borneo, two in Aden. Other units in Borneo, and those engaged in Thailand, have had to leave their families in Singapore or the UK. This separation rate is too high, and we have had to take certain exceptional measures to reduce it.

The formation of the airfield squadrons at the same time as the formation of the units of the MES, has led to an increase in turbulence, especially in BAOR, and to very heavy demands upon the more professionally qualified members of the Corps, such as Garrison Engineers and Clerks of Works.

I will now give a short account of what has been happening in various theatres.

BAOR

In common with other Arms, the Engineers in BAOR have started to get armoured personnel carriers, and the 1st Divisional Engineers have now had a year's experience with them, including water crossing trials. They have proved a great stimulus to interest and enthusiasm, as well as generating many problems. The CRE 1 Div has also been lucky enough to have the first issue of unit helicopters in his own flight, a development which will soon extend throughout the Corps. I had the great pleasure in May of being flown by a Sapper officer in one of our own machines, an experience to which I have been looking forward for many years. It is a great landmark.

The Berlin Field Squadron found themselves with an unexpected and challenging task when a Russian aircraft crashed into a limb of the Havel, and they were required to salvage it. Their divers, supplemented by others from the Advanced Watermanship Training Centre at Kiel, had to work in deep silt which meant operating blind and by touch alone for long periods—an unnerving experience. They were completely successful and the Squadron earned high praise.

32 Armoured Engineer Regiment has now acquired its own Officers' Mess at Hohne, and the opening entertainment which I attended was preceded by the Beating of Retreat by the RE Band and was a most successful occasion.

Next year will see complete squadrons of the new Reserve Army starting to train in BAOR. This creates problems, but will be a great advance.

The high state of morale and efficiency BAOR units have managed to preserve in spite of exceptional turbulence reflects great credit on their commanders.

Mediterranean

I now turn to the Mediterranean, starting with Cyprus. 33 Field Squadron and 62 (Cyprus) Park Squadron have a large commitment to support other arms in training and in IS emergencies and to act as infantry in certain situations. They support the RAF at Akrotiri and have built a small lighter harbour there including a 700 ft long mole. They have carried out quite a number of construction tasks, and the CRE has been working very closely with the Regional Director MPBW to their mutual benefit. He has also given considerable help to the United Nations Force in Cyprus.

In Malta the Fortress Squadron and the Park Squadron have continued with a series of very useful local projects, such as clearing some reservoirs in Gozo of silt thereby increasing their storage capacity. They also sent a troop for three months to assist CRE Cyprus. These men are very good, versatile experienced tradesmen, and they also provide combat engineer support in exercises in Libya.

In Gibraltar the main work of the Fortress Squadron has continued to be the operation of the Calpe Hole and Windmill Hill power stations and the extension of the tunnelling system. It has also been assisting MPBW by the provision of building materials, particularly stone, which have been short due to the closing of the frontier. However, it has proved difficult to justify the full strength of the squadron in support tasks for MPBW and I fear that it will have to be reduced in size in the near future.

Middle East

The successful conclusion of the Radfan operations in 1964 did not bring peace to the South Arabian Federation. Dissident and terrorist attacks continued throughout the year and strong Engineer backing has been necessary to support military and internal security operations. The major civil engineering task of building a black top road from Lahej to Habilayn has gone on well, though delays have occurred as a result of attacks on men and plant. A survey of the next stretch of projected road from Habilayn to Dhala has also been completed. This was a dangerous and difficult task, ably carried through but it is unlikely now that the Corps will construct this section.

Engineer support for the RAF has gone splendidly in Mideast and we appear to have well-satisfied customers. Besides a large number of minor works, extensions and improvements to runways and taxiways have been carried out at remote places by the units concerned.

The execution of works services outside Aden, which until recently had been one of the worst problems, has been made less difficult by the arrival of a Specialist Team (Construction) in the theatre. The well-drilling specialist team had to return home at the end of its tour, but a special troop has been formed from within the theatre and is rapidly learning its new well-drilling skills.

The civil assistance team has continued with its "hearts and minds" work of assisting the tribesmen and supervising irrigation projects.

The Chief Engineer's problems, never easy, have been complicated by events in Africa and he has had to send detachments to Zambia and Malagasy, to support the RAF.

Although the Government has announced the intended withdrawal from

Aden by 1968, I can foresee no early reduction in the Sapper effort required there. For one thing there is a continuing demand for works services for the Federation Army, which the PWD and MPBW may be unable to discharge.

It is worth remarking upon the extent to which the Engineers in this theatre have come to be looked upon equally as the servants of all three services. Indeed the Chief Engineer has found himself dealing directly with the Commander-in-Chief, the Navy, Army and Air Commanders and the High Commissioner with almost equal frequency. He has also, of course, had intimate dealings with the Regional Director MPBW whose tasks up country he has had almost entirely to take over.

Far East

Thailand. In the Far East theatre the main matter for concern has been the continuation of the airfield project in Thailand for a year longer than intended. This of course has contributed greatly to the general state of stretch, especially among technicians. You were told last year that this airfield at Leong Nok Tha was officially opened in June, as indeed it was, and very good it appeared to be. However, at the end of the rainy season, tests revealed that its load bearing capacity was not up to the standard required. This was a considerable shock and disappointment, and a technical investigation revealed that water had penetrated the top seal which should have been waterproof. There are a number of reasons for this which I will not go into and indeed the experts are not entirely agreed on the exact cause. But fundamentally the trouble can be put down to the lack of time for field testing caused by insufficiently early access to the site. Reliance therefore had to be placed on laboratory-scale tests alone.

This is the kind of engineering risk that often has to be faced in war and whether such a thing is justifiable in peace is always a matter of opinion. There were many weighty factors such as urgency, and shortage of money, which operated and it is likely that any hesitation or delays at the time would have invited refusal of the whole project.

We are now engaged on superimposing a layer of concrete, and this work is expected to be finished by the end of the year.

It says much for the resilience of the Sapper and the quality of his commanders, that after the initial disappointment, morale at the site has remained very high, and they are now working "flat out" with great enthusiasm, determined to finish the new task on time, in spite of the very real difficulties this remote site imposes. I need hardly say that the training value is immense.

East Malaysia. In Borneo, work has continued on the improvement of communications in the form of roads, airstrips and helicopter pads, and in the improvement of infantry company bases. The State Governments have been assisted with a resettlement project and rural development schemes. The wide variety of engineering tasks in these territories have often entailed work by small detachments and sub-units remote from their headquarters, which gives wonderful opportunities for the development of enterprise and self reliance among junior ranks.

There have been four nationalities of engineers, British, Gurkha, Malaysian and Australian, operating under our CRE. The Australians have contributed a succession of squadrons working on a road in Sabah in very difficult country with an almost complete lack of stone.

A valuable side effect of confrontation in Borneo has been the impetus it

has given to the expansion, development and training of the Malaysian Engineers with a number of seconded British Officers and other ranks.

A notable event was the departure for Hong Kong in January of 69 Gurkha Field Squadron, which had had longer spells of service in Borneo than any other unit of the Army. In all they did thirty-three months service in Borneo, and were for six months the only engineer field unit there.

Western Malaysia and Singapore. Continued support has been given to the Commonwealth Brigade by 11 Independent Field Squadron with its integrated Australian troop, and by 68 Gurkha Field Squadron at intervals between its service in Borneo. This squadron was involved in flood relief operations last December in Kalantan. 11 Squadron, 59 Squadron and 54 Corps Fd Park Sqn have all had tours in both Thailand and Borneo and have therefore had considerable spells away from their families. 51 Field Squadron (Airfields) is now established at Seletar and has assumed since March our responsibilities towards the Far East Air Force.

Hong Kong. 69 Gurkha Field Squadron from Borneo changed places with 67 Gurkha Field Squadron in Perowne Barracks in January. Hong Kong is always subject to sudden emergencies of some kind and this year it has been catastrophic floods. We have no details yet, but I have already heard from the Commander British Forces that the Sappers have acquitted themselves well.

United Kingdom

12 Engineer Brigade. 12 Engineer Group—recently become a Brigade on change of commander—has been the formation mainly affected by the high incidence of emergency tours overseas, but they have managed none the less to conduct exercises in Canada, Malta and British Honduras. In the UK an airstrip was built on Mull and 36 Engineer Regiment has recently completed an amphibious training exercise involving the construction of a POL installation and airstrip near Dundee, the exercise being mounted from HMS *Fearless*, the first of the new assault ships.

3 Div. Units of 3 Div Engineers have carried out exercises in Canada, Norway, Denmark and Libya and a troop of 3 Field Squadron has done a six-months emergency tour in Aden, made necessary by the increase in subversive activities last autumn. For once they are concentrated at Tidworth and Aldershot and training hard.

Bomb Disposal. The UK bomb disposal unit has been fully employed as usual. The minefield at Trimmingham in Norfolk has at last been declared clear, after thirteen years' work, and numerous bombs and missiles in the UK have been disposed of.

Survey. During the past year 42 Survey Engineer Regiment has twice sent Topographic troops to the Middle East to carry out operational surveys in the South Arabian Federation. In the Far East 84 Survey Squadron have continued to support the Borneo operations by producing control for new mapping.

Survey have continued to take part in the American Satellite Tracking operations and two RE officers have been attached to the British team which is at present working in Gizo Island in the Solomons. We expect that the survey support for these operations will be increased during the coming year.

A major contribution to the standardization of maps and air charts will be

made when the joint service 1:250,000 map is produced. Survey are at present engaged on a large programme in conjunction with the Americans, and sheets of various parts of the world will start appearing shortly.

Postal and Courier Communications. Forces Postal and Courier Communications Units are continuing to provide worldwide service to the Royal Navy, Army and Royal Air Force. In addition to their normal commitments P & CC Units have been busy providing exercise support in Sardinia, Italy, Turkey, Norway, Denmark and Canada and operational support is being currently given to the RAF in Zambia and in Bechuanaland, and was recently given to the Navy in Mauritius. It is interesting to note that P & CC handle about thirty-eight million letters, packets and parcels annually and turnover at Forces Post Offices reaches nearly £5 million per year.

It is always a moot point whether our Clerks of Works or Postal men are farther-flung. There is not much in it.

The RSME. The planning for rebuilding of the RSME started over six years ago. The construction of the first of several projects started in 1962 when the Duke of Edinburgh laid the foundation stone of the new Chattenden Barracks. This project is now virtually complete, and 12 RSME Regiment, the Tactical School (including Signals Wing) and the Field Engineer School will move from Gordon Barracks to Chattenden Barracks on the 1 September this year, and will be joined there by the Bomb Disposal School from Horsham. The official opening by the Minister of Defence for the Army will be on 9 November. The first half of the rebuilding of Plant Roads and Airfields School at Wainscott was completed earlier this month and the second half is now being planned and should be completed in 1968. The large project for the rebuilding of Brompton Barracks has now been going on for eighteen months and the buildings are being handed over as they are completed. At the end of this year the Depot Regiment will move to Brompton Barracks; Kitchener Barracks will then be used as temporary accommodation for HQ RSME whilst the main Headquarters Building is modernized internally. New workshops and classrooms for the Technical Training Group are being taken over progressively and the bulk of all this work will be completed by next summer. The REHQ Mess will be taken over by the contractors for renovation on the 1 December this year and should be ready in the autumn of 1967.

All this turmoil has made it very difficult for the RSME to run in a normal manner, but they have managed. We have had however to cut out the RE Veterans' Week-end this year, and the RE Demonstration, which is to be a biennial event in future.

We have recently reintroduced a series of short courses at RSME for the training of officers at squadron commander, regimental commander and Chief Engineer level. The content of these courses is both military and technical and the proportion of technical content increases with the seniority of the student.

The Training Brigade. In the Training Brigade, the main worry has been over the future of Chepstow and Dover.

The proposed raising of the school leaving age has led to an examination of the future of the army apprentices and junior soldiers. As a result of this, it has been decided that all apprentices, other than technicians, will undergo two years training instead of three, as at present, and that it will no longer be possible to maintain a large number of junior leaders units. These

will be replaced by junior soldiers units at which boys will serve for one year before passing to adult service. In our case we have received some dispensation for Sappers to stay longer because of their special training needs, and the outcome is that we are being allowed to retain Chepstow for our apprentices, and Dover for our junior soldiers, very much as at present. It is a great relief to me that we are able to keep these units, which make such a valuable contribution to the Corps, intact.

It is now expected that construction of the new permanent home for HQ Training Brigade and 1 Training Regiment RE in the vicinity of Hawley Lake will start in 1968.

Officer Recruiting. In general our officer recruiting is improving. Against a requirement of sixty-six regular subalterns a year, we had fifty-four in 1965, and look like getting sixty this year. An encouraging feature is that the number of university direct entrants is increasing, and in 1965 we gained five cadetships in the new university cadetship scheme.

In the long term, the new career structure sets a proportion of sixty to forty regular to non-regular entry, and to achieve the 40 per cent non-regular, we shall have to recruit more officers for limited service commissions, which have so far not proved very attractive. We are doing well in the number of short service officers commissioned from Mons, but we must try to get more of them to stay on limited service commissions.

Our worst difficulty remains the shortage of regular captains, due to under-recruiting since 1956. This has been mitigated to some extent by commissioning Warrant Officers for short service commissions, and indeed it is only because of the high quality of our WOs and Senior NCOs that we have been able to do so; none the less we have great difficulty in finding experienced junior officers for extra-regimental and training posts, and most field units can only expect to have experienced captains and sometimes junior majors, in key posts such as Adjutant or Squadron 2 I/C.

Soldier Recruiting. Recruiting in 1965 was not quite as good as in the previous year. Nevertheless, despite the MacLeod transfers and a low priority in recruiting, we were able to keep the Corps strength just above the manpower target, and to attract a high standard of recruit. In the next two years we face a major challenge, as we must make good the large runouts from the very good recruiting years of 1961 and 1962. This will exercise all our ingenuity as we cannot expect higher priority than other arms.

Publicity. We are continuing to publicize the Corps and all that we have to offer by every means and as widely as possible. To help to meet the extra effort which will be required to balance Army intakes against run-out in these next two years and to safeguard against the future, it is intended to increase throughout the Army, the number of established NCO recruiters. It is anticipated that the 1968 the Corps will have thirty-six RE Army recruiters and eight RE long service list Army recruiters making a total of forty-four established recuiters. Recruiting is something in which all of us can help, and in the case of potential officers for the Corps particularly, much can be achieved when officers, both serving and retired, have the opportunity to talk to suitable young men.

Conclusion

It has always been the concern of the Corps to keep a proper balance between combat and professional engineering, and it becomes weak in either

at its peril. The balance was seriously upset by the removal of the Works Services in 1959, and there is no doubt that we need to widen and deepen our technical base, if only to measure up to the additional commitments we now have. Furthermore the tendency to give up overseas bases can only lead to an increased demand for construction overseas in emergencies, and this will generate a need for more supervisory and trades skills, and more professionalism among officers. To prepare to meet these needs, without diminishing our combat skills, is a main concern of myself and my staff today.

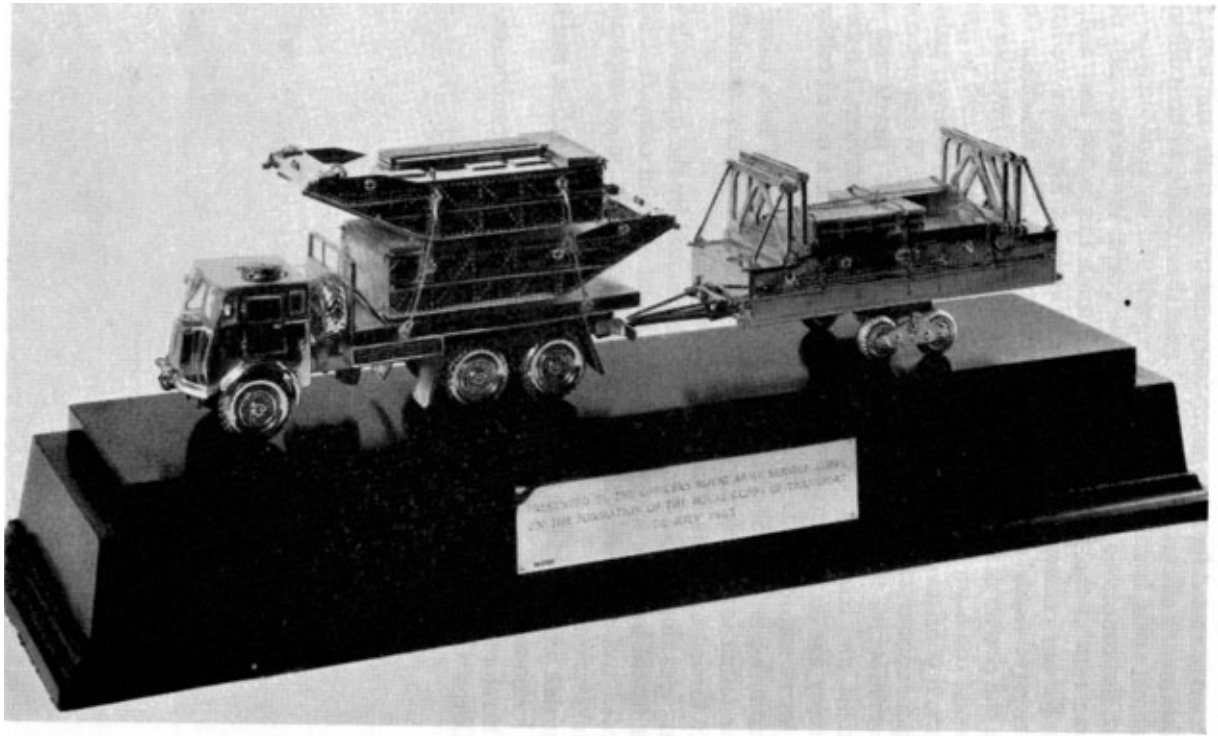
I am also concerned about the size of the Corps. We are currently down to 8.46 per cent of the Army's strength. I think this is too low, and is one reason for our constant state of stretch. In the past five years we have had units engaged almost continuously on construction tasks, which the Order of Battle and charter of the Corps were not designed to cover. I wonder whether in the past the Army Order of Battle has not been tied too much to particular places and political conditions, which are liable to rapid change, rather than to organic soundness to meet any unforeseen eventuality. When one considers the versatility of the Sapper, his particular value in "hearts and minds" situations, and the support he can give to all three Services, I believe that something like 10 per cent of Army strength would be a more healthy figure both for us and for the Defence Services.

Finally let me say that when some of the problems I have talked about appear rather intractable and depressing, I have the instant antidote in my ability to visit our units, which I do a great deal.

Any idea that the Sapper is the least bit moved by the upheavals we talk about would be quite wrong. He is his usual cheerful competent self, well regarded and respected everywhere, the more so the more unpleasant the circumstances.

Further we have at this time a really fine lot of commanders, and it is not only I who says this.

Therefore, Gentlemen, I look on the future with great confidence, and on the Corps with great pride.



The Engineer-In-Chief's Address

The Silver Centrepiece Presented by the Officers of the Royal Army Service Corps

To commemorate the past association of the Royal Engineers and the Royal Army Service Corps, to serve as a tribute to the services rendered by the Transportation and Movement Control branches of the Corps of Royal Engineers, and to record the formation of the Royal Corps of Transport on 15 July 1965, the officers of the former Royal Army Service Corps have presented a silver centrepiece to the Royal Engineers Headquarters Mess.

The centrepiece, a silver model of a 10 ton bridging lorry and trailer carrying floating bridge equipment, made by Walker and Hall of Sheffield, was presented to the Corps by Major-General Sir William G. Roe, KCB, CB, a Colonel Commandant RCT, prior to a lunch given in the RE HQ Mess on Tuesday, 17 May 1966. The ceremony was attended by a large number of serving and retired officers of the RE, RASC and RCT and the guests included Major-General A. T. de Rhé Philipe, CB, OBE, late RE, a Colonel Commandant RCT; Major-General W. J. Potter, CB, CBE, Transport Officer-in-Chief; Brigadier L. J. Aspland, OBE, Commandant RCT Training Centre; Colonel J. R. Burgess, TD, the Secretary, Regimental Headquarters RCT; and Lieut-Colonel J. H. Walters, Staff Officer to the TO-in-C (A). The senior representatives of the Corps were General Sir Frank E. W. Simpson, GBE, KCB, DSO, Chief Royal Engineer, who received the presentation piece on behalf of the Corps, Major-General J. H. S. Bowring, OBE, MC, Engineer-in-Chief, Brigadier I. H. Lyall Grant, MC, Commandant, RSME, Colonel B. G. Bloomer, Deputy Commandant, RSME and Colonel R. G. Bishop, Colonel (E) RSME.

Before uncovering the presentation piece Major-General Sir William Roe stated that he was delighted to be asked to make the presentation. It was fitting, he said, that the association of the RE and RASC should thus be commemorated because it had existed from as far back as 1906 when, in the early days of military road transport, a party of RASC non-commissioned officers and men had, with Royal Engineers, taken a convoy of early military mechanical transport from Chatham, via Strood Hill to Woolwich. He also believed that the hand-over of the Transportation and Movement Control branches from the RE to the RCT was an event that demanded appropriate recognition and he hoped that the Corps of Royal Engineers would accept the centrepiece as a tribute to their outstanding transportation achievements prior to 1965. The piece, he said, depicted quite clearly a classical example of the mutual efforts of the RE and RASC.

Accepting the gift on behalf of the Corps the Chief Royal Engineer said that he was delighted to welcome Major-General Sir William Roe and the other guests to the Headquarters Mess on such a unique occasion. Although he had been consulted on what form the presentation piece should take, he had no idea, until it was uncovered, that it was so perfect in its style and execution. The Corps, he continued, greatly appreciated the gift of such an excellent piece of silver and it would always be given a honoured place on the Mess table. It was true, he admitted, that he had been saddened by the idea of the RE relinquishing Transportation and the Movements Control duties, but he was quite certain that in their new guise, under the Royal Corps of Transport, they would, like many other services that the Sappers had in the past developed and handed-on, gain even greater renown in the future.

Mass Blasting in Malaya using Ammonium Nitrate and Diesel Oil

By Major A. J. D. Hughes, RE

A mass blast yielding more than 80,000 tons of well-fragmented rock was detonated at the Public Works Department's quarry at Bukit Ruloh near Kota Bahru in North Malaya on 13 May 1965, as a demonstration of new techniques. The blast was achieved using ammonium nitrate (a common fertilizer) mixed with diesel oil as the main explosive, and the 108 boreholes were 3 in. in diameter and nearly one hundred feet in depth.

5001 Airfield Construction Squadron (then RAF) had been working near by and had got to know the State Engineer of Kelantan, who lived in Kota Bahru. It was due to liaison between this squadron and Mr Aidan Coleman, the State Engineer, that the Chief Engineer FARELF was invited to attend this demonstration blast or to send a representative.

Two days before the blast saw the assembly in the Hotel Irama in Kota Bahru of the State engineers of Pahang, Trengganu and Kelantan, together with their field executives and the technical representative of Atlas Copco, Mr Brian Borthwick who organized the demonstration. Two officers from 5001 Airfield Construction Squadron, an officer from the Federation Engineers, and the author, attended the preparations for the blast. The actual explosion was witnessed by various other people including a number of officers from the near-by RAF airfield.

Aim of the Blast

Besides showing the new technique of the use of ammonium nitrate and fuel oil as a cheap and effective explosive, the Atlas Copco demonstration was to show the effectiveness in drilling deep holes in fissured granitic rock of the Atlas Copco Rock Drill type BBE 51 and the excellent fragmentation possible if the planning, drilling and blasting pattern were all tightly controlled.

Theory

In most countries of South East Asia successful open cast drilling and blasting has been dependent upon the development of drilling machines and techniques which would overcome the problem of heavily fissued, fractured and cavitied rock. Earlier experimental blasts had established that the following principal factors were necessary to attain a successful result on a task of this size:—

(*a*) The optimum borehole diameter was about 3 in.
(*b*) The bench height should preferably exceed 60 ft.
(*c*) The drilling angle should be between 70 and 75 deg.
(*d*) Ammonium nitrate should be the blasting agent with graded charge density in order to prevent "lifting".
(*e*) Millesecond "V" pattern detonation should be used.

Design for Blasting—Boreholes

The "know-how" concerning the drilling, loading and blasting using ammonium nitrate has been acquired by Atlas Copco's experience in mining in Sweden. Previous experience guided the choice of borehole diameter, depth, spacing and burden for each type of rock.

In this case the rock at Bukit Buloh quarry was of a young granitic type, extensively fissured in planes parallel to, and at right angles to, the quarry face, as well as in horizontal planes (photo 1).

It was decided that the spacing and burden of the blast holes should be equal and, in view of the low cost of ammonium nitrate (one-fifth cost of normal high explosive), that the blasting ratio should be between 2 and 3 tons of rock per lb of explosive.

The quarry at Bukit Buloh had been chosen as it had already a bench some 90 ft high, extending to a width of face of some 360 ft with a face angle of about 75 deg. The bench top varied in depth from about 50 to 60 ft.

Calculations

Accordingly the calculations can be summarized as follows:—

(*a*) *Bench height* = 90 ft vertical.

(*b*) *Drilling depth* = 95 ft (allowing for 75 deg slope and part below quarry floor for clean toe break out).

(*c*) *Charging depth* = 85 ft (allow 10 ft at top for sand stemming—equal to burden).

(*d*) *Assume AN/FO* pneumatically loaded* with average charge density 72 lb/cu ft. (This = 3.6 lb per ft of 3 inch diameter holes.)

Hence charge per hole = 85 × 3.6 = *306 lb.*

(*e*) *Hence yield of rock* (at 2 tons/lb) = *612 tons per hole—minimum.*

[*Hence 108 holes will produce 65,000 tons minimum*]

(*f*) *Actual weight of rock* (measured) = 2 tons/cu yd

Hence yield per hole $= \frac{612}{2} =$ *306 cu yds*

(*g*) *Since spacing = burden*

$$\text{Therefore } \textit{Burden} = \sqrt{\frac{\text{Volume of yield per hole}}{\text{Bench height}}}$$

$$= \sqrt{\frac{306 \text{ cu yds}}{90/3 \text{ yds}} \times \frac{9 \text{ sq ft}}{1 \text{ sq yd}}} = \sqrt{91.8}$$

$$= 10 \text{ ft (approx)}$$

(*h*) *Booster charges*

AN/FO requires 6 to 10 per cent of its own weight as booster charge ie *Minimum* booster charge per hole

$$= 306 \text{ lb} \times \frac{6}{100} = 18.36 \text{ lb}$$

and *Maximum* $= 306 \text{ lb} \times \frac{10}{100} = 30.6 \text{ lb}$

But for holes deeper than 50 ft this should be divided 2/3 to lower booster charge at bottom of hole, and 1/3 to column booster midway. Suitable booster was in sticks of 2 in. dia × 2.5 lb of 75 per cent special gelatine.

Hence selected:—

Lower booster charge each hole 6 sticks = 15 *lb HE*

Mid Column booster charge each hole 3 sticks = 7.5 *lb HE*

Total booster/hole = 22.5 *lb HE*

* AN/FO = Ammonium Nitrate/Fuel Oil.

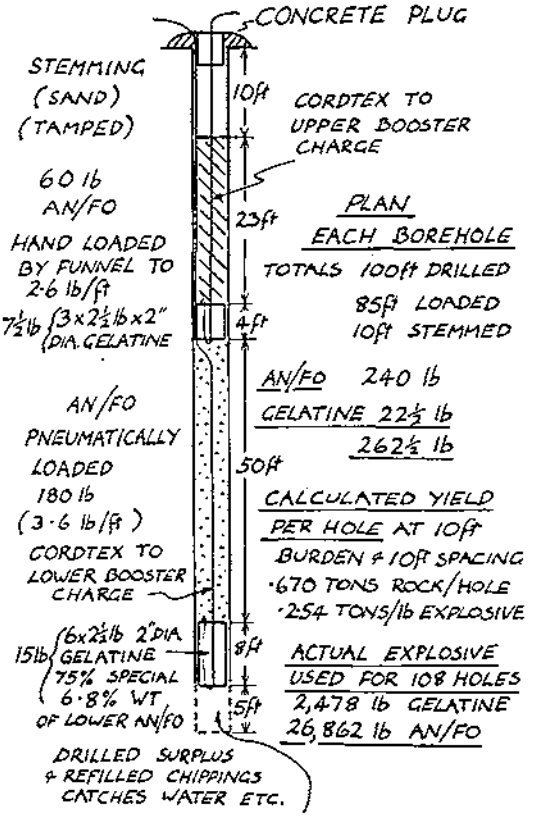


FIG 1 BORE HOLES 3" DIA

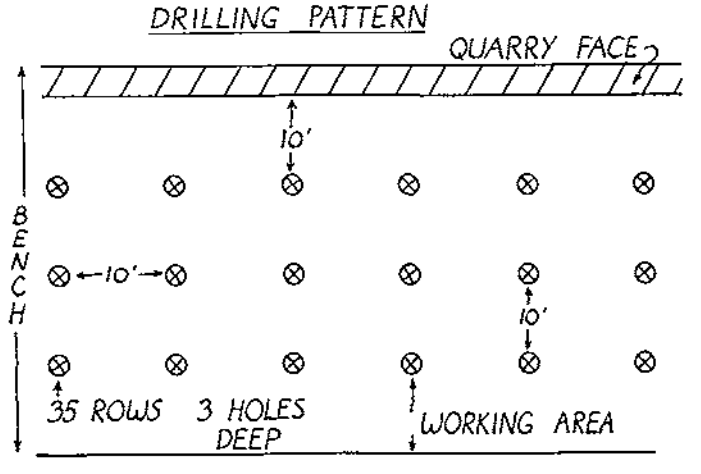


FIG 2.

Decision on Blast Hole Loading

Experience suggested that in order to minimize "lifting", for convenience in loading and also to give effective lower bench break-out of the rock—that each borehole should be loaded as follows:—

Drill hole to 100 ft depth (at 75 deg)

(*a*) *Bottom 5 ft*—back filled with chippings as a sump for moisture, rain etc.

(*b*) *Next 8 ft booster*—15 lb special gelatine (six sticks: 2 in dia × 1 ft 4 in × 2.5 lb)

(*c*) *Next 50 ft AN/FO*—180 lb AN/FO pneumatically loaded to 3.6 lb per ft of hole

(*d*) *Midway column booster in next 4 ft*—7.5 lb special gelatine (three sticks 2 in dia × 1 ft 4 in long × 2.5 lb)

(*e*) *Top AN/FO 23 ft*—60 lb AN/FO hand loaded at 2.6 lb/ft of hole.

Note: This lower weight of loading assists in minimizing "lifting".

(*f*) *Stemming—10 ft of sand*—hand tamped

Totals: 100 ft hole : 240 lb AN/FO : 22.5 lb gelatine (9 per cent of AN/FO)

= 262.5 lb explosive

Hence theoretical yield/hole at 10 ft spacing, 10 ft burden

$$= 10 \times 10 \times 90 \text{ ft (hole depth)} \times \frac{1 \text{ cu yd}}{27 \text{ cu ft}}$$

$$= 333 \text{ cu yds rock}$$

$$= 666 \text{ tons rock} = \frac{666}{262.5} \frac{\text{tons}}{\text{lb}} = 2.54 \text{ tons/lb explosive}$$

It can be seen that this lies midway between the 2 to 3 tons/lb blasting ratio previously decided upon.

A section of a blast hole is shown duly annotated at Fig. 1.

Drilling Pattern

Unlike the conventional drilling pattern for boreholes (shown in the RESPB on quarrying), where each row of boreholes is staggered, earlier tests had shown that "V" pattern millesecond delay detonation gave the best fragmentation results and also reduced ground vibration, thus allowing the blasting of deep benches in this very broken and fissured rock.

The drilling pattern selected is shown at Fig. 2. There were 33 rows of holes 3 holes deep.

Row 34 had only bench top area to allow for 2 holes and row 35 for 1 hole.

However 4 rows required extra holes drilled at an angle to account for the overburden (short holes). Thus the holes drilled were:—

33 rows × 3	=	99 holes
row 34	=	2
row 35	=	1
rows 2, 3, 28, 29 short holes for overburdened	=	4
extra boreholes	=	2
Total		108 holes

Typical profiles/sections of the quarry face and inclined blast holes are shown at Fig. 3.

PROFILE/SECTION OF SPECIMEN
ROWS OF BOREHOLES

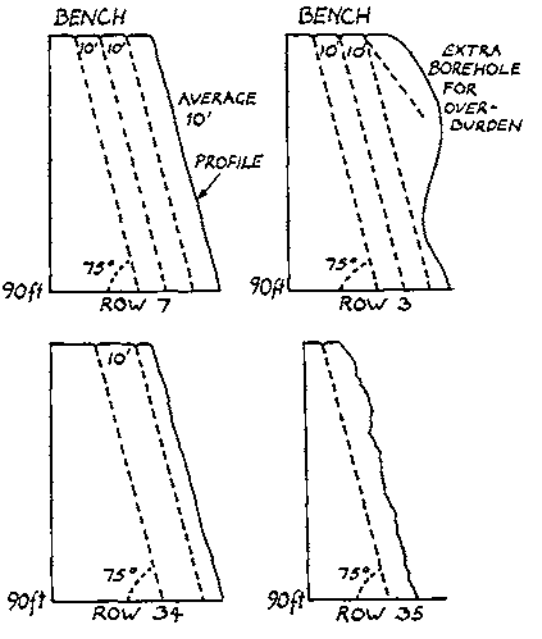


FIG. 3.

RING MAIN
(MILLISECOND 'V' PATTERN)

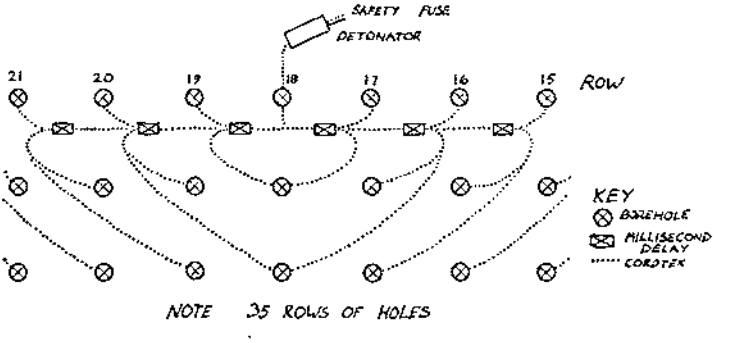


FIG. 4.

Firing "V" Pattern Detonation

In order to achieve good fragmentation, no lifting and a clean break out, the following were essential factors:—

(*a*) Each hole's charge required grading. This was achieved by the high density bottom charge.

(*b*) A good overall detonation of the charge was needed. This was achieved by the bottom and column booster charges and by connecting both these charges with their own individual cordtex detonating cord. Thus each borehole had two lengths of cordtex emanating from it, connected as shown in Fig. 1.

The system of connecting these boreholes, using the millesecond delays, is shown in Fig. 4.

It will be noted that this system of connexions using the millesecond delays and cordtex results in the front centre borehole being blown first, followed by a series of V's on either side of it. This results in the lower section of the quarry face being kicked out progressively from the centre. The slight backward angle of the holes (75 deg) had two effects:—

(*a*) It approximated to the existing quarry face and tended to assist in providing a safe backwall after the blast.

(*b*) It tended to assist in the "V" pattern detonation providing good fragmentation by taking advantage of the breaking effect of blasting rock against rock, followed by the additional fragmentation due to gravity impacts of the top rocks falling down and into contact with the quarry face to the rock pile from a significant height. Additionally the placing of the booster charges and their connexion by cordtex (running the full length of the borehole) probably provided extra booster effect.

Initiation of the Charge

The decision to use cordtex and safety fuse was one of safety. It would have been cheaper to use electric detonators wherever possible, but local tradition did not permit the use of electric detonators, due to the fear of premature detonations which might be caused by static electricity in this area of electric storms.

The millisecond delays used had the appearance of two detonators, back to back connected by a smaller diameter piece of detonator tubing. These millisecond delays were duplicated, being connected in parallel.

Practical Work

The actual job was carried out in the phases shown below:—

		Time
I	Reconnaissance, design and planning. Concurrently movement of the drilling machines to the site ..	4 days
II	Ordering and delivering of drilling rods, bits and accessories. Accurate profile measurement starts	3 days
III	Drilling (10,800 ft of rock). Concurrent profile measurement	22 days
IV	Checking and reaming out holes as necessary ..	7 days
V	Flushing out blast holes, subsidiary drilling, preparations for loading	5 days
VI	Loading and firing	1 day
	Total	42 days

Drilling Machines

The choice of drilling machine was dictated by the granitic type of the rock. The choice is between drilling small diameter holes with consequent small spacing and burden to achieve good fragmentation against larger diameter holes, but fewer of them with an increased spacing and burden. The cost and speed of drilling and the tendency for small diameter holes to jam drill bits and rods in fissured rock are other factors.

The 3 in diameter hole was known from experience to represent a good compromise for large mass blasts in these conditions.

The essential requirement for fissured granitic rock were:—

(*a*) A fast drilling speed with a maximum percussive power on a 3 in diameter bit.

(*b*) A high rotation torque to eliminate the problems of bits sticking.

(*c*) A large flushing capability, essential to remove the sediments contained in cavities and to lift to the surface rocks or stones displaced from the walls of the hole.

(*d*) A "retrac" capability for extracting the bit in cases of it becoming jammed, or even of complete rock collapse.

The new Atlas Copco BBE 51 rock drill provided the required properties for these difficult conditions. Its $4\frac{3}{4}$ in diameter piston produced the percussive power. It had a 3 hp six-cylinder separate rotation motor, which produced very high rotation torques and its high flushing capacity, allied to these other properties fitted it for the job. Additionally, as a reserve capability, it had a special "retrac" capability including a specially designed bit with backward facing cutting edges which, with sufficient power, can drill itself out of a hole in the case of complete rock collapse. One foot behind this bit was a "retrac" coupling with reaming edges, which assisted in rod withdrawal and hole cleaning. These tasks required rotation power only.

The chain feed for the drill was arranged to include a worm drive between the air motor and chain. This gave a lifting power of several tons to the driller when pulling his rods. Despite this special equipment, it is clear that drilling is a specialized task calling for expert knowledge and practice.

For convenience, the two drilling machines were mounted on crawler tractor vehicles. These provided easy mobility and a stable platform for the drill. Once aligned over the hole at the required angle the drill was set up. One further aid was special overburden drilling rod and casing equipment for the four rows of holes requiring this. (See Fig. 3, row 3.)

Two BBE 51 machines were used to drill the 108 blast holes (100 ft deep). These each required 600 cu ft air/min, of which 150 cu ft/min was used for flushing. (Photo 2.) This air was provided by ordinary compressors, which were also required on site anyway for use with the ammonium nitrate/fuel oil pneumatic loading machines. As an indication of the skill required for drilling, the drillers on this project lost four drill bits when drilling the first fifty to sixty holes. However after this training period, when they had mastered these new machines and the rock conditions, the last fifty holes were drilled at high speed without incident in this difficult rock. A simple and effective method of stabilizing the hole entry was used. This consisted of cementing a small collar over each hole when it was completed. Into this was placed a 3-in wooden plug. This saved holes from collapse and from loose matter falling into them. (See Fig. 1.)

Checking, Reaming Out and Flushing

This was done largely with the BBE 51 drills, using rotation power only—a simple operation with its separate rotation motor. The holes were also flushed by air, using 2½ in outside diameter × 2¼ in inside diameter plastic hose connected up to the compressors.

This latter operation achieved two functions. Firstly the holes were cleaned and the full diameter proved for sufficient clearance for lowering (on the end of cordtex) the bottom booster charges (2 in diameter sticks of gelatine).

The air flushing necessitated several men holding the hoses progressively from the bottom to the top of the holes. Unless held firmly the hoses were liable to fly into the air, and a certain amount of amusement resulted from the odd man suddenly finding himself airborne during the flushing operation!

Mixing AN/FO

One feature of using AN/FO is that the shortest time between loading and firing the charge should be arranged. In these tropical conditions it was considered that the whole 12 to 13 tons should be mixed and charged and fired within about six to ten hours. This meant that special arrangements were required for screening the contents of the bags of ammonium nitrate in order to break up all lumps before mixing with the fuel oil. The mixture required exactly 5.6 per cent diesel oil by weight. The ammonium nitrate has to be "prilled" (produced in very small balls of a few millimeters in diameter) in order to flow through the pneumatic loading machine and hoses. The make selected was Japanese Mitsubishi ammonium nitrate in 30 kg (66 lb) bags. These bags contained an inner plastic bag holding the prills, but even so, when emptied on to the screen each bag contained lumps, which had to be broken up on the screen by labourers with wooden paddles.

The locally produced pivoted hoppers with their screens were so made that, when screened, the hopper pivots and tips into the loading hopper of the concrete mixer.

In order to empty and mix over 400 of these bags of ammonium nitrate in the short time available, two 10/7 concrete mixers were used. The batch size for each mix was five bags of ammonium nitrate (5 × 66 lb = 330 lb). It was essential that the diesel oil was measured accurately for each batch. This was done by piercing drain holes in the sides of the measuring cans at the exact level to equate to the quantity required for the 5.6 per cent diesel proportion. Cut down 40 gal drums with handles were used to convey the AN/FO mix to the pneumatic loading machines or, when hand loaded, to tip into locally-made large funnels.

The Durox Export (Sweden) pneumatic loading machines are cone-shaped. Compressed air is fed above the loaded AN/FO mix and forces it through valves through a long 2–2½ in diameter loading hose. This hose is fed down the borehole. The most effective shattering effect at the lower part of the quarry face requires a high density of loading only capable of being achieved by pneumatic methods. The advantages of this system in fissured rock is that the mix fills any small side cavities in the rock when under pneumatic pressure—thus ensuring the charge is firmly contained.

However the use of these loading machines requires a certain amount of "know-how" and practice. One loading team was very much quicker in this operation than the three others.

Loading and Firing

The lower booster charges were lowered on cordtex the day prior to firing. The tops of the cordtex were held in position and the holes closed by wooden plugs, which fitted the concrete collars at the mouths of the holes. Early next morning loading started. The AN/FO mix was pneumatically loaded as shown in Fig 1, each batch fed to each loading machine was 90 lb AN/FO (two batches per hole). The mid column booster charges were then lowered on another length of cordtex to rest on top of the lower AN/FO mix.

Next the upper AN/FO mix was loaded by hand—tipping into large funnels. The top 10 ft clearance was checked-for periodically using a long thin bamboo pole. Finally sand was tipped into the top 10 ft of each hole and lightly tamped. Towards the end of these operations all possible personnel, stores and machines were sent down from the working area on the bench to the near-by quarry area.

A select gang connected the firing circuit (which I have loosely termed a ringmain in Fig. 4). Due to the large number of millisecond delays lying on the quarry bench-top when connected, it was important that no unwary foot trod on one. After completing the series of colour slide photographs on the preparations for the blast the author descended to the quarry area reasonably quickly!

There were two hides for observers to view the explosion. Both were located in front of the quarry face and only 200–300 yds away. Mr Brian Borthwick and an assistant lit the safety fuse and walked away—some thirteen tons of explosive blasted shortly afterwards.

The Blast

It was possible to discern the effects of the millisecond delays and V pattern detonation. The centre charges could be seen in photography later to have started first and the "kicking out from the centre" effect was also evident on some colour slides.

Photograph 3 shows the bench before firing (the centre part) and photograph 4 shows the results of the blast. Even in this latter photograph, it is notable that the rock was well shattered, only a few large lumps being visible.

To the observers present it was surprising that very little was thrown into the air by the explosion. Not one stone landed on the roof of the nearer shelter some 250 yards from the quarry face—and only one or two ripples were observed in the pond some fifty yards in front of the shelter. (Photo 6.)

Conclusion of the Blast

The demonstration of the use of ammonium nitrate and fuel oil by Mr Brian Borthwick, of Atlas Copco, Sweden, was most effective.

Clearly, as used for quarrying, it is a cheap and effective method suitable for mass blasting and producing well fragmented rock. At Bukit Buloh, the calculated yield of 65,000 tons of rock (minimum) was well exceeded. Subsequent measurement showed the yield to be more than 80,000 tons of rock, more than 98 per cent of this being sufficiently well shattered to feed the quarry's primary crusher (jaws 42 ins × 30 ins).

Improvisation. Particularly interesting to a RE officer in the preparations for this blast were some of the improvisations used.

It was difficult to ensure that the lower booster charges, once threaded on

the cordtex, could be lowered down the boreholes in the fissured rock without being jammed. The method intended for difficult holes (3 in dia) was to first push white plastic piping down the hole (OD $2\frac{1}{2}$ in, ID $2\frac{1}{4}$ in). The 2 in dia gelatine sticks (threaded on to cordtex) were then to be lowered down the piping and the piping withdrawn. This did not work exactly as planned, as the tube was not sufficiently concentric after being bent to fit into the hole, but, by lowering the tube, the hole had automatically been checked for clearance and no problems were then experienced in lowering the booster charges after they had been threaded on to cordtex.

Another problem was the accurate measurement of the profile of the quarry face opposite each row of three boreholes. The problem was solved by mounting a 2-in tubular boom on to the U frame of a quarry tractor. A measuring tape with weight was then lowered over the apex of the boom. Photograph 5 and 6 shows this effective arrangement. Both this system and the mounting of the drilling machines on crawler tractors gave the advantage of easily movable stable platforms for these purposes.

Possible uses for the British Army. Undoubtedly for large-scale quarrying in a dry climate this system could be of use to the Army. However, the bags of prilled ammonium nitrate would be unlikely to be up to the storage requirements for world wide Service use. Additionally the limit of six to ten hours, which appears to be the normal maximum for the time between loading and firing, would tend to limit the uses of AN/FO for many operational purposes.

A one man "manpack" loader is commercially available for smaller charges and would probably be more suitable for general Army use.

AN/FO would undoubtedly be a useful improvised explosive, as both materials are readily available in most countries.

Techniques. The demonstration was of the greatest interest in that it showed new techniques and stimulated ideas.

Acknowledgements

Grateful acknowledgements are due to Mr Brian Borthwick of Atlas Copco, who so kindly allowed the services into the demonstration and who has allowed extracts of his report to be quoted. Also to Mr Aidan Coleman, the State Engineer of Kelantan, who invited the Services to the demonstration and who owned the quarry. Both were extremely hospitable towards the RAF and Army officers present.

Photo. 1. This shows the granite nature of the quarry face (centre portion) before the blast. A drilling machine can be seen at the top of the picture on the bench top.

Photo. 2. Drilling a 100 ft borehole. The drill uses 600 cu ft air/min. It has a separate air motor for rotation and special "retrac" arrangements.

Mass Blasting In Malaya 1,2

Photo. 3. The quarry face before the blast showing the bench to be blown.

Photo. 4. The same quarry face after the blast, showing well fragmented rock. The frame-works for rain shelters for the explosive, when stacked on the bench top, on the working area to the rear of the bench can be seen still in place.

Mass Blasting In Malaya 3 & 4

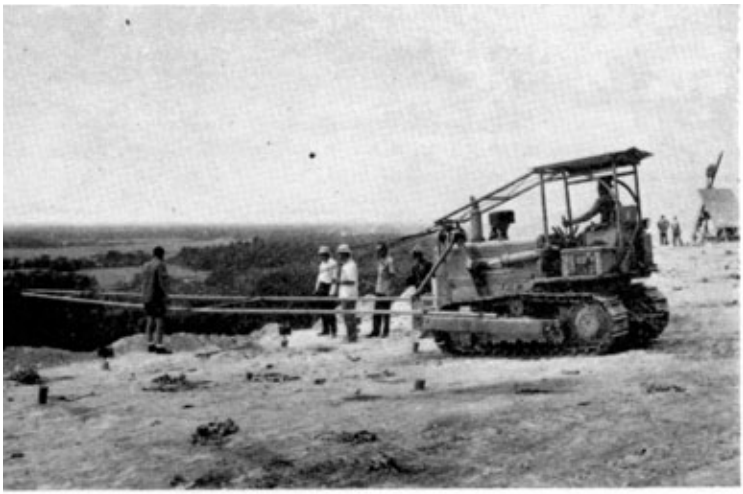


Photo. 5. The improvised boom for quarry face profile measurement. *Left* Mr Aidan Coleman. *Near tractor* Mr Brian Borthwick. *Background* Typical Kelantan countryside.

Photo. 6. Measuring the profile. *Arrowed* Pond into which very few rocks fell on blasting. *Behind* (*arrowed*) The nearer shelter containing the author and others during the blast. *Foreground* The wooden plug and concrete collar to hole number 20.

Airstrip Construction in Borneo 1963-65

By Major G. N. Ritchie, RE

The author wishes to acknowledge the invaluable help he has received in preparing this article by being able to draw on the experiences of 69 Gurkha Independent Field Squadron.

Introduction

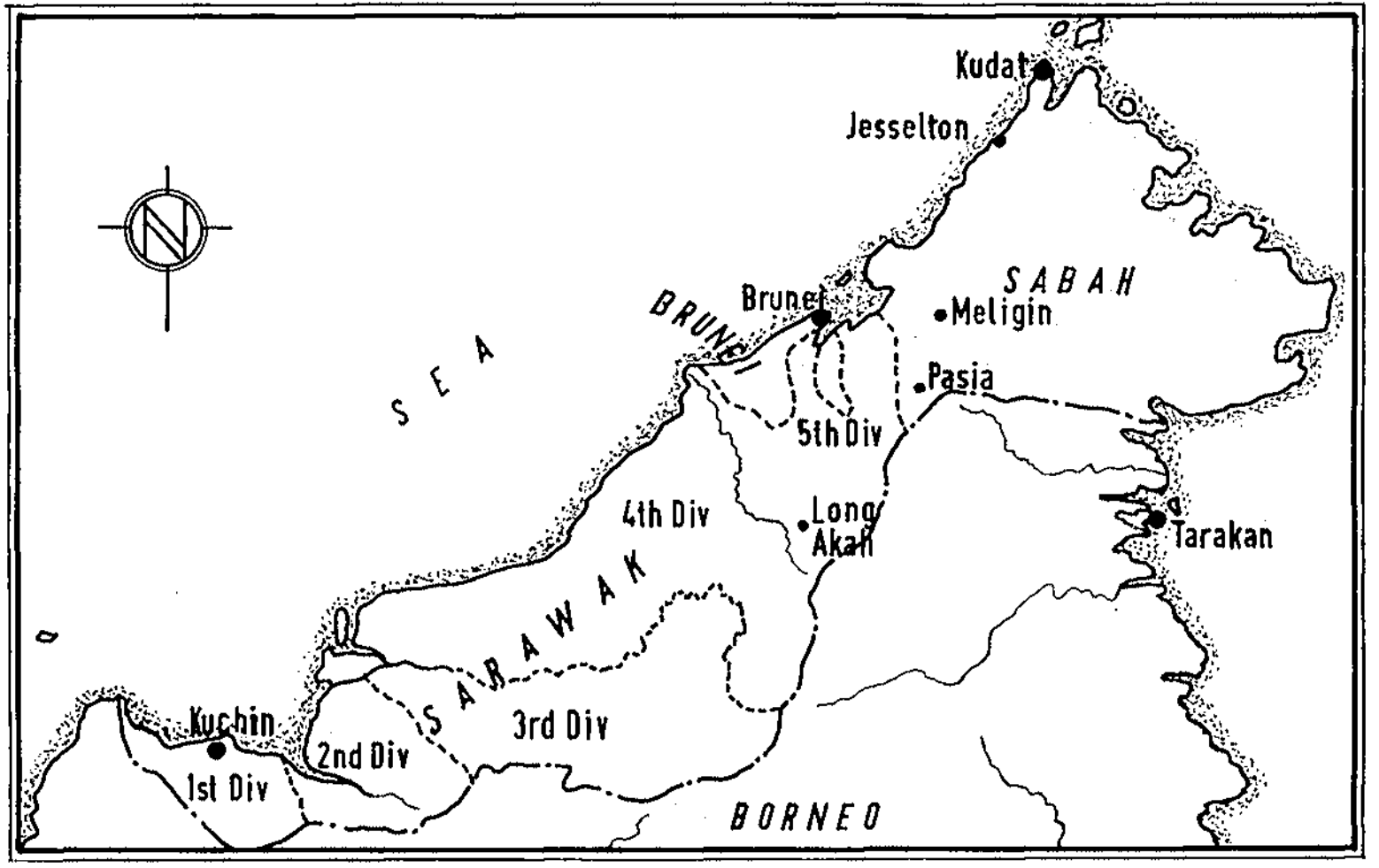
Since December 1962 squadrons of the Gurkha Engineers have been deployed in Borneo where they have been developing and putting into practice the techniques required to carry out major construction tasks at the end of an often tenuous L of C. The greater part of this work has been the building of air strips for Twin Pioneer aircraft using plant brought in by medium stressed platforms (MSP) and the current range of helicopters.

These Gurkha Engineer squadrons have been practising the techniques required by "Sappers Inaccessible" described by Lieut-Colonel F. W. E. Fursdon in the September 1965 issue of the *RE Journal*, and discussed by Lieut-Colonel E. McL. Mackay in his paper to the Institution of Mechanical Engineers which was published in the December 1965 *RE Journal*.

The aim of this article is to discuss some of these airstrip construction projects with a view to extracting lessons from them and seeing what guide they give for the future.

Although small bulldozers were lifted by Dakota and glider into Europe and Burma during the 1939–45 War the first operations by the Corps and possibly in the world using plant knocked down ("Knockdown" is the expression used to describe the techniques of breaking down plant into helicopter loads; "Broken-down" is not used for obvious reasons!) for carriage by helicopter took place in Malaya in 1954 when first 78 Malayan Field Park Squadron RE, and subsequently 11 Field Squadron RE and 410 Plant Troop moved Fordson Major tractors using RN Whirlwind helicopters. Although these machines proved a great bonus in the construction of such jungle air strips and forts at Shabai and Melintang—much of the work was in fact carried out by aborigine labour. Besides making the task possible this course meant that the aborigines were drawn away from the influence of the Communist Terrorists by the white man's gold and brought under the local control of the Malayan Field Force Police. That most of these jobs took about twelve months meant that mutual confidence grew and established itself between the two elements and this in itself had its effect on "Hearts and Minds" campaign.

An interesting side effect was the large debit which 11 Squadron built up on their NAAFI Container Account. Beer came in by air drop with each bottle carrying a return charge of 10 cents. During the course of 1955 the


Kudat
Jesselton
SABAH
Meligin
Brunei
BRUNEI
SEA
Pasia
5th Div
4th Div
Long Akah
Tarakan
SARAWAK
Kuching
2nd Div
3rd Div
1st Div
BORNEO

squadron built up a debt to NAAFI of about 1,200 dollars for empty bottles. Although the full bottles went in on the end of a parachute no one could really blame the RAF for refusing to helicopter the empties out!

Long Seridan

In Borneo the first operation involving the airdrop and helicopter lift of engineer plant to build an airstrip took place in early 1963. After the Brunei revolt was crushed there was a requirement to open up the 4th and 5th Divisions of Sarawak (see map) so that the Security Forces could quickly deploy into the deep jungle and thus strike at any rebel gangs and bring confidence and security to the loyal, but primitive, up river peoples.

Long Seridan is a small community located 65 miles South of Brunei in an area of rugged jungle and confused hills and ridges. It had a simple grass strip built by the missionaries, as most Sarawak air strips were, used by them for weekly flights by their Cessna, as a soccer pitch and as the buffalo grazing area. 69 Gurkha Independent Field Squadron were asked to repair and develop Long Seridan and initially it was decided that this should be to MRT standards. As a result of a joint air recce it was agreed by OC 69 Squadron with the Air Task Force Commander that 1,000 yds of one-way runway would be accepted for Beverleys.

Captain Dominic Verschoyle of "C" Troop went in by helicopter with his survey party on 9 January 1963 and got ready to receive a Caterpillar D4 (1943 vintage) and a Wobbly Wheel Roller due for delivery by MSP. (The Caterpillar D4 until very recently was the only tractor for which AATDC clearance and the dropping equipment existed. Although the larger D4C is cleared for HSP dropping its rigging equipment has only just become available for operational use. Emergency action was put in hand to get International BTD6 tractors taken over from the RAF cleared for MSP dropping but this was not complete until the second half of 1966.) In addition various other machines including a Ferguson 203 with front and back end equipments and trailer, a Ferguson 35, various types of Greens Vibrating roller plus the Troop its G1098, and a load of general and special stores were due for delivery by helicopter and airdrop.

None of the equipment had passed through the hands of AATDC for clearance for carriage as helicopter underslung loads but the operational situation and a great deal of willingness and ingenuity on the part of the RAF, the AASO and the Engineers quickly solved this problem.

On site Verschoyle's problems started immediately after arrival. The weather closed, air supply became impossible, and for the next twelve days, he and his advance party tightened their belts and developed a taste for local cooking.

Their time was not wasted however and the hold-up in the arrival of plant, stores and men did not greatly delay matters. In a task of this kind which involves clearance of a large area of jungle, a fairly exact survey and the subsequent movement of large quantities of earth; a spell on the ground by himself at the beginning enables the Engineer to get down to the planning and the organization of the job.

Pressure will always come on at this point to make some estimate of the ETC. This is extremely difficult in a job of this type which cannot be expected to result in an "instant airstrip" and only careful survey and planning can make even a rough guess possible. In a country where the annual

rainfall can be four times that of Manchester (35 in per annum) ETC can be synonymous with RIP for the less than canny Engineer! Add to this elderly dozers and an erratic spares supply system and we see how difficult a "guestimate" becomes.

Although it had been anticipated that the D4 would be essential in the clearance phase of the project, this proved incorrect. Verschoyle found during the period when he was waiting for his air drop to start that the local tribesmen were highly skilled in the matter of jungle clearance. Although their equipment was promitive their technique and methods were highly developed and using razor sharp axes they rapidly felled, cut up and carried away the trees. The tiny D4 would rapidly have built up a solid wall of tangled trunks and branches had it been used during this phase as we have seen even the largest machines fail and stall attempting similar work.

Eventually using the resources only of his own Troop, slightly reinforced by elements of the Squadron Headquarters, Verschoyle reassembled the plant air dropped and flown in by helicopter. The MSP were also stripped down and evacuated by returning helicopters. In addition of course the Troop had to establish itself in its defensive camp, make arrangements for its administration and the engagement of local labour, and open the construction account. (The Civil Air Department of the Sarawak Government contributed $5,000 to the cost of the strip and most of this was spent on local labour—and the cost of a cow which committed suicide in one of the drainage ditches!)

By mid-March clearance of the site was complete and it was possible to see where the 1,000 yds of runway was to lie and which was restricted by the river which lay on three sides of the site. At this point the Squadron Commander was able to visit Long Seridan. (When helicopter sorties are at a premium it is usually more important to move an Indian than a Chief although many Chiefs fail to appreciate this!) What he saw and envisaged when the first Beverley would approach the strip sent him back to the Air Task Force Commander with the suggestion that they visit the strip, if possible with a Beverley pilot. This was arranged and shortly afterwards the two of them heard the Bevereley Squadron Commander express his views in forthright terms at Long Seridan. Summed up these inferred that somebody, but not he, might be able with the Almighty as co-pilot to land an empty Bevereley on the strip but they would never get the thing airborne again. With this decision made the project became SRT for Twin Pioneers although with very generous length and dispersal areas for both fixed wing aircraft and helicopters.

Two difficulties were retarding construction. Weather always affects earth-works in South East Asia where rain falls almost daily throughout the year. The second was our inability to get a grader on to site. The BK10 was in service in 1963 but the machine anticipated the availability of the Heavy Stressed Platform (HSP) and it associated rigging equipment by about three years. (Although BK10 have been dropped on HSP this has been possible only on exercises using the AATDC rigging equipment.) Having no grader the D4 was required to work to the very limit of its capabilities and those of its operator in order to produce an acceptable formation and the result is a tribute to the skill of the latter. The essentialness of the D4 as dozer, grader and compactor was highlighted by its frequent withdrawal into the project workshops where WOII Crook and Corporal Quinnell worked wonders

(including replacement of the main clutch) but when the D4 was off the road progress on the project stopped except for jobs such as turfing or ditching which could be done by hand labour.

Eventually the day came, about five months after arrival on site, when the movement of plant had to take place in reverse; off site and back to base in Brunei. There were difficulties. The focus of operations, due to Confrontation had moved South to the 1st, 2nd and 3rd Divisions of Sarawak and the helicopter force had moved with them. This meant that the move out would be by Twin Pioneer whose pay load was about 2,000 lb loaded through a side door measuring about 3 ft by 4½ ft and about 4 ft above ground level. You will remember that we had a D4 and a Wobbly Wheel Roller on site! In a remarkably short time thanks to initiative and inventiveness on the site, backed up by the tremendous enthusiasm and assistance we got from our Twin Pioneer crew the site was cleared; except for some rotting tentage and the bowl of our Wobbly Wheel Roller! Our experience and the forethought of the Malaysian Engineers caused them to examine these problems in some detail and the result is that they have built up a family of plant (including a sectionalized Wobble Wheel Roller) especially designed for movement in this way. In December 1963, 69 Gurkha Independent Field Squadron were replaced in Borneo by 68 Squadron Gurkha Independent Field Squadron withdrawn from the Strategic Reserve in England. By this time the Malaysian Engineers were also arriving to share the engineer tasks arising from Confrontation.

68 Squadron carried out the second "air-transported" airstrip at Long Pa Sia in the Interior Residency of Sabah. It was possible to benefit from some of the lessons of Long Seridan in building Long Pa Sia but circumstances did not make this easy and in the main the second operation confirmed the lessons of the first.

After six months re-training in Malaya 69 Squadron returned to Borneo in July 1964 to continue operations in the Central Brigade area. A large programme of air strip construction remained on the books and the first was to be the reconstruction of the strip at Long Akah on the Baram River in the 4th Division.

Long Akah

Long Akah brought a gleam into the eyes of the old hands in 69 Squadron. For a short happy period in early 1963 some lucky Sappers had done some maintenance on the airstrip there and they knew that not all Borneo girls wore cheap white brassieres! Somewhere is a photograph of an embarrassed Gurkha Sapper wheeling a bouncing beauty in his wheelbarrow!

After eighteen months heavy use Long Akah eventually failed and was closed to fixed wing aircraft after a Twin Pioneer crashed on landing.

Captain John Croft did his recce with great care and a few test holes showed that the runway was based on a material whose consistency closely resembled rice pudding! His insistence on bringing back soil samples although causing a certain amount of friction with his helicopter pilot showed on analysis that all was not lost. Rumour, probably based on fact, said that the strip was built by John Seel, The Director of Civil Aviation Sarawak, during vacation using local labour. The holes had been filled by cutting down trees and the fill compacted by human feet! Even so it had given good service and lasted well but what now?

The site was the only possible one in the area, the flying approaches were good but the suggestion that we should push the existing strip into the river and start again from scratch seemed a bit time consuming and drastic!

Eventually we decided our best plan would be to improve the surface, sub-surface and side drainage, compact as thoroughly as we could having dug out the worst patches, and surface the strip anew.

Surfacing was a problem. Turfing was unacceptable as a solution, because although it would suffice to bind the surface it would add little to the strength and in any case would keep the strip out of commission except for emergency use for about six months. A possible solution was to surface using gravel crushed from stone won from the river. The main disadvantage of this course was our dependence upon a long period of fairly low water on the Baram River. This was a chancy business at best and must lead to very haphazard arrangements because we had no reasonable means of getting a drag line on site and the gravel would have to be won from exposed banks by hand and using the Ferguson 203.

In order that the job should be done properly and completed as quickly as possible and also to improve the surface strength it was decided to surface in PSP. Sufficient stocks of this were stacked on Brunei airfield having been placed there for emergency use about a year before but the lapse of time and rotation of Headquarter staff resulted in an impression that the PSP was for some specific emergency. Fortunately OC 69 Squadron knew that the original idea was for *any* emergency. It would also be possible to get the two hundred tons of PSP and assorted stores the two hundred odd miles from Brunei to Long Akah by road and river.

Having made our plans for the way we would do the job we then made our plans for the airlift of the equipment we would need for the job. It was not a practical proposition to move the plant by river due to the size of craft available for the last leg of the journey. Our bid was for two of the original Caterpillar D4 and one Wobble Wheel Roller. This would require three MSP for the two D4 and one for the roller. The balance of one Ferguson 203 with ancillaries, one towed Allen-Oxford grader (bought second-hand from the RAF Airfield Construction Organization in Singapore) and various vibrating rollers were to be lifted in by helicopter. In the light of Long Seridan experience the bowl of this Wobble Wheel roller was sectionalized on site by 69 Squadron Workshops and subsequently moved by Scout helicopter to its next task.

Captain Duncan Morris with A Troop went in as soon as possible to establish themselves in a defended camp on the site and carry out some patrolling because in this particular area they were very much out on a limb. The Kenyahs of the Baram are however extremely loyal and it would be unlikely for any Indonesian to come across the Border without his presence being immediately reported upon. In addition to these tasks Duncan had of course to get the site planning and organization complete.

On the appointed day the drop came in and although the weather was poor and the DZ only of about half the five hundred yard square size laid down in Volume III of *The Manual of Joint Warfare* all four MSP came down on the old airstrip which was the DZ. The move of the other equipment as underslung knocked-down loads by RN Wessex 2 was straight forward except that we opened up one intermediate Landing Site where the aircraft refuelled and thus increased their payload.

One of the D4 broke down almost immediately after arrival and proved our point concerning doubling up of the main equipment on site. It provided an immediate source of spares on site for the other machine however and as such was invaluable. We had endeavoured to ensure that the D4s came in with complete FAMTO dropped on the platform with them but the tie up between staff, Engineers and AASO at the mounting base in Singapore had failed to ensure that this happened.

Simultaneously with the air move of the plant we began the move of PSP, fuel and other stores from Brunei to Long Akah. This was a distance of about two hundred miles and was accomplished in a surprisingly smooth combined operation involving the Engineer Stores Detachment in Brunei, the Gurkha Army Service Corps, 10 Port Squadron RE, a motley collection of native boatmen and 69 Squadron.

The stores were moved by GASC transport for the first 85 miles over roads varying from excellent to sand track to the mouth of the River Baram where they were transhipped and carried by a 10 Port Squadron RPL for the first 90 miles up the Baram. At Long Lama the RPL were unloaded and for the last 120 miles the stores were moved by long boats powered by 40 hp Johnson outboards and driven by local boatmen. PSP was an ideal cargo for these long but narrow boats because of its shape and some of them could carry loads of up to 4 tons. The light plant also moved to Long Lama with the PSP and from there was lifted to Long Akah by RN Wessex helicopters.

"A" Troop was dogged by bad weather and plant breakdowns throughout the Long Akah operation and it eventually took from 28 September 1964 until 12 February 1965 to get in the twenty-eight working days which we had estimated would be required of the force we put in for the operation. Sic transit gloria 69 Squadron!

In addition to the airstrip project the Troop and equipment were able to carry out a number of useful "Hearts and Minds" jobs including an earth road, a 70 ft bridge and a site for a mission hospital. The latter operation involved the construction of an improvised Class 12 raft to carry the D4 against a 5 knot current. Six Johnson 40 hp engines mounted on the raft made this possible.

"A" Troop 69 Squadron were in Long Akah from 30 August 1964 until mid-June 1965 and then moved themselves and their equipment further upstream to Long Banga and another similar task. One of the D4s was written off as BER and abandoned in Long Akah.

From Long Akah, Duncan Morris moved his Troop and his equipment straight to Long Banga about fifty miles as the crow flies and nearer to the border.

Experience now began to pay off and Long Banga proved one of the Squadrons most successful projects. The task was completed well inside the planned time but ironically "A" Troop had to remain on site to water the grass they had planted. This SRT strip was completed with all the following ancillaries:—

(*a*) Dispersal areas
(*b*) Concrete helicopter pads 75 yds away from the strip
(*c*) Fuel dumps well clear of the strip
(*d*) DZ for supply drops clear of the strip.

Meligan

Throughout the early part of the Long Akah operation Captain David Philpott of 69 Squadron had been standing by waiting to carry out an airstrip recce at Meligan which is situated in South West Sabah close to Brunei and Sarawak and as such, important for its position on the route from the interior of Sabah, Sarawak and Indonesia to Brunei and the coastal areas.

Meligan already had a very rough strip suitable only for Single Pioneers but which had broken up and become unserviceable. It was now planned to build a new strip and Philpott was waiting to go in with a Twin Pioneer pilot to find a site and confirm its suitability particularly in regard to approaches. Sabah unlike Sarawak contains many areas of open "grassland" free of dense jungle. Meligan was one of these and thus it was possible to carry out a useful Joint Recce right at the start.

Philpott's recce eventually resulted in a plan for a runway with over runs, and a large parking area. The working area was to be surfaced with 3 in of crushed river gravel of maximum size of $1\frac{1}{2}$ in. The gravel was to act as a wearing surface only which would drain quickly and also prevent erosion of the compacted clay base. Grass in contrast would have been cheaper and quicker to lay (but would need subsequent growing time) but holds surface water and tends to make take-offs longer. Furthermore grass cannot stand up to more than forty aircraft movements per week in Borneo due to consequent erosion and rutting. This gravel surface was not designed as a pavement as the compacted podzolic clay base was calculated to provide a CBR of at least 7 which is ample for SRT aircraft of Twin Pioneer and Andover types.

It was originally estimated that the project would require six months work by the Troop equipped as shown in Table 1. In the event it took about six to eight weeks longer than planned. In this case it was not weather which caused the greatest delays but breakdowns of the plant and the delays which arose in providing the spares. Only about 35 in of rain fell during the project and although this is equivalent to the annual rainfall in Manchester it is only one quarter of the annual average for Borneo.

Captain Mike Calvert of "B" Troop arrived on site with S/Sgt Cross the Military Plant Foreman (MPF) and a small administrative detachment on 1 March 1965. Work started on 1 April and the first aircraft landed on 4 November 1965.

The Fly-in

The main body of "B" Troop came in by helicopter on 6 March and in addition to sixteen 1-ton containers which brought in stores for the camp and basic stocks of POL, rations, ammunition and defence stores the Troop received between 8 March and 19 March a total of eight MSP carrying a variety of earth moving equipment weighing a total of 56,200 lb and eighteen helicopter sorties bringing in 38,073 lb of "knocked-down" equipment. One underslung helicopter load was accidentally released over the jungle and in spite of an intensive search on the ground was never recovered.

Details of the heavy-drop and fly-in of the equipment are shown at Table 1. This was not without its excitements because although the area selected for the DZ was the largest and most open that we had been able to offer in the last two years it was obviously not without its difficulties as will be seen from the remarks column of Table 1.

TABLE 1

Airdrop and Helicopter Lift into Meligan

Date	Means of Delivery	Weight (lb)	Details of Load	Remarks
8 March	MSP 1	N/A	Fordson Super Major Wheeled Tractor	Overshoots DZ and ends upside down in river. Recovered and after minor repairs, works throughout project
8 March	MSP 2	N/A	Fordson Super Major Wheeled Tractor	Dropped with one battery not fitted. Cannot be started or towed off DZ because of accident to No. 1 and because No. 1 has different electrical system
9 March	MSP 3	N/A	D4 Tractor less blade and CCU	Successful drop but only 20 yds from river. Starts immediately
9 March	MSP 4	N/A	D4 blade and CCU	Malfunctions and digs deep hole in DZ. Load is robust and therefore undamaged but Stub axle and Jack Lever Arm bolts are missing therefore cannot be fitted to D4
10 March	MSP 5	N/A	Morewear Dumper	Undershoots DZ. Platform and load fall off DZ, 50 ft down cliff. Only slight damage to load and successfully recovered
10 March	MSP 6	N/A	D4 Tractor less blade and CCU	Successful drop and it is noted that Stub Axles are fitted but Jack Lever Assembly Pins missing
11 March	MSP 7	N/A	D4 blade and winch	Successful drop but as previously due shortage essential parts cannot be fitted to tractor
11 March	MSP 8	N/A	Wobble Wheel Roller	Successful drop
10 March	Belvedere Sortie 1	2,556	Backacter for Ferg 203 complete	Underslung in Cargo net
	Belvedere Sortie 2	2,000	Buckets and blade for Ferguson 203	Underslung in Cargo net
	Belvedere Sortie 3	2,352	Mixed load of parts for Ferguson, Conveyor and Stone Crusher	Underslung on SWR strops
	Belvedere Sortie 4	2,002	Mixed load of parts for Ferguson 203, Trans-Atlas Grader and Conveyor	Underslung in Cargo net
11 March	Belvedere Sortie 5	2,238	Mixed load of parts for Trans-Atlas Grader and Ferguson 203	Underslung in Cargo net
	Belvedere Sortie 6	2,422	Rear wheels for Ferguson 203, Hydraulics for Trans-Atlas Grader	Underslung in Cargo net
15 March	Belvedere Sortie 7	1,500	Mould board circle, Telescopic rams and linkages for Trans-Atlas Grader	This load was accidentally dropped into the jungle and never recovered
17 March	Belvedere Sortie 8	1,500	Back axle Ferguson 203	Underslung on SWR slings
	Belvedere Sortie 9	2,500	Engine for Ferguson 203	Underslung on SWR slings
17 March	Belvedere Sortie 10	2,240	Trans-Atlas Grader Frame	Underslung on 10,000 lb chains

Date	Means of Delivery	Weight (lb)	Details of Load	Remarks
18 March	Belvedere Sortie 11	2,000	Parts for Stone Crusher	Underslung on SWR slings
	Belvedere Sortie 12	1,933	Body for Stone Crusher	Underslung on SWR slings
	Belvedere Sortie 13	2,332	Chassis of Stone Crusher c/w axles and wheels	Underslung on SWR slings
18 March	Belvedere Sortie 14	2,043	Engine and screens for Stone Crusher plus boxes of spares	Cargo Net Underslung
19 March	Belvedere Sortie 15	2,457	Bowl of Scraper	Underslung on 10,000 lb chains
	Belvedere Sortie 16	2,851	Tyres, hydraulic hoses Ferguson parts, Jerry cans	Carried internally
	Belvedere Sortie 17	2,753	Yoke, drawbar wheels and tailgate of Scraper plus misc items	Underslung in cargo net and carried internally

Although loads can be dropped very accurately from both Beverley and Argosy and presumably C130, Hercules too, this accuracy is dependent upon the following factors, amongst others:—

(*a*) Accurate knowledge of the height above sea level of the DZ. This in turn enables the aircraft height to be accurately measured. DZ height can be found using a helicopter altimeter.

(*b*) Clear DZ marking. Centre, corners and 100 yd distance markers down the side.

(*c*) Clear indication of wind speed and direction.

On completion of the fly-in the equipment on site was as shown in Table 2. The times taken to knock down and reassemble items brought in by helicopter are shown.

TABLE 2

Airdrop and Helicopter Lift into Meligan

Item	Delivered	State	Timings Knock-down	Timings Reassemble
1. Fordson Major	MSP	Serviceable. Fell off DZ. Recovered from river and repaired. For Morewear Dumper		
2. Fordson Major	MSP	Serviceable. Battery missing on delivery subsequently flown in. For Trans-Atlas Grader		
3. D4	MSP	Base machines serviceable but blades not fitted due missing essential items		
4. D4	MSP	Stub axles eventually found on DZ but Jack Lever Arm bolts missing. Also Woodruff keys lost from Winch		
5. Morewear Dumper	MSP	Serviceable. Fell off DZ. Damaged on delivery but machine recovered and repaired		
6. Wobble Wheel Roller	MSP	Serviceable		

7a. Ferguson 203 Tractor	Belvedere lift	Rear end equipment hydraulic leads damaged. Brakes unserviceable due to loss of linkages. Steering unserviceable due loss of Woodruff keys		
7b. 710 Digger	Belvedere lift	Unserviceable due broken hydraulic pipes	1½ hrs	2 hr
7c. 702 Loader	Belvedere lift	Unserviceable due broken hydraulic pipes		
7d. 712 Blade	Belvedere lift	Serviceable but cannot be used due damage to base machine		
8. Trans-Atlas Grader	Belvedere lift	Unserviceable due loss essential parts in accidental release over jungle	1 hr	—
9. 4/6 cu yds Le Tourneau Scraper	Belvedere lift	Serviceable but cannot be used due unserviceability CCU of D4 tractor	2¼ hrs	3 hrs
10. Stone Crusher	Belvedere lift	Serviceable but discharge chutes damaged	2½ hrs	3 hrs
11. Belt Conveyor	Belvedere lift	Serviceable	N/A	N/A
12. Vibrating Rollers	Belvedere lift	Serviceable		

By 1 April the plant was in a condition ready for work. Difficulties had arisen, however, which showed the need for an efficient control organization at the point where loading on to the MSP takes place, where machines are knocked-down and loaded on to helicopters and of course at the delivery point. This is necessary to ensure that machines go forward complete with such items as batteries, FAMTO, any necessary re-assembly tools, additional spares and with any loose items securely fastened in place or in a separate container. The loss of Woodruff keys delayed getting the D4 winch into use and because its oil seals were unserviceable on arrival the other D4 could not use its CCU. Basic items such as filters, tyres and tubes, drive belts, hydraulic hose, gaskets and oil seals must go in with the machines to avoid subsequent delays.

Because it will often be difficult for the User Unit to supervise the loading of equipment on to platforms because this probably takes place at a rear airfield, Engineer Resources must make arrangements for this. When movement is by helicopter the User Unit should whenever possible arrange for the same team to knock-down and reassemble and also to pack the loose items and any special reassembly tools.

One very important lesson learnt during the fly-out of plant from Meligan was the necessity to work out the weight of each part or bundle of parts well ahead. Knowing this, last-minute adjustments can easily be made to aircraft loads. The pilot must be fully briefed on where he is to put the load on arrival and should be asked for details of his payload during his return journey. For this good communications between the various locations is essential. As a result of good forward planning and an efficient organization in each link of the chain; in 28 Wessex hrs, 58 tons of plant were evacuated from Meligan to a point 30 miles away.

The Earthworks

The site was covered in course grass and bracken growing up to 7 ft high. Attempts to burn this proved unsuccessful and so the roller and tractors were used to get it flat enough for detailed survey.

As was recommended in the report after Long Seridan the system for calculating earthwork quantities set out in RESPB 5c is not accurate enough for sites with significant changes of profile every 100 ft, as the assumption of a constant cross section does not hold. As a result of a number of aircraft recces using this method Calvert suggests multiplying the estimate made by this method by between 1.5 and 2.5 dependent upon site conditions.

Due to density and quantity of vegetation and to the depth of topsoil the earthworks in the initial phase took much longer than expected. This was aggravated by plant breakdowns but the cleared area eventually measured 2,300 × 150 ft and had involved the movement of some ten to twelve thousand cubic yards of topsoil some of which went down to a depth of 18 in. A second survey was now made as a result of which minor alterations to alignment were made to save earthwork.

The runway was built to a crossfall which although simplifying the earthworks made grading the surfacing to an accurate gradient over the full width of the strip more difficult. It would seem that a cambered profile makes control of the surfacing phase easier and also reduces erosion of an unbound and unwaterproof surface.

The crushing plant was set up and gravel winning began early in the operation. Gravel was dug from the river bed using the Ferguson 203 Backacter and hauled to the crusher by the Morewear dumper. For this haul roads were built to the gravel sites and effort expended on these was well worth while. The crusher output was slightly under 3 cu yds per hr calculated against the hours run and produced 1,600 cu yds of crushed gravel.

Grading and compaction of the surface was difficult as the Trans-Atlas grader (new parts borrowed from 4 Malaysian Engineer Squadron were flown in to replace those lost in the fly-in) was not capable of very precise work and the vibrating roller was not fully serviceable. A fair result was obtained, however, and this will improve as settling takes place. Some maintenance will no doubt become necessary from time to time.

Plant

Some comment is necessary because this was the first time that a full family of plant had been put on site. A number of these were "one offs" as far as the Corps is concerned but their usefulness was assessed not only as individual items but as members of the family.

Caterpillar D4. As said previously these machines are now over twenty years old and although their engines were in good order the repeated breakdowns in their transmission systems indicate that they are past economical use and repair. They are being replaced by Caterpillar D4C and D4D which require HSP and by International BTD6 taken over from the RAF Airfield Construction Branch.

Between breakdowns however the two D4 on site ran a total of 2,718 hrs.

Le Tourneau Scraper 4 cu yd (two off, both in FARELF). This proved a great success and a most effective earthmoving equipment. It was heavy on SWR which had to come from England, and the correct size SWR is not available from RAOC sources. The machine worked an estimated 800 hrs on site.

The machine which will fill this role is the Vickers/Onions 4/6 cu yd, a hydraulic machine which was accepted for service in May 1966. It knocks-down with the largest load weighing about 3,250 lb.

Fordson Major tractors. Gave good trouble-free service. Unfortunately the two machines were not identical particularly in their electrical systems. In four-wheel drive in dry conditions the tractor can pull a full 8 cu yd load up approximately 1 in 8 slopes without difficulty.

Morewear dumper. A very useful equipment with a full 8 cu yd capacity. Easily loaded by the current range of bucket loaders and airdroppable on MSP.

Ferguson 203 with loader and digger. By the time this machine arrived on site it had been used on at least two previous tasks in Borneo and others in Malaya.

Its earth movement capability is limited because it lacks power and weight but it is a useful troop tool with its accessories which include Backacter and Fork-lift and towed grader blade. For use in projects of this type where earthmovement is an important factor and mobility is not, the tracked version of this machine the Ferguson 244 is probably a much more effective equipment.

Rollers. The wobble wheel roller is a simple and effective machine and can be towed by a variety of tractors dependent upon conditions. The Ferguson 203 can act as the two in best conditions. Unless the bowl is sectionalized so that it can be knocked down evacuation by the current range of helicopters can be impossible.

Vibrating rollers have a good effect to weight ratio but the nature of their design results in rapid deterioration of the engine in the models used to date in Borneo. RSME is building up knowledge and experience of these machines. For the airborne family of plant they are probably the best answer.

Trans-Atlas grader. A full description of this equipment appeared in Lieut-Colonel Mackay's article. It consists of a hydraulically-operated mould board circle and grading blade fitted to a Fordson Major tractor by fitting a yoke to the rear wheels and mounting the blade and front wheels on this yoke.

Experience at Meligan showed that the machine, although suitable for maintenance, is not man enough for construction.

Chief Engineer Far East has purchased two Allis Chalmers DD graders for evaluation. These machines which weigh about 9,000 lb are in use by PWD in Borneo. Within days of purchase in Singapore one of the machines had been lifted by helicopter into Long Pa Sia in April 1966.

MEXE have successfully knocked-down the much heavier BK 10 into less than 3,000 lb loads and flown these under a Wessex 5 helicopter.

Stone crusher and elevator. These were essential equipments to the task, easily and quickly broken down and reassembled and carried by helicopter.

Conclusions and Lessons

Three years experience of airstrip construction in Borneo has enabled us to draw the following lessons for staff procedures, engineer and air movement techniques and earth-moving equipment requirements:

(*a*) *Joint planning.* Particularly in COIN operations there must be consultation between the service and civil organizations to determine the requirement for the strip in the first instance, the time scale of the operation and the provision of cash for the project.

(*b*) *Joint Recce* by the Engineer and an airman, preferably one with experience of the most critical aircraft to use the strip must take place. Air recce will often suffice but this should always be confirmed by a visit by the

airman to the site after the trees have been cleared to confirm suitability and advise on the clearance of approaches and any psychological hazards to flying.

(*c*) *Co-ordination.* There must be close co-ordination between Engineers, Staff, RAF and AAASO at all echelons. This is particularly important in air dropping operations where the user unit will probably be far removed from the mounting airfield. It is essential that any particular requirements concerning platform loads are passed back and that equipment loaded for air dropping is in first class working order and complete in every respect.

(*d*) *Engineer Recce and Plan.* There is a great deal to be done on site before the first yard of earth is moved. The more detailed the survey and plan the smoother the operation. This is particularly so when delivery of even a bolt and nut or 6 ft length of ARMCO is achieved only as a result of a complicated administrative arrangement. This period also makes possible the assembly on site of fairly large and complicated equipment brought in in the knocked-down state.

(*e*) *Engineer Equipment.* Each operation has been supported by a larger and more diversified selection of engineer plant. From experience the following principles to guide our current and future practice have evolved:—

1. The family of plant must be well tried and include dozers, shovel loaders, scrapers, graders, rollers, and haul equipment. These equipments should have as much commonality as possible to simplify maintenance repair and spares supply. They should also all be transportable by the same means, eg MSP and 3,000-lb helicopter and should not include a "rogue" which requires a greater helicopter lift than available. (The working party on engineer plant has taken these factors into account in its recommendations.)

2. The family of plant must be the heaviest which can be got to the site, employed on the task and subsequently evacuated.

3. The provision system for this plant must be flexible enough to enable heavier or more efficient plant to be bought and the out-dated equipment sold as helicopters and aircraft with greater carrying capacity become available.

4. The engineer plant must be supported by repair and spares supply systems which ensure that machines are returned to the job without delay. There are obvious advantages in using the same makes of plant as those held by PWD and large civil operators in the theatre. The main difficulty of this course arises in the clearance of a multiplicity of machines for air-drop and air-carriage.

5. Techniques and organization for the knock-down movement and reassembly of plant moved by helicopter must be perfected and laid down as drills and operational procedures. The evacuation from Meligan showed what was possible as a result of forethought, planning and organization. (Valuable work has been done in this field by the Engineer Base Installation, Singapore, the Gurkha and the Malaysian Engineers. In 1965 a project began at MEXE which is to examine and lay down knock-down techniques for all engineer plant likely to be employed in this role. The result of these studies and the clearance of the loads for helicopter carriage are to be published so that they are available to all RE units and others concerned.)

Bomb Disposal Royal Engineers 1966

By Lieut-Colonel A. G. Townsend-Rose, RE, MA
Commanding Bomb Disposal Unit (UK) RE

Twenty years after the war many are surprised that there is still a role for the Bomb Disposal Unit RE. Few are aware of how that role has changed and what remains to be done throughout the world. Nor are officers informed on new techniques and equipment which could be of use in many theatres, and of the capabilities of NCOs and men who have qualified in the new trade of Bomb Disposal Engineer.

This paper summarizes the responsibilities of the three Services. It outlines Engineer tasks remaining in this country and overseas and the current Engineer organization, equipment and techniques. The opinions regarding future world-wide Engineer BD deployment are those of the author, but not his alone.

Responsibilities, Tasks, and Organization

The responsibilities of the three Services are laid down in the pamphlet *A Planning Guide to the Division of Administrative responsibility between the RN, Army and the RAF in Operations WO Code 2276.* Broadly the Royal Navy deals with all weapons found below high water level and on Admiralty property. The Royal Air Force deals with all British bombs and aircraft weapons, and all weapons found on Air Force property. The Royal Engineers are responsible for three main tasks in this country: firstly to deal with any remaining German bombs, secondly to clear the remaining anti-invasion "B type "C" beach mines, anti-tank mines, bridge mines, etc. which of course were laid under Engineer control, and thirdly the methodical clearance using mine detectors, of wartime (1914 era included!) and post-war training areas which have been, or will be, returned to civilian use. In the case of beach mines, the responsibility is to clear them down to low water mark. The Royal Army Ordnance Corps is responsible for the clearance of any ammunition otherwise found which is normally reported through the police. The division of tasks within the Army in this country is laid down in a Home Office circular and has presumably not been subject to staff discussion. The agreement was at working level and illustrates the good (and necessary) liaison between RE and RAOC.

The current rate of bomb clearance is between five and fifteen a year. Ten years ago it was eight to twenty and so it is clear that there will be a job to do for many years yet. Many bombs are found by contractors working in quarries, reservoirs, and on building and road contruction sites. Some are found by the BD Squadron after careful reconnaissance, borehole location and shafting. Certainly most German bombs are in an excellent condition and will be dangerous for many years yet.

The clearance of beach mines is a simpler problem. About forty are destroyed each year, this being about 0.15 per cent of those laid and clearly within the limits of human error in the laying or clearance stages. Furthermore the number being found is decreasing at an exponential rate within a half life of about two years. It was on this evidence that the beach at Mundesley in Norfolk is being opened to the public. Although over 100 mines

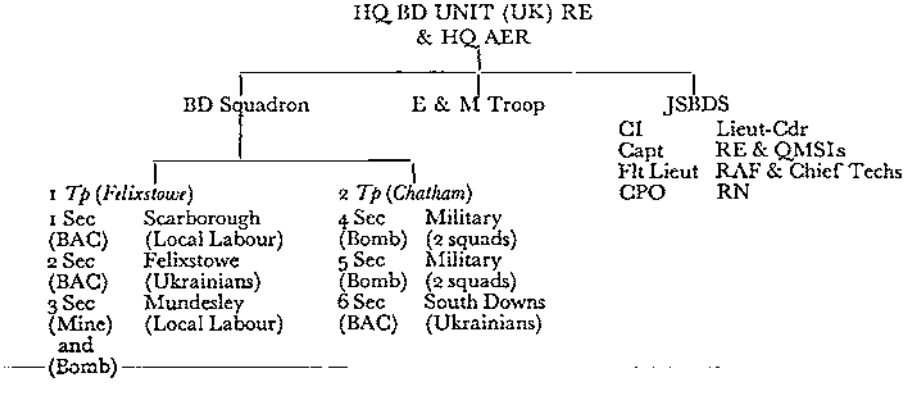
are still officially unaccounted for, the number being found has decayed to one a year, two being found in 1963 and four in 1961. To maintain a party on this 3 mile beach is clearly bad economics when more mines are being found on highly populated public beaches elsewhere. Most mines are deteriorating from salt water action but some are in excellent condition. Luckily the greatest finds are after the equinoxial gales outside the summer holiday season. In 1965 the unit cleared a bridge of chamber charges, and sincerely hope this was the last.

Battle Area Clearance was taken over in 1962 from a number of civilianized BAC units. The main tasks are at Fylingdales (Scarborough), Orford (Felixstowe), the South Downs (Brighton) and vast areas in North Devon, South and North Wales. There are also many farms still to be completed and jobs to do on current training areas which are being re-afforested. At Fylingdales and in Wales the work is tied to a Forestry programme. Overall the task is still enormous and it is difficult to estimate a time for completion.

The organization of the Bomb Disposal Unit Royal Engineers is shown in Fig 1. The Squadron is formed into two composite troops covering the north and south of England respectively. Some sections are firmly based, but others have a very mobile life. The manpower is mixed military and civilian but each section or bomb squad is commanded by a sergeant with a corporal as second-in-command, one of whom is present at all times with a vehicle and full first-aid equipment. An essential part of the squadron headquarters are the central bomb, beach and battle area clearance records. The OC spends much of his time corresponding with local authorities and forestry branches trying to create satisfied customers with his meagre resources.

The Unit Headquarters administers the Joint Services Bomb Disposal School which trains Naval Clearance Divers, BD Engineers and RAF BD Technicians. RAOC ammunition courses visit the school for one day, but the RAOC does not provide an ammunition instructor, nor are any RAOC men trained in bomb disposal. The School has Joint Service instructors, the Chief Instructor being Joint Service in rotation. The E & M Troop handles all heavy equipment, pumps, boring rigs, etc and serves both Squadron and School. The Headquarters is also (at the time of writing) HQ AER for three BD (AER) Regiments. The whole unit moved from Horsham to Chatham in August 1966, into a magnficient new barracks at Lodge Hill.

FIG 1



Equipment and Techniques

In addition to numbers of fire, sludge and submersible electric pumps, compressors and generators, armoured dozers, winches, cranes, pile drivers and excavators, all of which should be well-known throughout the Corps, there are several interesting equipments in use in the unit.

The transistorized mine detector No 4 C continues to be widely used for searching for any metallic (conducting) material, and over 100 are in daily use. For many years BD has used a comparative magnetometer (known as the ERA) which compares the earth's field in two "flux gates" at either end of a non-magnetic tube. Fully transistorized instruments have been available for some time for both surface and borehole work from the Dr Forster Institute. Fig 2 shows the Model 4013 surface locator and Fig 3 the Model 4014 borehold locator. These instruments will of course only locate ferrous or other magnetic materials (including magnetite boulders!) and there is a clear distinction in BD between detection and location. A surface locator will find a 250 lb bomb at 20 ft or a rifle buried at 10 ft! The 4013s are one-man instruments, do not require warming up and settling down periods ($\frac{1}{2}$ hr for ERA locators) and are not tied to bulky stationary amplifiers. Their use has trebled the output per man in beach mine and other surface locating roles. Borehole locators are needed to find deep buried objects. The 4014 was used by the RN in Malta harbour and in the mud of a Berlin lake where, in the hands of a Sapper NCO, it located certain aircraft engines. Locators cannot be used like detectors. Their readings, along north-south lines, must be plotted, converted into Gauss and Gamma and finally interpreted. It is interesting to note that one torch cell powered Forster locator off the civilian market is less than half the price of the Military-designed gradiometer and the relative battery costs for 50 hrs working are of the order of 5*s* to £15, the latter for special mercury cells which are dangerous when expended.

There are two interesting boring machines. The Boyles trailer-mounted mud-flush rig continues to be the best BD equipment in use. It has been adapted for air-blast boring with advantages and disadvantages but clearly vibration and hammer-in-the-hole techniques are not suitable for boring down to delicately fused bombs. The other equipment is the auger, and by far the best is the Australian Proline Auger (Fig 4). Users, when writing their requirements, often wrongly say they want a "manpack" equipment, which later becomes converted into "maximum component weight" terms. BD requires the "best possible auger" which can be humped by four men into the back of a lorry, over a garden wall, or up a railway embankment. It must also go through (in pieces), narrow gates and be able to bore holes very close up to walls. The Proline will dig a 4 -in diameter hole 40 ft deep in many soils in an hour or two. Holes are unlined but we have not yet had to dig out a locator search-head. It will also dig larger holes. Clearly some understanding of geology is needed if machines are to be used to their best advantage and the BD unit uses the 1 in solid and drift series maps of Great Britain, with some success.

In many situations hand excavation is still necessary and many BD NCOs become extremely proficient at timbering shafts. For cost effectiveness reasons the Calweld mechanical excavators (Fig 5) are used where possible, and techniques of using the 9 ft diameter fibre-glass linings are still being

developed. In particular the US Army EOD staff is interested in this MEXE adaptation of a US machine!

When shafts become waterlogged (or if a shaft is being dug 20 ft beneath the Thames water level as on the Hammersmith Bridge Coffer Dam job) there is need for pumps capable of dealing with mud laden salt or fresh water, without producing fumes. BD favours electric submersible pumps of the SUMO variety and one pump is being converted to 400 cycle wiring for trials. Such a pump would surely be of use within the Corps.

The most important new technique is the development of small charges to initiate low order detonations in fillings or to cut weapons without detonation so that their contents can be burnt. A working party has been formed with RARDE, RN, RAF, and JSBDS representation to study past UK and foreign reports and to plan and carry out trials. Liaison has been built up with the US EOD branches and with the Royal Netherlands Air Force who have been clearing British bombs by these methods. The cone charge X1E1 contains about 1 oz PE and the curvilinear cutting charges are similarly filled. Details of their employment cannot be discussed here. Suffice it to say that beach mines have been destroyed without even cracking beach hut windows 30 yds away, and techniques have been developed to deal with weapons from mortar bombs to 1,000 lb aircraft bombs. The last trial included the disposal of a very large rocket motor.

Joint Service Training

Responsibilities for bomb disposal in war are enumerated in APSE 72. However, bomb disposal engineers are more schizophrenic than any other tradesmen, being completely concerned with bombs, mines and ammunition of the past to the point of their own safety. Yet they have to understand the implications of the "render safe procedures" for solid and liquid propelled guided weapons, the hazards of their guidance systems to the disposer, and the hazards of their various warheads and other lethal contents which includes compressed air! The school also teaches sailors, sappers and airmen the disposal of chemical weapons. In all these subjects it has the experience of the three Services to call on and subjects are allocated to the instructor best suited to each. The Royal Navy in particular teaches gamma radiography (not to be confused with magnetic gamma) and so-called "low order demolition" techniques. BD engineers are trained to handle all current BD equipments including low order techniques. They are taught, for instance, to deal with LOX and RFNA and the dangers of alpha emitting material. They are taught the law regarding the transport of explosives and handling of radioactive sources.

The introduction of a trade for BD engineers has defined the standard for training, has raised the levels of knowledge and skills and has produced a new qualification in RE Records. It is now possible to post men with BD experience into the senior posts of the Squadron and School, although this is in no way meant to be desparaging to the present incumbents. It can only be regretted that the RAOC cannot provide an instructor to teach land service ammunition, but the subject is well covered by a Sapper. The School maintains the central BD library and was even able to recognize an old American bomb when described by the Americans in the Philippines! Hence the School is more than a teaching establishment, and is the fount of BD knowledge where new techniques are discussed and new equipment tested.

The World-Wide Picture

The Royal Navy maintains groups of BD trained clearance divers at sea and in various ports at home and overseas. The Royal Air Force has one BD squadron and two flights in the UK and groups on airbases overseas. The RAOC has ammunition technical officers wherever land service ammunition is supplied at home and overseas.

In addition to the BD Squadron in UK there are two groups of locally enlisted BD engineers overseas, in Malta and Hongkong, whose officers and NCOs attend courses at JSBDS before taking up their posts. These groups only deal with a few incidents each year, and BD has become very much a secondary role for them. Nevertheless there is a major disposal job in Penang Island where there are hundreds of Japanese, 60 kg, 250 kg, and 500 kg bombs buried in pits and tunnels at two major sites. These are also islands in the Pacific which still need clearing, and tiny Betio in Tarawa has just been cleared by a party from UK of over 100 tons of Japanese and American shells and bombs. These are relics of the last war, but the Americans are concerned with more recent incidents in South Vietnam. It is worthy of note that members of the RAOC have lately earned distinction in Aden, dealing with enemy parcel bombs. There was a time when the Royal Engineers considered dealing with booby traps their prerogative.

The Future

As BD engineers pass into the field units, Squadron Commanders will find they have valuable tradesmen. With a modern locator they will be able to find buried arms; with a charge X1E1 they will be able to destroy a shell or mine without damaging property; and with a Proline Auger in the Field Park, post holes and very deep field latrines should present no problems! All BD engineers should also be "Whiz-kids" with pumps and mine detectors!

It seems to the author that the present BD groups in Malta and Hongkong are no longer established where the major work is likely to be. The problems of local enlistment and their other responsibilities would seem to debar them from employment far from their bases, and they soon become out of date with the latest BD skills. A solution would be to remove the letters (UK) from the BD unit (UK) RE and to increase this unit's military manpower to enable it to deploy small squads on long detachment overseas. Support could then be obtained from field units in the theatre concerned.

The Corps should become re-aware that they are explosive experts, and Field Squadron personnel, with or without BD engineer tradesmen, should deal with all enemy mines and booby traps.

Fig 2. JSBDS Instructor with Forster 4013 surface locator.

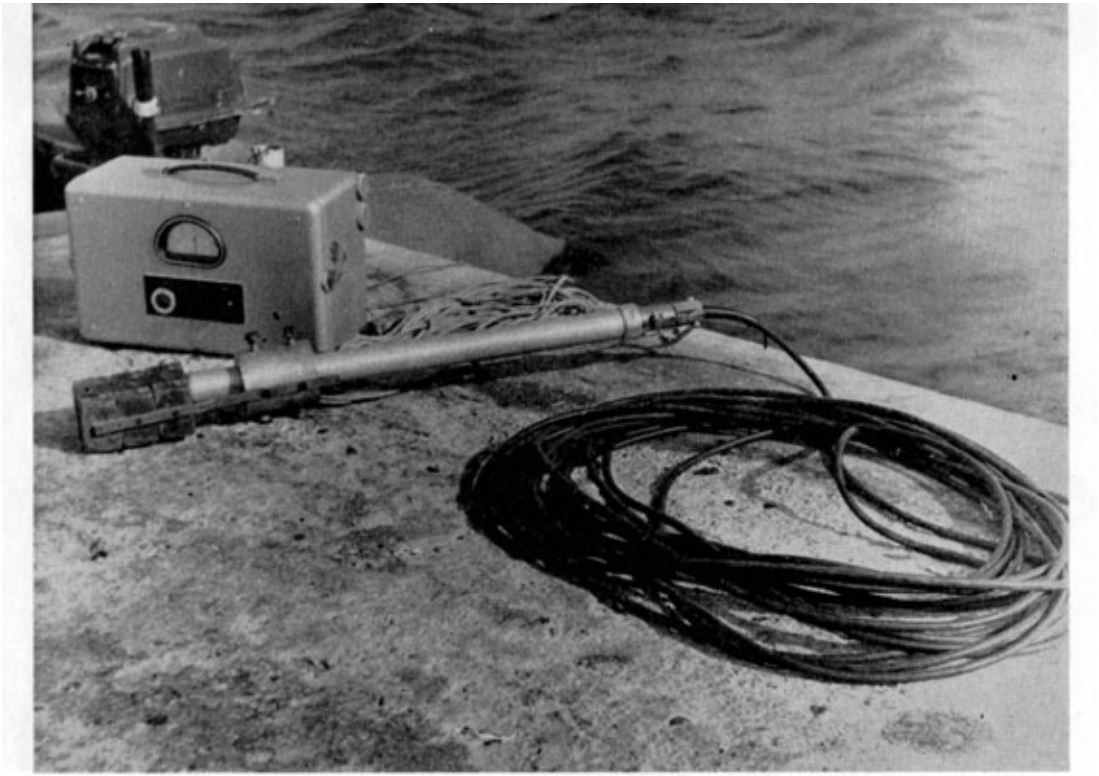


Fig 3. Forster 4014 borehole locator ready for RN trials (buoyancy has been added to the search head)

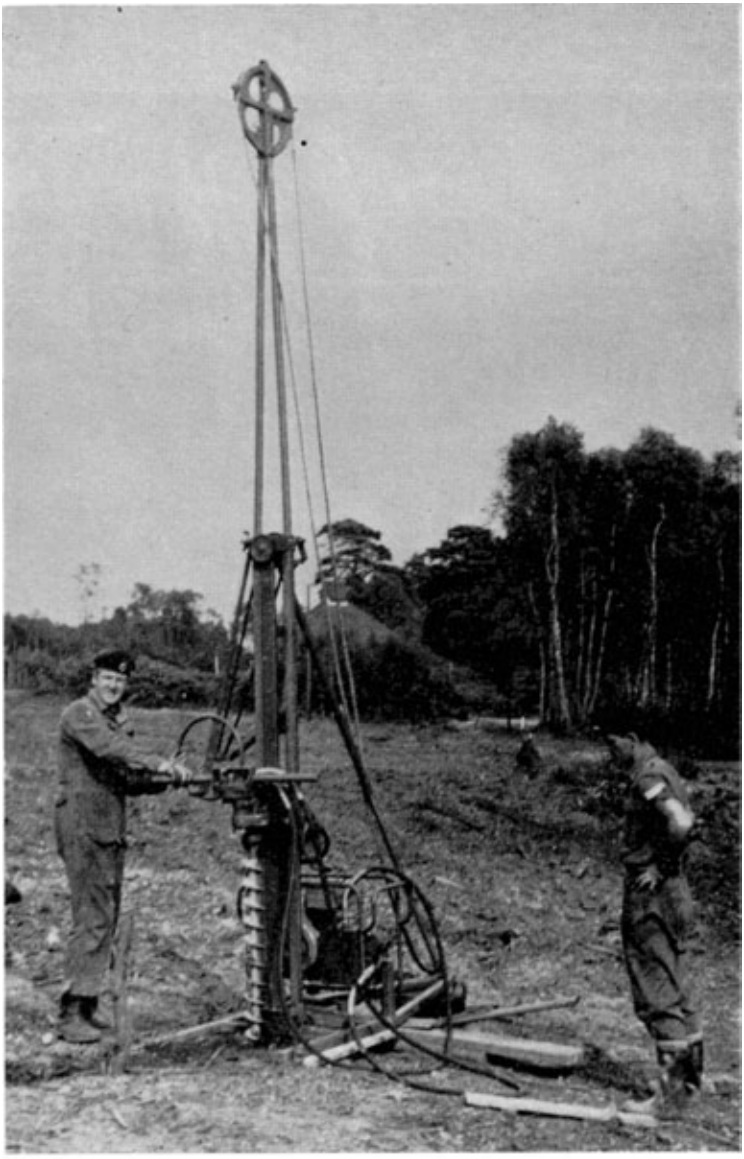


Fig 4. Proline fully-fluted auger at work

Fig 5. Calweld excavator working with Drott tractor

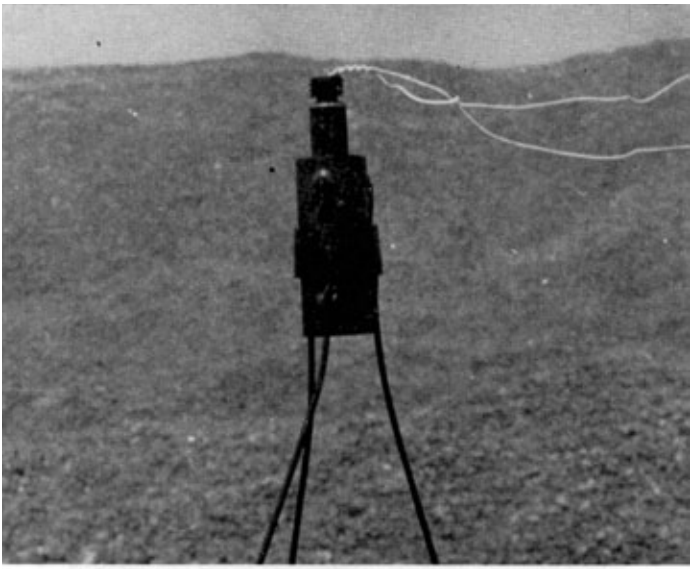


Fig 6. Container charge XIEI

Fig 7. Result of attack on a 500 lb aircraft bomb

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The Use of Nuclear Explosives in Defence Planning

By MAJOR D. R. WHITAKER, RE, MA, MINUC E

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EVERYONE has heard of nuclear weapons, but few of nuclear explosives. Yet there is the same connexion between the two as exists between conventional high explosive weapons and the high explosives which are used by civil and military engineers for many purposes. Both have warlike and peaceful uses, and it is as logical to use the magnified effects achieved by nuclear over conventional explosives for peaceful achievements as it is to use it for warlike advantage. Generally speaking, the more massive the earth-moving task, the more economic does the use of explosives become, the limit usually being defined by the proximity of habitation and installations which might suffer blast or ground shock.

The Russians appear to hold the record for large conventional explosions. According to a Russian article, a quarry in Northern China, near Lanchow, was rendered suitable for open-cast mining by single detonations underground of 1·64 kilotons (1,640 tons) of high explosive in July 1956, four kilotons in November, and 9·2 kilotons in December of the same year. The article states that some 22 million cubic yards of rubble was removed and some 10 million cubic yards of rock was broken. In 1964 they used about nine kilotons in a single detonation to dig a nine-mile ditch in Bokhara. To emplace this last amount of explosive must have required the excavation of some 10,000 cubic yards of underground chambers, all with access shafts.

About eight years ago interest began to develop in the possible use of nuclear explosives for engineering purposes. The United States Atomic Energy Commission, in particular, launched a research programme called Plowshare and have since issued numerous reports on the development of possible applications. Although the Russian 9·2 kiloton high explosive shot referred to above probably consisted of many separate emplacements to achieve maximum effect, it is to be noted that a nuclear device of equivalent energy would be contained in a volume of about two cubic yards, compared with the 10,000 cubic yards in conventional form and would cost, according to A.E.C. published prices, about one-tenth the price.

The economic advantage of being able to use these small, cheaper packets of enormous energy has provided the incentive to overcome the problems arising from the essential difference between conventional and nuclear explosive effects. This is the radioactivity derived from the fission processes in the device and from the activity induced into the surrounding medium. These problems, as reported by A.E.C., are gradually being overcome and it is suggested that, in future planning, be it for civil or defence purposes, account should be taken of the possibility that nuclear explosives may become available within the next few years in spite of the technical and political difficulties of their use that are currently apparent.

Before discussing the implication of this technology on defence planning, it is necessary to review the extent to which it is now developed. Generally speaking, the possible applications of nuclear explosives divide naturally into two categories. In the first the device is fired deep underground. A cavity is formed having a lining of molten rock which forms a puddle at the bottom of the cavity and which entraps the major part of the radioactivity. The medium above the cavity then usually caves in and a chimney or cylindrical zone of broken rubble extending upwards results. Around the cavity a considerable volume of the medium is crushed and fractured. A one-kiloton device would produce a chimney with a diameter of perhaps 80 feet and a height of 200 feet: a 100-kiloton device would produce a cavity with a diameter of 400 feet and a height of 1,000 feet. This application offers a possibility of mining more easily ore bodies and other mineral deposits, and has the advantage of little or no radioactivity escaping into the atmosphere. It has also been suggested that underground storage caverns for things like natural gas, or for waste radioactive isotopes.

In the second application the device is placed at a depth such as to produce a crater on the surface. An extension of this technique is a row of devices so placed that, when fired simultaneously, it will form a continuous trench. Obvious uses for large, single craters are as reservoirs for water storage and as harbours. A deep, round 'instant harbour' with a diameter of about 1,000 yards could be constructed with a two-megaton explosion, the crater either cutting across a coastline or being formed a few hundred yards inland and having a narrow channel, also blasted by nuclear explosives, leading to it from the sea. A row of charges could be used for blowing a cutting to take a road, rail, or canal through mountainous country. Conventional excavation techniques limit such cuts to a depth of 100 to 150 feet, but nuclear explosives would allow ten times this depth, or perhaps more. Excavation of the ditch for large ship-carrying canals across level country is also a much studied possibility. Other uses of cratering charges include the construction of channels up gently shelving beaches to give beach landing facilities, the clearing of passages through coral reefs, the removal of underwater hazards to shipping, the production of aggregate for road building and similar projects, the construction of slide dams to form reservoirs, and the creation of landslides to block defiles.

Crater and cavity dimensions resulting from nuclear explosions of any size can be predicted mainly as a result of data obtained by the U.S.A.E.C. They have fired a number of single nuclear charges and many high explosive single and row charges in a variety of media, specifically to obtain the data required for such predictions. The Project 'Sedan' 100-kiloton shot, which formed a crater 1,200 feet across and 300 feet deep, roughly the diameter of Trafalgar Square and twice as deep as Nelson's Column, was the largest of these experiments.

There seems, in fact, every prospect that all the problems associated with the use of nuclear explosives for civil engineering have been sufficiently mastered, with the possible exception of radioactivity. A great deal of attention is now therefore being focused on the suppression of this radioactivity. By the development of clean devices, that is to say, devices which have only a small fission content and derive most of their energy from the fusion process, and by the use of certain emplacement techniques, activity levels are being substantially reduced. The A.E.C. has published the fall-out pattern pro-

duced by the 'Sedan' event when it was fired in 1962, and have compared it to the fall-out which would have occurred if the experiment had been conducted in 1965 and the fall-out levels which it is thought possible to achieve in the near future. The comparison shows a hundred-fold reduction, so that there is every likelihood that it will be reduced to acceptable levels and that the dominant safety considerations will be blast and shock.

The A.E.C., for whom the American Army Engineers do quite a lot of work, demonstrate the confidence they have that nuclear explosives will be accepted as an engineering tool by the effort they are putting into studies of the Isthmian Canal scheme. The present Panama Canal is rapidly becoming inadequate for modern shipping and the cost of making it into a sea-level canal, over $2,000,000,000, is about three times what it could cost to build a new canal using nuclear excavation techniques. It is proposed to use a total of between 160 and 270 megatons of nuclear explosives in many charges, the actual amount depending upon which of two possible routes is chosen. This is scheduled to be prefaced within the next two to three years by a demonstration of the techniques within United States territory in a project called Carryall, which involves a two-mile road and rail cutting through the Bristol Mountains in California, and which will use two megatons of nuclear explosives in 22 charges. Much depends on this project. If it demonstrates successfully the feasibility of using nuclear explosives, not only will the construction of the Isthmian Canal by this method become more likely, but numerous large civil engineering projects all over the world, hitherto regarded as too costly or impossible by conventional means, may be undertaken in a similar way.

Although for the purpose of future planning it may be presumed that radiation hazards will be reduced to controllable and acceptable limits, it has to be remembered that there will still be the effects of blast and ground shock, just as there would be from very large conventional explosions. There is certainly no chance of ever creating a second Serpentine in Hyde Park, for instance, with an explosion. However, it is generally in the remoter, little inhabited parts of the world where large geographic engineering schemes which could use nuclear explosives are required, the unfriendly terrain accounts for the lack of population. The distances at which damage starts to occur—and this is normally falling plaster and cracking shop windows—depends on meteorological and geological conditions, and can be predicted for any particular situation and minimized by firing under advantageous conditions.

The application of nuclear explosives to defence planning can be direct or indirect. Overseas development clearly offers a huge field for such techniques, and projects connected with it, such as road and rail building, have definite if indirect defence implications. Under-developed countries normally require large, expensive engineering projects to provide electrical power, to control water distribution, and to improve communications. The first two aims are often interconnected, a dam being built to form a reservoir, thus giving a suitable head of water for a hydro-electric scheme as well as a stabilized flow for irrigation purposes. Examples of such schemes are the Aswan Dam on the Nile and the Kariba Dam on the Zambesi. Sites for similar schemes have been suggested in other parts of Africa, but a careful study would have to be made to decide if it would be feasible to carry these out with nuclear explosives.

The need for water conservation schemes has been amply demonstrated by

the recent drought in Africa, but is equally obvious in areas similar to the Aden Protectorate, where a seasonal heavy rainfall is lost in a few hours by evaporation and seepage into the earth. The excavation of small reservoirs straddling the water courses could be carried out by nuclear explosives. Such reservoirs could in particular be placed at the head of wadies along which roads have been constructed, where they would act also as a sink to prevent the periodical washing away of the road after heavy rainfall. These reservoirs would probably have to be lined with impervious material, and unless exceptionally convenient sites were available, water would have to be pumped out of them. Life would be brought to desert areas and the advantage of British protection would be more easily visible. Nuclear explosives could also perhaps assist in the construction of roads through these desolate mountainous areas as well as in the better known developing countries such as, for instance, Malaya. Such roads could have tactical significance in assisting the deployment of troops—the Chinese Road through Tibet to the Indian Border is an example of such a road—as well as expanding the economy of the country concerned by opening up agricultural areas and mineral deposits. Such mineral deposits could, in many instances, be more easily recovered by the nuclear methods mentioned earlier, and harbours formed from craters to help export these increased resources would complete the picture.

The more direct application of nuclear explosives for defence could only be evaluated by the defence planners reviewing any projected operations in under-developed territory in which the absence of roads, water supplies, harbours, beach landing areas, and so on were major factors. Military engineers are not yet all aware of the potential that nuclear explosives have recently been shown to have for mammoth earth-moving tasks and, of course, until they have been practically demonstrated and are known to be available, it is reasonable that they should show some caution in planning to use them.

It is important to compare the cost of using nuclear explosives with the cost of moving earth by more conventional methods. The cost of setting up a nuclear explosion arises from geological (and several otherogical) surveys, planning, emplacement, the cost of the explosive packet, and safety precautions. Survey and planning are part of any major engineering project, conventional or nuclear. Emplacement entails boring a two- to three-feet diameter hole for each device to an optimum depth of burial. This depth may be as great as 1,000 feet for a large yield device and require a heavy drilling rig, but it should be possible to bore holes for low yield devices using fully mobile rigs. The United States Atomic Energy Commission announced about a year ago the costs for devices which they were prepared to provide, arm, and fire. These varied from $350,000 for a ten-kiloton device to $600,000 for a two-megaton device. It can be presumed that a large part of these costs is that of the nuclear materials. Such materials are invariably Government owned and the actual cost to be charged for the devices would presumably be judged in relation to the intangible value of overseas development.

The significance of the 200-fold increase in yield for a doubling of cost is important. It means that for only about twice the cost, perhaps 100 times more earth can be removed. Thus the larger the job, the more economically advantageous it becomes to use nuclear explosives. As a very rough guide, and taking into account emplacement and safety cost, a ten-kiloton device may move rock at about 7*s.* per cubic yard, a 100-kiloton device at about 7*d.* per cubic yard, while a one-megaton device may result in a cost of only 2*d.* per

cubic yard. Conventional costs are in the order of 15s. per cubic yard. Since in any defence application the emplacement and safety operations could well be undertaken by military personnel, it would seem that the actual cost of a large project using nuclear explosives could be kept quite low.

As mentioned earlier, apart from technical difficulties there are some obvious political hurdles, not the least of which is the extent to which peaceful nuclear explosives will be permitted with Test-ban treaties. The current partial Test-ban Treaty prohibits all nuclear explosions other than those underground explosions which do not cause radioactive debris to be spread outside the territorial limits of the State under whose jurisdiction or control the explosion is conducted. It has already been mentioned that nuclear explosives specifically designed for excavation may be made so clean that, even if they are used for cratering, only a negligible amount of radioactivity would be released into the atmosphere. However, it must also be assumed that detection techniques will be improved so that to ensure that there would be no violation of the Treaty during the testing of nuclear explosives for peaceful use, or in any real application of them, such a degree of caution would have to be exercised that it would, for all practical purposes, preclude their use except for completely contained, underground explosions. If, in fact, in the interests of non-proliferation, a comprehensive treaty were successfully negotiated, their use would be prohibited in all circumstances. The technical enthusiast would, of course, like to have inserted in such a treaty some provision for peaceful uses. Clearly this would be a matter of political judgment on the extent to which such a clause might prejudice the long sought prevention of proliferation.

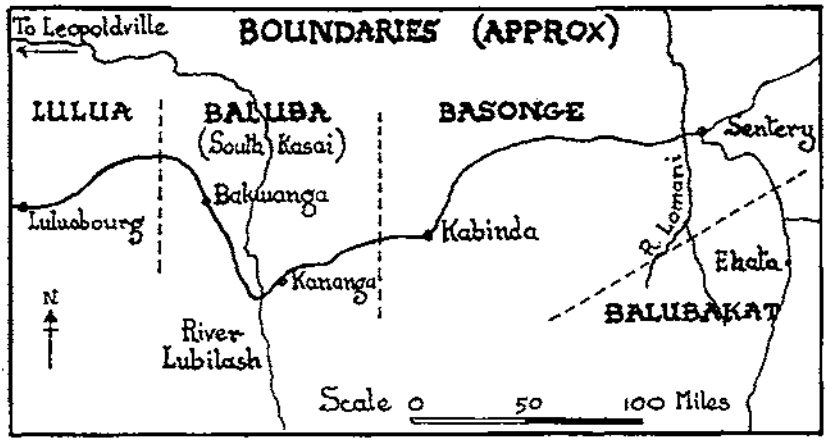
Will the use of nuclear explosives ever become a reality? As one scientist recently pointed out to me, there have been few major technical innovations that have not initially received a suspicious reception. This has been followed by a reluctant acceptance of the inevitable only after a waste of valuable time, plans for exploitation of the innovation having been made only after this acceptance. Perhaps we shall be more ready on this occasion.

A United Nations Operation by Sappers in the Congo

By Captain D. N. Hall, RE

United Nations operations in the Congo were full of the unexpected. The operation in which I found myself as a troop commander serving with the Ghana Field Squadron in the winter of 1960 was no exception. Though it was not a spectacular action, and though there were no bad casualties as a result of it, it illustrated some of the appalling tribal and political difficulties caused by granting independence to an under-developed country with no one powerful authority to control it. The operation also presented some interesting thoughts of how best to protect a long convoy moving along narrow tracks bordered by long grass which could easily conceal very effective ambushes.

The Ghana Field Squadron, acting as infantry, had arrived in Leopoldville in October 1960 in Russian aircraft to relieve an outgoing battalion there. Within a month this enlarged squadron, with some British officers, had travelled by barge up the Rivers Congo and Kasai to take over from a Tunisian battalion in the diamond centre of Bakwanga. This was in the middle of the autonomous state of South Kasai, a state of the Baluba Tribe and ruled by King Albert Kalonji. His Army, over 2,000 strong, and largely officered by Europeans, was well equipped with modern mortars, machine guns and automatic rifles. Our Field Squadron, organized into three companies with no support weapons, stationed itself in the capital of the State, securing the airstrip and presenting a very weak deterrent to Kalonji's ambitions of gaining territory and wealth.



The tribal and political picture was complicated. Kalonji, with his State within the Kasai Province, had loyalties bent towards Tshombe and away from the central Government of Leopoldville. On his western border was the Lulua Tribe which supported the central Government. Furthermore, old territorial disputes between the Lulua and Baluba tribes had been aggravated so that there was almost continuous trouble on that border. There were fewer reports of incidents on Kalonji's eastern border with the Basonge Tribe, but

this could have been because communications in that area were almost non-existent. It was not clear who, if anyone, the Basonge supported, but beyond them and to their south was a political group of complete savages known as the Balubakat. There was little information about these warriors except that they had by trickery massacred an Irish patrol in Katanga a few weeks before. Many press reports at about this time confused the Baluba with the Balubakat, but though some of its members were Balubas, it called itself a political movement with no ties to any particular tribe.

Overlying these divisions of authority was the entirely unpredictable Congolese Army. This was under the nominal control of General Mobutu about 500 miles away in Leopoldville, but it lacked discipline and command to make it little more than an armed rabble. Sometimes troops of an area gave the local administration some support, but they were always likely to attempt sudden local coups. An example of this was when the Stanleyville Army arrived unannounced in Luluaburg the following spring. The Army took brutal control of the town for a few days before being ousted by the United Nations and sent home. The Congolese Army, then, added greatly to the general confusion. Kalonji's troops were a law unto themselves, in that they were in no way controlled by Leopoldville, but were State Troops. The reactions of these various parties to the UN forces was clear only in that relations between Kalonji's Balubas and the Field Squadron were always tense, and the Balubakat had made their position quite clear to the Irish. The Congolese Army was not to be trusted, for one excitable Congolese private soldier could easily start a shooting match.

Soon after arrival at Bakwanga, the Squadron was ordered to send a strong patrol to Sentery, a small town with a Roman Catholic Mission, about 200 miles to the east, near the border of Katanga. Reports had been received that the town had been sacked by the belligerant Balubakat, so we were to investigate and report on the situation there, and see whether the four missionaries, three nuns, a Madame Rosio and three Greek traders were safe. This journey would take us across Kalonji's eastern border, through territory of the Basonge Tribe and as far as the fringes of the area dominated by the Balubakat.

It was in an atmosphere of uncertainty that the 137 man patrol left Bakwanga for Sentery on 2 December in a convey of twenty-four vehicles. It comprised "C" Company of the Field Squadron, a troop of the Recce Squadron, recovery and signal elements, and some medical support. The whole was commanded by the Field Squadron Commander, Major Wright, while the armour was under the command of the Recce Squadron Commander, Major Dixon, 5 RTR. There had been a little time on the day before departure for infantry/armour training, but this cost one of the five ferrets. It lost a complete wheel assembly by backing into a tree.

The convoy was led by 2nd Lieutenant Woodley, a National Service Sapper Officer serving with the Recce Squadron in the Congo. It stretched for over a mile along the narrow dusty track through undulating bush. It was thought that the first 50 miles through Baluba territory might be unexciting, for Kalonji had agreed to this move and had lent one of his officers to travel near the head of the convoy to the border. On the other side of the border the Basonge reactions were unknown, so the patrol had to be ready with either bullets or smiles.

The first obstacle was the Lubilash River, still in South Kasai. The ferry

was on the far bank, and the terrified operator had fled into the bush on seeing the UN force approach. A party of three, including a hefty bren gunner all precariously balanced in a fast leaking "dug-out", crossed the river paddling with shovels and themselves brought the ferry clumsily back across the 300-ft, fast-flowing river. The first load to cross by ferry was a ferret, armed with its Browning machine gun, and one of the three platoons which was to occupy the high ground commanding the ferry site on the far bank. Then started the laborious task of getting the main body across. This took four hours, and left just enough time to reach the airstrip of Kananga village before last light. Here the patrol leaguered, forming into a square with four ferrets on the corners slightly offset so that each covered one side with fire in enfilade. The airstrip was the only place where good fields of fire would give an advantage for rifles and LMGs over the shorter ranges of home-made guns and bows and arrows. After alarm positions had been allocated, a couple of stand-tos were practised to impress the local inhabitants, who had never seen UN troops.

The following day, the liaison officer was shed at the last outpost of Kalonji's Army on the South Kasai border. Then appeared the first area of death and destruction, where all villages had been burnt and deserted. The patches which had been cultivated were now over-grown. The road was blocked by heavy trees, and an old bridge had to be negotiated with care, for most of its decking had been burnt away. This was "no man's land" between the Baluba and the Basonge Tribes, and it was slow going for the patrol, which had to clear each road block in turn. As the patrol wound its way up the hill from the burnt bridge, the leading ferret suddenly reported Congolese troops ahead. In an instant the point platoon, acting as support troop, had deployed into the bush on either side of the road, and was moving steadily forward. Meanwhile, as no shots had been fired by the opposition, the troop leader shouted from his hatched down ferret "*Envoyez ici un seul soldat*".

To emphasise the point he showed a hand with one finger extended. As if by magic, a platoon of troops emerged from the bush slinging their rifles, some lighting cigarettes, and some imitating the troop leader's one finger sign. He had inadvertently made the political salute, showing that the patrol was friendly. Had he called forward two soldiers the story might have been entirely different, for a two-fingered sign was the Kalonjist's salute.

The Congolese troops escorted the patrol into the town of Kabinda where the Commissioner of Police and Chief Administrator, M. Manono, were extremely pleased to see UN forces, asking at once that a permanent detachment should be based there. This was a bad sign, for it showed that the warlike Balubakat had been threatening them; they also feared that Kalonji was about to invade from the west.

At Kabinda, Major Wright learned that the latest news of Sentery was not alarming. So far as was known the town had not been attacked and, as those townsmen were of the Basonge Tribe, it was thought that Sentery would be friendly. Therefore the patrol advanced fairly confidently the next day, crossed the River Lomani, and reached Sentery as dusk fell. The news from Kabinda had been right, and the patrol was warmly welcomed. The Fathers, Nuns, Madame Rosio, and the Greek traders were all safe.

The journey had taken three long days to cover only 220 miles. The track had been rough and dusty, there had been road-blocks to clear and two ferries to cross. Now was the time for a little rest and maintenance, and time to sum

up the situation in and around Sentery. Our medical officer, Captain Melsom, soon found the hospital and spent the first forty-eight hours operating non-stop. Among his patients was a ward full of forty men, all lying face down. Everyone of them had had their buttocks cut off by pangas after a successful ambush by Balubakats.

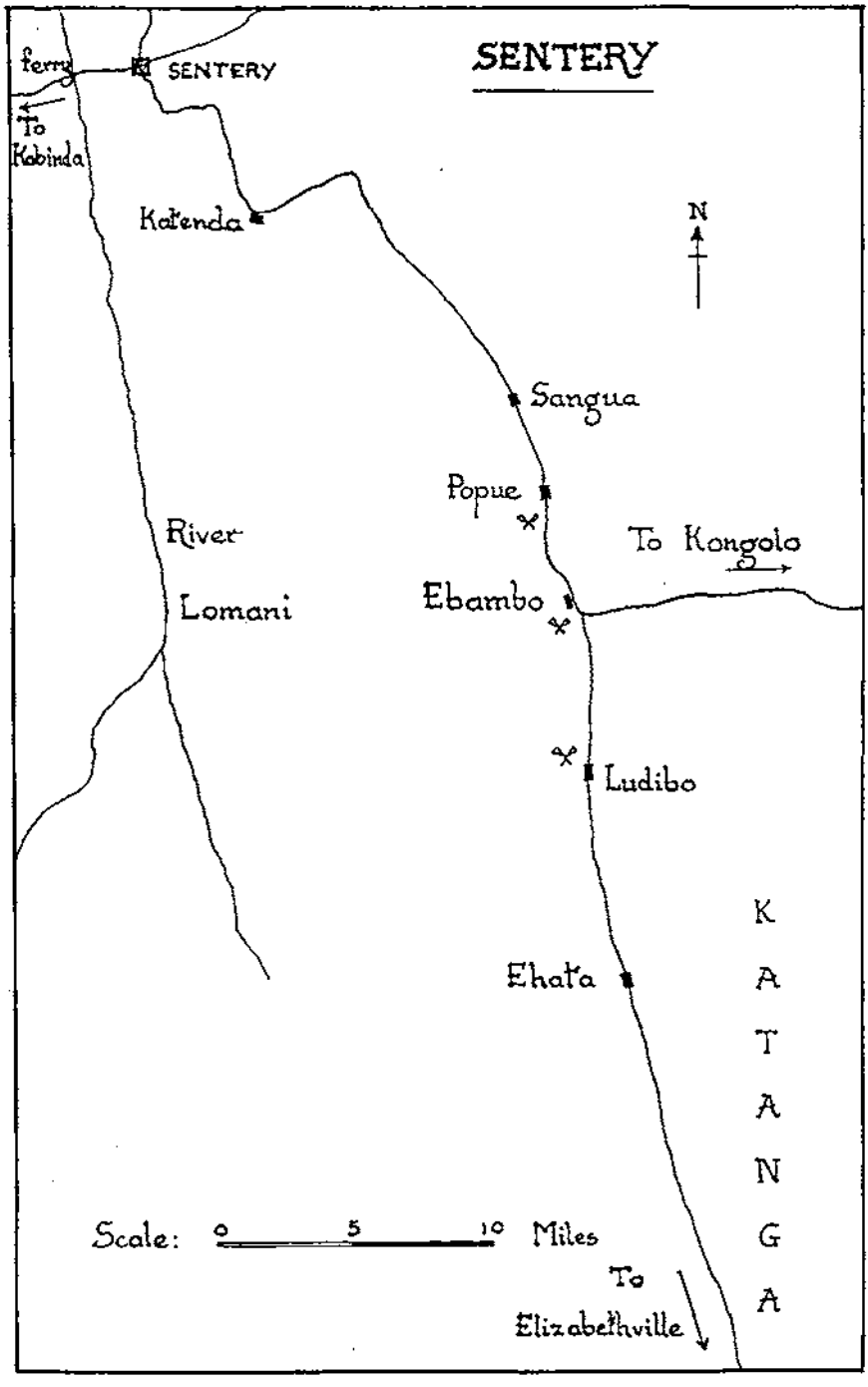
A conference was held with M. Goie, the head of administration in Sentery, and others. It was pointed out that there was a real threat of an attack by about 2,500 Balubakats who were massing to the south-east. It was agreed therefore, that the patrol should enter Balubakat territory to show force so that they would be less enthusiastic about attacking the peaceful town.

Preparations started at once. While a plan and orders were being prepared, Major Dixon organized some infantry/armour training which was to prove useful during the coming days. A wealth of information was obtained that night when some of the officers dined sumptuously at the Catholic Mission. Amongst the other guests was M. Goie who seemed particularly worried about the patrol's safety in Balubakat territory. The meal included steak and the Fathers had dug out some pre-independence Chianti. As the Father Superior poured out the wine he told us of our probable enemy. He said that the Balubakat formed a political group and was inter-tribal with an aim of disrupting any present form of administration. He recounted their means of attacking villages and of ambushing convoys, which was of particular interest to us. By cutting through the trunks of two large trees, holding them upright by vines, they would wait until the convoy was between the two, and fell them. They could then attack their prey, appearing at about three yards range from the long grass. This meant hand to hand fighting so we could at least be prepared by having bayonets fixed.

M. Goie brought the subject up again over coffee saying that his troops had returned from battle with a bloody nose three times in the last month, and that in the last battle twenty out of twenty-six withdrew wounded. Morale was, therefore, extremely low and as such a large force of Balubakat were only 30 miles away, possibly at that very moment planning to attack Sentery, the inhabitants were in a state of near panic, and there was little that his one corporal and thirteen soldiers could do.

After the Congolese guests had left, the Fathers were asked what they would do if Sentery were attacked. Father Jean's eyes lit up behind his large spectacles and he opened the cupboard behind him revealing a selection of fire arms. "*Pour le sport*" was all he said with a grin over his tiny face.

There was a feeling of excitement and tension in the morning as the strong patrol took a dilapidated track south. The troops sat back to back on boxes down the centre of the trucks looking out and down on to the thick high grass on either side. Their bayonets were glinting and their rifles loaded for instant action. Certain changes had been made to the order of march now that the administrative vehicles and troops could be left in Sentery. The Recce Squadron Commander's ferret now travelled directly behind the two leading ferrets, the track being too narrow for him to have moved up quickly from the command group each time the patrol stopped. Furthermore, Major Wright wanted a person of some responsibility well forward once we started to employ the tactics of "recce by fire". The two rear ferrets were moved forward to the command group so that there was more fire-power in the first half of the patrol.


SENTERY
ferry
SENTERY
To Kabinda
Kalenda
N
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Ebambo
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Ehata
KATANGA
Scale: 0 5 10 Miles
To Elizabethville

After 25 miles of uneventful driving, the patrol stopped at Sangua which was to be the last friendly village. Here the people congregated round the patrol, giving the troops groundnuts and plantain, part of their meagre and threatened crops. Two of the villagers volunteered to accompany the patrol in case there was a chance of a parley with the enemy. The local Army of Sentery had already declined the offer of a few seats on the trip.

Signs of civilization soon stopped after Sangua. Here was clearly another "no man's land", but this time there was the stench of recent death and devastation. The village of Popue was still smouldering, and a little further along the road was a scene of battle with clubs, bows, and arrows scattered about the road. The vehicles had to thread their way past dismembered bodies which had matured well in the sun. One unattached head clipped by the tyre of a truck, bounced between the banks like a football.

The track off to Kongolo was blocked by a fallen tree, and soon our way was similarly barred. Now came the moment when training was put to test, not only the practice runs on Sentery airstrip, but all the training done in Ghana for operations in the Congo. As the Browning machine guns put bursts of fire into the road-block and the bush on either side, Lieutenant Afrifa's platoon jumped from their trucks and deployed in the long grass at right angles to the track with the platoon headquarters in the centre. They moved forward clearing the bush on either side of the convoy and firing their weapons to show business. As the platoon advanced past the ferrets, so the machine guns ceased fire so that the area of the road-block could be cleared. The Commander had decided to use this "recce by fire" rather than commit the support platoon unprotected to the bush. If the opposition was there, it had turned and fled at the sound of the impressive fire power. By the time the leading platoon was in position round the road block, the next platoon had arrived with axes, saws, picks, shovels, and ropes to clear the way. Here was an advantage in having Sappers, who were accustomed to the principles of levers and to moving heavy weights. The obstacle was soon safely cleared and the column moved forward, picking up the troops *en route*. Hardly had this been done when the whole process had to be repeated. There were four road blocks, and then came habitation once again. The first village of about thirty-odd huts, lay in a clearing on the left, and it had obviously been hurriedly deserted only minutes before. As I took the two men from Sangua into the village to call for a representative to come forward, I felt that every move we made was being watched by many eyes from the protection of the long grass round the village. It was of no use: nobody materialized, and as it would have been madness to go into the bush in search of them, the patrol moved on. Not more than fifty yards beyond the village a corpse lay on the track for the birds and animals to eat. This was obviously one of the most primitive societies in the world. There were no more road blocks, and though each village was deserted, those in the last vehicle sometimes saw armed men emerge from the bush.

The convoy snaked round in a village on the border of Katanga, to return by the same route 54 miles to Sentery in a downpour of tropical rain. The show of force had been sufficiently large to deter an attack on the patrol, but this did not satisfy M. Goie who seemed even more worried. When in the afternoon Major Wright went to bid him farewell, he begged for the departure to be delayed for a few weeks, and it was eventually agreed that there would be one more patrol.

At six o'clock three days later, the patrol moved along the same route past the same smelly battlefields. There was no alternative track, for this was the only one leading from Sentery into Balubakat territory. The enemy had been active, for suddenly the leading ferret tumbled nose first into a 5-ft camouflaged pit. Apart from bad bruises, the crew was uninjured. As the recovery operation took place, a man appeared about three hundred yards down the track, and stood watching, perhaps laughing at the successful prank, but provoking a desire among the more blood-thirsty to shoot him down. The obstacle was followed by ten road blocks of felled trees, and one more camouflaged pit was seen in time. The drill for clearing the blocks improved rapidly, but care was still taken to ensure that no ambush had been laid on the obstacle. The speed of work in no way disheartened the opposition who tried to lay traps for the convoy's return, in one place excavating a culvert half way across the track. This time more armed men appeared as the last vehicle passed the old road blocks.

On return, it was found that even a second show of force into Balubakat territory had done little to increase confidence in Sentery. Further deputations were made to the airstrip for a UN force to be stationed in the town to protect it. Certainly these people deserved support, for they wanted peace and were trying to make a go of their independence. But then there were hundreds of similarly deserving cases all over the 905,000 square miles of the Congo. The UN forces were already overstretched, and to disperse them further would only lead to greater insecurity. Indeed, a Company in Port Franqui was massacred almost to a man four months later because the dissident Congolese soldiers were able to surprise and, in most cases, outnumber, each little group in the town The rear party of the Field Squadron at Bakwanga was being of little use as a deterrent, for it was vastly outnumbered by Kalonji's soldiers Therefore the patrol had to return and just hope that it had prevented the Balubakat from attacking the brave Fathers and terrified people of Sentery.

The patrol had relied for its safety largely on its formidable appearance. The sight of a long column of vehicles, of the determined looking soldiers sitting back to back with weapons at the ready and bayonets shining, and of the slick and well rehearsed drills at road blocks would all help to dissuade a possible attacker. Yet how vulnerable the patrol must have been. An ambush of about fifty, probably small by Balubakat standards, could so easily have appeared out of the grass, successfully attacked a small section of the convoy, and returned, to be instantly lost, all within a matter of seconds.

The patrol had been a valuable experience for the Ghana Brigade. We had learnt how to move as infantry and armour in a long convoy with possible ambushes only a few yards on either side. We had learnt drills for dealing effectively with road blocks, and we also realized the value an observation aircraft would have been under those conditions. We did not use some of the useful lessons from the Indo-China War for protecting harbour areas. Had we had time, we could have tried burning and cutting the long grass to give adequate fields of fire. Instead we leagured in the form of defensive squares on the already cleared airstrips, having our most powerful weapons, the machine guns, placed on each corner so that they covered each side in enfilade. Had we mines, trip flares, and wire, we could have laid them to protect ourselves. But as we had none, we could only cover the surrounding area with small arms fire. All the drills and lessons we learnt were to prove their value

to us and others in later operations. At least Sentery was safe for the moment. Major Lawson of the Third Nigerian Brigade describes in his book *Strange Soldiering* how he flew into Sentery by light aircraft almost a year later to find the situation there very similar to that of December 1960.

A Survey Tour Down Under

By Lieut-Colonel R. S. Hawkins, RE (Retd), MA, AMIMechE

Most people in England in 1852, who had visited the Great Exhibition in Hyde Park the previous year, had at least some idea about tracts of land, spattered over the globe, and known as Colonies. On the whole they appeared either hot and uncomfortable, or barren and undeveloped; the average "paterfamilias", paying income tax at sevenpence in the pound, was dismayed to think of good money being spent on developing such lands, maintaining law and order there, and financing highly-paid Governors. The most distant was Australia and its nearby islands; nevertheless emigrants and their families had, for the last fifty years, settled in this country and flourished there. Its distance from the Mother Country had made it a convenient dumping ground, since 1788, for offenders, convicted for practically any offence short of murder, and transported by the shipload, at first to the so-called "Prison Farm" at Port Jackson, New South Wales.

The public opinion of the free settlers was of sufficient weight to stop this flow in 1840, and Her Majesty's Government switched the convict ships to Van Diemen's Land, and later, in 1850, to Western Australia as well. Van Diemen's Land had in fact accepted convicts under restraint and ticket-of-leave men, since the early days of settlement; they were employed on Public Works and hired out to free settlers. The flow of convicts continued at about 3,000 a year, and so there was nothing remarkable when the sailing ship *Lady Montagu* (763 tons) set out from Plymouth on 9 August 1852, carrying 280 male convicts and a guard consisting of Lieutenant Gray, one sergeant and thirty-four men of the 99th Regiment. There were several Government passengers—Mrs Gray, Captain J. S. Hawkins, RE, his wife Leonora, his two children, Mary (aged 4½) and Denis (aged 3), the children's nurse, a religious instructor, a Government servant, one sergeant, one corporal and fifteen privates of the Royal Sappers & Miners, and the soldiers' families "nine women and nineteen children".

John Summerfield Hawkins, then aged 35, saw the coasts of England recede for the second time in his military career. He had entered the Royal Military Academy before his fifteenth birthday and received his commission in the Royal Engineers at 18, in the seventh year of the reign of William IV, and then spent a year in the Cadet Company at Chatham. He next served seven years in Ceylon, two and a half years in Ireland, followed by six years

on the survey of Great Britain under the Board of Ordnance, in the York-Liverpool area. He was promoted 1st Captain in April 1852. His voyage on the *Lady Montagu* was due to a chain of events, initiated by another RE Officer, Sir William Denison, then Governor of Van Diemen's Land.

Denison was a remarkable Sapper, and turned out to be a brilliant and well-loved Civil Administrator as well. In 1846, as a captain aged 42, he was nominated by Sir John Burgoyne, Inspector General of Fortifications, at the request of the Colonial Secretary, Mr Gladstone, who had asked for an "engineer officer, qualified for the post". On appointment, Denison was knighted and he reached Hobart early in 1847.

The Colony was in a parlous state, the finances were low and there was dissention in the Legislative Council over the influx of convicts. At that time, the white population was about 70,000, of which less than half consisted of free settlers. Denison, however, convinced the Council that a hasty discontinuance of the system would seriously prejudice the labour situation for essential development work. Every available convict had been hired, and there was a labour deficiency. The discovery of gold in New South Wales and Victoria in 1851, aggravated the situation, as ticket-of-leave men and pardoned convicts crossed the straits to the gold diggings.

The Colony's Survey Department found itself hard pressed to maintain the output required for Public Works (roads, ports, townships etc) and land grants to settlers, and in 1851 Denison asked the Colonial Secretary for a detachment of Sappers & Miners to aid in this work. In February 1852 Burgoyne, at the Office of Ordnance, Pall Mall, received this letter from Downing Street:—

"Sir,

I am directed by Earl Grey to request that you will acquaint the Master General & Board of Ordnance that the Lieutenant Governor of Van Diemen's Land has applied for the assistance of a Subaltern Officer of the Royal Engineers, and a small party of Sappers & Miners to aid in carrying on a Trignometrical Survey in that Colony. It is proposed that their pay and allowances should be defrayed from the Land Revenue of the Colony, and that the Officer, in addition to his ordinary pay should receive a Civil Salary of £300 and allowances amounting to £200. The plan cannot be adopted until it shall be known whether the Lords Commissioners of the Treasury will be prepared to sanction the expenditure; but I am to request that you will acquaint me whether, in the event of its meeting with their concurrence, the Master General & Board of Ordnance would be able to secure a Subaltern Officer and a few Sappers & Miners for this service. . . ."

The letter continued that the Sappers would be paid by the Colony. Burgoyne considered the Service "very desirable" and was prepared "to recommend an officer, and to furnish a detachment of Sappers when required" (19 February 1852). Various other equally effusive letters passed to and fro, and on 5 April 1852 Burgoyne wrote "I beg to submit the name of Captain Hawkins for this duty, and to state that there will be no difficulty in furnishing from the Survey Companies a party of six or eight Sappers & Miners as required".

Meanwhile, Denison in Van Diemen's Land had asked for a larger party of Sappers (despatches took three months in transit), and by 5 June, Burgoyne was informed "Sir John Pakington therefore thinks it desirable that as many as fifteen Sappers & Miners, inclusive of Non-Commissioned Officers

should be sent. . . ." By 10 January 1853, the Brigade Major of the Royal Sappers & Miners Depot, Woolwich, had calculated the annual pay of one sergeant, two corporals and fifteen privates, including allowances for "Repair of Arms, Losses by Men's Debts, Burial of the Dead &c. and Agency to Paymasters" to be £408 17*s* 8½*d*. This precise sum was authorized in the Royal Warrant of 24 February 1853, for raising "an additional number of Royal Sappers and Miners to be employed on Service in Van Diemen's Land", —and signed "By Her Majesty's Command, PALMERSTON".

John and his party of Sappers therefore sailed a full six months before the Royal Warrant was finally approved. The *Lady Montagu* passed within 200 miles of the coast of Brazil, turned South East and made landfall at Table Bay, Cape Colony, and then sailed on again, to anchor in the Bay at Hobart on 10 December. Mary noted every detail of this wonderful voyage through the eyes of childhood, and eighty-three years later recorded her memories. "The voyage took four months in a convict ship", she wrote, "the soldiers being the guards, who, Papa said, were more trouble than the convicts! I quite remember seeing the latter line up for their tot of rum. Once a ship was sighted which we feared might be a pirate but, to our great joy, it soon disappeared in the distance. On arriving at Hobart we were received by the Governor, Sir William Denison, of the Royal Engineers. We stayed at Government House until we found a suitable house, well outside the town on the River Derwent, where we lived for about four years. I remember walking to the town, when those with me were several times anxious about meeting bushrangers". In April 1854, John was presented with another son, and Mary remembered her "brother Jack,[1] being carried in the arms of a man in black and yellow, one of the convicts hired as a servant".

Although unco-ordinated chain surveys for land grants, etc had been carried out since the early days of settlement, the first base line for a proper triangulation was not established until 1849 at Ralph's Bay, near Hobart. Measurement was by "rods of old Baltic fir, about fifteen feet in length and two inches square; they were saturated with boiling oil, and varnished, rolled in flannel and packed in sawdust in Coffers six inches square, closed at the ends, but leaving the rods free to contract and expand. To the ends of the rods were attached Brass Caps . . . one cap bore a zero mark only, and the other a vernier scale . . . determining measurements to 1-400th of an inch". A 10 ft steel standard was later obtained from England, and in 1852 the Ralph's Bay base was remeasured by more precise means, and another base line measured at Longford, 100 miles to the North. The two bases were then connected by primary triangulation, covering roughly a quarter of the area of the Colony, in its Eastern half. In 1854, observations for the main triangulation were continuing in the NW and SW of the island and two other survey parties were expected early in the year, for carrying on the secondary and minor triangulation. However, Major Cotton, Deputy Surveyor General, stated in January "the exteme and urgent demand at present for surveys of small blocks of land, and the want of strength in the establishment, delays this work".

John and his Sappers were soon at work as an integral part of the Survey Department, which was clearly hard pressed to fulfil its urgent commitments for land grants and Public Works and, at the same time, continue the important but recently started triangulation. In view of these conflicting

[1] Later Brigadier-General J. W. Hawkins, RA.

requirements, the local press was not averse to criticizing, and an irate gentleman wrote to the *Hobart Town Advertiser* (26 July 1855) with reference to a previous article:—

"You will perceive the operations of the Survey Department are managed, that is to say, mismanaged, by three heads, Mr Power who is not a professional surveyor, Major Cotton of the East India Company's Service, and Captain Hawkins, RE, who ought to be at Sebastopol, and the results of triple management are now so patent, that I need not enlarge upon them.

"But since the committee of '52, an addition has been made to the Survey Department, by importing some of the Corps of Sappers & Miners, under Captain Hawkins. This would be well if Captain Hawkins accompanied them to the field, which he does not do, but relies on the work of his privates; and the consequence is, that the grants are issued upon plans furnished by them, without a field examination; . . . for, if Lieutenant Clarke spoke correctly in the Legislative Council of Victoria, these soldiers are not to be entrusted with surveys without some better security for the correctness of their plans, which can of course be 'cooked'." The Editor commented "Our strictures apply to the management of the whole Department; we do not agree with his remarks on the Sappers & Miners—we believe they are a very useful body of men".

At the time, John was in fact at Sydney. Denison, in 1854, had been appointed Governor of New South Wales, and he soon found there the same survey problems that he had encountered in Tasmania (so renamed in 1853). On 4 July 1855, he appointed a Royal Commission "to make enquiry into the present state of the Survey Department in Our Territory of New South Wales, with special reference to the following matters, . . . etc". The Commissioners were Morris Pell, Esq, Mathematical Professor of Sydney University, Captain Andrew Clarke, RE, Surveyor-General of Victoria, and "John Summerfield Hawkins, Esquire, Captain in the Royal Engineers". The enquiry started on 7 July with Pell as Chairman; a vast quantity of evidence was taken from all sorts of witnesses, and there was a detailed examination of the technical, administrative and financial affairs of the Department. The findings and recommendations were completed and signed on 11 August, and these showed in retrospect the extraordinary conditions and difficulties besetting the Survey Department in those early days.

John had taken a jaunt by sea to Sydney for this enquiry, and on this occasion he considered a proposal from Denison that, on completion of his current work in Tasmania, he and his Sappers should be seconded to New South Wales for a further year's work in that Colony. This was put into effect, and John was appointed Commissioner in the Office of the Commissioner for Railways, at a salary of £825 paid from 10 February 1856. He and his family, two servants and the seventeen Royal Sappers & Miners, sailed from Hobart on 9 February on the iron screw steamer *Tasmania* (284 tons), arriving at Sydney four days later. It was a pleasant voyage in midsummer but his wife was, in the Victorian sense, slightly "indisposed". The ailment was, however, abruptly terminated at Sydney, on 19 June 1856, with the birth of their fourth child, a son, duly baptized Walter Francis.[1]

At the time, the only railway in use in the Colony was the twelve mile suburban link between Sydney Town and Parramatta, opened in September 1855. There was also a line under construction from Newcastle to Maitland.

[1] Later Colonel W. F. Hawkins, CMG, AMIEE, RE.

John's work in New South Wales was summarized in his report, which was published on 17 March 1857 in the "Proceedings" of the Legislative Assembly. It started off in the following manner:—

"*General Report* on the Explorations and Surveys made by the Detachment of Royal Engineers[1] under the Command of Captain J. S. Hawkins, RE, with a view to Railway extension in the Colony of New South Wales.

Sydney 24 February 1857.

1. The Duty assigned to the Detachment on its arrival in the Colony, was the prosecution of Railway Explorations and Surveys, . . . My attention was at first directed to the proposed western extensions from Parramatta to the Hawkesbury and Bathurst. Subsequently, at the request of the Australian Agricultural Company, two Surveyors were sent to Port Stephens, to undertake a trial survey from the place, through Stroud, in the direction of the Manning River and Armidale; these men were rationed, their chainmen paid, and means of transport, etc provided by the Company. The exploration of the country between Goulburn and Yass, and thence to the Murrumbidgee, with the view to ulterior extension to the River Murray and Colony of Victoria, has also been undertaken by men of the Detachment.

2. On their first arrival, as soon as the men were quartered at Parramatta, the first duty undertaken, was to prepare the numerous tracings requisite for their guidance in the performance of a difficult duty in an intricate and but partially surveyed Country. I may here observe, that every portion of their work has been performed by the Sappers themselves, without any extraneous assistance whatever. A considerable portion of their field equipment was also prepared by them, including the construction of levelling staves and the engraving of copper plates for the graduation of the staves and for protractors for plotting plans—duties requiring extreme care and skill."

The report continued with considerable technical information, comments and recommendations. Hundreds of miles of levels had been taken in attempts to find lines with acceptable gradients, and the report was clearly of enormous value in assessing the most promising lines for future more detailed survey. For example, extracts from the body of the report were as follows:—

"The first field duty undertaken was the survey and levelling of two lines . . . leading from the Parramatta and Liverpool Railway to Prospect Hill. . . . The first line branches from the Railway about a mile beyond Parramatta Station, and at a distance of nearly 4½ miles it forms a junction with the second trial line. The country it passes over is not very favourable, being irregular and undulating; but there is nothing very formidable or impracticable in it for a Railway, though the necessary works would be too costly for a tramway. It would have to surmount about 100 ft in a third of the distance, which would give a general gradient of nearly 1 in 80, as probably the most severe. I am not, however, prepared to state that the line was selected by the Surveyor with sufficient judgement to ensure its being the best that can be obtained in this direction."

"The valley or ravine of the Grose has been explored, but without success. This was undertaken in consequence of the possibility of obtaining a practic-

[1] The Corps of Royal Sappers and Miners was incorporated with the Corps of Royal Engineers on 17 October 1856.

able line (with the necessity, however, for two tunnels) from the western foot of the Blue Mountains to Bathurst, if connected with the head of the Grose by a tunnel 3 miles in length. I may here observe, that I do not think it will be found practicable to make use of the valleys of any of these rivers; but neither do I think it will be found possible to carry out Railways to any extent, in this or most other countries, without having recourse to tunnels, notwithstanding the very great expense attending their construction. In concluding this portion of my Report, I must express my conviction that no practicable line for either a railroad or tram-way from the Hawkesbury to Bathurst exists between the Cox and Colo Rivers."

With all his commitments in the field, and preparations for carrying them out, John had to do a lot of work on the pay, administration and welfare of his Sappers and their families. There was no established precedent for their pay, etc and he had to initiate proposals in this matter. He of course wrote all his letters in his own handwriting, in the rather effusive style of the official correspondence of those days. He opened proceedings with this letter to the Surveyor-General:—

Survey Office, Sydney.
March 20th 1856.

"Sir,

I request that the following recommendations, suggesting the rates of pay and allowances to the Detachment of Royal Sappers & Miners under my Command, for employment on Railway and other surveys in this Colony, be submitted to the Governor-General for his consideration and approval. I have based the proposed rates as much as possible on those given to the Sappers employed in the Mint, and on authorized Military scales of allowances; giving consideration however to the rates the men were formerly receiving; and with some small modifications, which, if necessary, I shall be prepared to explain."

The rates proposed (not given here in detail) were:—

1st. The usual Military pay.

2nd. The usual Colonial allowance.

3rd. Working pay, payable only on days on which the men were actually employed.

4th. A field allowance of 1s per diem.

5th. Rations to the men at Headquarters and their families on the usual Military scale. (Commuted money allowance was also suggested in lieu).

6th. Rations to the men employed in the field, and to their Chainmen on the Colonial Daily Scale No 3, or money allowance in lieu.

7th. Issues of fuel and light to the Detachment at Headquarters, or their families. (The daily rate for a sergeant in winter was 40 lb coal and 4 oz candles.)

8th. "As the water in the wells at Parramatta is not fit for drinking or for culinary purposes, a supply will be necessary for the men at Headquarters and their families."

John followed this up with another letter, proposing "unemployed" pay at half working pay rates, during the time the Sappers were in lodgings in Sydney, pending movement to quarters at Parramatta. A third letter asked for "instructions relative to the rates of pay and horse or forage allowance I am to receive, while employed in this Colony. . . ."

This laborious correspondence was accompanied by a detailed "Memorandum" and Financial Estimate for the year 1856. The Memorandum explained for the benefit of the Colonial Government, how the Estimates were arrived at in relation to Military Pay and Allowances, and also gave details of the transport and local equipment required; for example "The probable cost of a moderate equipment for one party, with only one dray and two horses, will be from £250 to £300; but in this Colony, I understand, three and even four horses are constantly required—this is exclusive of instruments", and further "The men receive the regulated Regimental Clothing, but this last is of very little use to them in the duties on which they will be engaged, as they will have to supply themselves with clothing suitable for bush work. I propose arranging to obtain for them compensation for their clothing, taking care that they are properly supplied with uniform and fatigue clothing for Military Duties."

The Estimate for 1856 allowed for one sergeant, three corporals and thirteen privates, R.S. & M., and thirty locally employed chainmen, and was split up into salaries (£3,161), Allowances (£1,386) and Contingencies (£2,640). The latter item included £780 for the purchase of equipment, and £720 for the purchase of horses. The pay and allowances per day of a RS & M private would have been:—

	s	*d*
Regimental Pay	1	2½
Colonial Allce	0	6
Working Pay	5	6
Field Allce	1	0

He would also receive of course rations, fuel and quarters, or ration allowance in lieu when in the field.

All this meticulous administrative work on paper, caused a flood of counter correspondence from the Colonial Secretary (CS), the Department of Lands and Public Works (DLPW) which was the paying authority, and the Surveyor-General (SG), which had to be dealt with by John, in spite of his long journeyings on horse and foot in aid of his survey task. The CS first of all approved the recommended Scale of Pay and Allowances, but on 23 January 1857, DLPW wrote to SG on the subject of Ration Allowance for the surveying Sappers and Miners, "I am not prepared to sanction a proposal of this sort, which I cannot but think holds out temptations to the men in charge of parties to become irregular in their accounts, and to drop practically into a course unfair to those who are intended to reap all the benefit of the allowance." John had to pen another laborious explanation, backed by the SG who wrote "Captain Hawkins' explanation seems to me to be full and satisfactory; I do not see that any other course than that adopted, can be satisfactorily considered."

Early in 1857, John tendered his resignation as Commissioner as previously planned, for he had his own military future to consider, as well as the careers and welfare of his Sappers, and their families. The whole party had already been four and a half years overseas. The slightly acrimonious correspondence on pay and allowances continued for some time after he had sailed for England, but it ended on a happy note. DLPW wrote to SG on 4 September 1857 referring to the "Estimates prepared by Captain Hawkins for himself and the detachment of Sappers & Miners formerly under his Command, I

am directed to inform you that Mr Hay has been pleased to authorize the payment of the same out of the vote of £50,000 for Railway Surveys &c as it would appear that there can be no question of the moderate amounts of the Salaries of these men, considering the value of their Services."

The whole detachment, accompanied by their families, embarked on the sailing ship *Alnwick Castle* (1,087 tons) on 13 March 1857 at Sydney, John having been allowed "22/2 per diem for self and 1/6 per diem for servant for 83 days voyage" back to England. The baby Walter was only nine months old, and Mary, with her young maternal instincts roused, recorded in her memoirs "We had great difficulty in feeding Walter for some time; the only thing that would suit him was pea soup, and he became very plump and, for a long time afterwards, was called Fat Pussy!" The ship took the traditional West to East sailing route round Cape Horn, and eventually berthed at the Port of London on 4 June 1857. The survey tour was over. The party had not only completed its original mission and more, but it had circumnavigated the globe, and, without higher authority, increased its establishment by one future Gunner and one future Sapper!

Aftermath of a Battle

By Major-General B. T. Wilson, CB, DSO

On the night of the capture in May 1917 of Monchy-le-Preux, I led my West Riding Field Company of the 29th Division up the commanding hill near Arras, on which it stands. Our job, classed as urgent, was to barricade the two main exits of the village leading towards the enemy. During our approach across the open Down three burning houses lit up the scene like huge torches and seemed to be attracting plenty of German shell fire. The general effect of the illumination was at once awesome and romantic, but it looked like being a dirty night for the Field Company RE and so it proved. A British Cavalry Brigade, intent on a break-through to Cambrai, had galloped into Monchy-le-Preux in broad daylight and, being observed by the Germans, had got itself disastrously shelled. Thus when we got through some completely deserted streets to the Grande Place, we found it full of dead horses and the best place for one of our barricades was all jammed up with dead animals—cellars in the Grande Place still contained wounded cavalrymen. Noisy shelling continued for most of the night, fortunately clear of the barricade sites although even so one of the Sappers managed to get himself wounded. A number of unhappy cavalry horses were still at large in the streets and fields round about. Some of them were hopping about maimed with bad wounds and broken legs. So after putting the Sappers to work, I busied myself with my orderly doing what I could for the horses. Two or three of them I shot in the forehead with my revolver about which operation I had often read but had never performed, so it was a relief to see the pathetic sufferers fall instantly dead. I also collected two nice animals for the Company and could hardly wait for the completion of the barricades so as to be able to withdraw in good order and with military discipline to our trenches 2 miles back in the old German line. Just before dawn, however, I got stuck by the OC Regimental Aid Post in the Grande Place with the care of a large batch of walking wounded and the usual ordered march soon became a stroll. The more so since the turmoil of the night's shelling had ceased. The sun shone warm and the larks were singing deliciously on a lovely May morning. Casting round well ahead of my ambling little column to examine with a professional eye the always interesting debris of battle, which also interested my CRE, I dropped quite suddenly into a saucer-like depression which was just big enough to prevent any distant view of its astonishing contents—lying there peacefully in the bright sunshine, both dead, were a Cavalry subaltern and his charger. They were exquisitely turned out and their magnificent appearance was not marred by any visible wounds—for their sudden appointment with death they might indeed just have gone off a drill order parade on the Wiltshire Downs. In our war of entrenchments in 1914–18, it was unusual to happen on casualties in this unforeseen way because their units picked them up almost at once, as occurred an hour later on this occasion after I had telephoned the unit. I have long since forgotten the name and the Regiment of the subaltern but he and his horse were the finest example of death in the grand manner that has ever come my way and I have treasured the memory of it ever since.

Correspondence

HQ, Southern Command,
Wilton, Salisbury, Wilts.
10 January 1966

The Editor,
RE Journal

Dear Sir,

EIGHTY MINUTES TO SPARE

Major Hunter raised two points about the construction of Dhekelia emergency airstrip in his letter published in the December *Journal*.

On the first point I join him in hoping that what I had said about damage caused by swinging buckets or Michigan and Gainsborough arms does not—nor ever will—reflect PRA School instruction. What must be emphasised however is that the airstrip was being built for a real emergency, and not for a training exercise. At the time, Cyprus was faced with possible invasion by Turkish forces, and counter invasion by Greek forces (and these were no idle threats as I saw for myself driving through the Turkish invasion ports and crossing the Turco/Greek border shortly afterwards). Any such action was likely to result in the isolation of Dhekelia from the Akrotiri Sovereign Base Area and the British enclave in Nicosia, both of which had permanent airfields, and the subsequent evacuation of British families would have been impossible.

Speed was, therefore, of the utmost importance, and this was why we worked twelve hours and more a day for three weeks nonstop. Under these conditions, and with a shortage of operators allowing them almost no time off, I think it reflects very highly on the skill of the operators and on the training of the PRA School that there were no accidents in the quarry, and that even more damage to the tippers was not caused, in loading them with 9,347 individual loads amounting to nearly 66,000 cu yds of havara. In point of fact probably most of the more vital damage to the tippers was caused when boulders had been inadvertantly included in the load and were lying near the front of the body. During tipping, the boulders slid down with considerable force, and in some cases, hit the tail gates hard enough to distort them and make them impossible to fasten. In one or two extreme cases the impact split the tailgate post away from the body side. Where practicable, boulders were excluded from the loads, but this was not possible in every case.

The second point comments on the fact that an oil stripe was used as a centre line only. As time was short it was found impossible to oil the surface before the completion of the strip. The pilot of the first Beverley to land did not want the centre line marked by PSP which might cause tyre damage. The oil patches from earlier testing showed up so clearly from the air that the quickest and simplest answer to the centre line problem was seen to be an oil stripe, which was later extended to cover the whole width of the strip. The centre line was then properly marked with white painted panels.

Major Hunter is wrong in thinking that the oil did nothing to add to the strength of the surface. It is certainly true to say that with a surface spray the oil penetrates only about $\frac{1}{2}$ in, and with most soils the ground beneath the crust is weak, and the stabilized crust soon breaks up. Havara however sets very hard indeed, and the more traffic it takes the harder it gets until it becomes almost as impenetrable as concrete, as our CBR tests showed. If the surface is left untreated, and not used to any great extent—for example near the edges of the runway—it tends to crumble, and is easily eroded by wind, but with the oil stabilizing the actual surface skin this did not happen,

and the surface stayed firm. Under these circumstances, full oil stabilization was quite unnecessary, and in any case would have been impossible with the limited quantity of oil available. This was also the reason why our ratio of spread was as thin as 1 gallon to 4 sq yds for the initial spray after the completion of the extended strip.

Yours faithfully,
M. D. KING, Major RE

Note by Editor. This letter was held over from the last issue of the *RE Journal*.

E. H. Thompson, OBE, BA, FRICS,
Professor of Photogrammetry and Surveying,
University College London,
Gower Street,
London, WC1.

The Editor,
RE Journal

30 June 1966

Dear Sir,

COMMON HERITAGE

Having overcome my reluctance to criticise an officer under whom I have served, I would like to suggest that the expression "mad, married or methodist" should be, or be taken to mean, "mad, married or methody". Not only do I believe the latter to be historically correct but it is more in keeping with the facts. I have not noticed a particularly large low church content among my brother officers. On the other hand those of us who happen not to be methody shine out like naughty deeds in a good world.

Yours faithfully,
E. H. THOMPSON,
Lieut-Colonel, RE (retd)

G. P. Webb, P Eng,
456 Hanwell Road,
Fredericton,
New Brunswick,
Canada.

The Editor,
RE Journal

28 June 1966

Dear Sir,

ADVENTURE TRAINING IN IRAN 1965

I was most interested in Lieutenant B. Cox's "Adventure Training in Iran 1965", but must query the statement "two running generators, both aligned to within one-thousandth of a millimetre with their turbines".

Firstly we must assume that not only were the generators aligned with the turbines, but that since they were running, they were also coupled to them!

Secondly, while it is possible, and would be considered a very good result, to have the generator and turbine shafts aligned to each other within one-thousandth of an inch, an alignment of one-thousandth of a millimetre would be entirely fortuitous and since it would not be possible to measure the out-of-alignment to such a degree of accuracy no one would know the extent of perfection of the alignment. One thousandth of a millimetre is .0000394 in or approximately $\frac{4}{100}$ of one mil.

I believe one should be very careful when quoting tolerances in an article which will be read by engineers.

Perhaps I shall some day have the pleasure of showing Lieutenant Cox around one of the hydro electric schemes with which I have been associated.

Best of luck to him and his fellow adventurers.

Yours faithfully,

G. P. WEBB,
(Full Member of the Institution of Royal Engineers)

Major G. F. Hawker, RE (T), BSc
MIStructE, AMICE, MSocE (France),
7 Market Street,
Lewes,
Sussex.

27 June 1966

The Editor,
RE Journal

Dear Sir,

ROYAL ENGINEERS IN GHANA

In the course of his interesting article on the Royal Engineers in Ghana (*RE Journal*, June 1966), Colonel Lawrie gives a list of OCs 35 Field Squadron, GCE for 1946 to 1956. This is slightly inaccurate in that during my service with the unit (then known as 35 (Gold Coast) Independent Field Squadron WAE) from August 1951 to December 1952 the OC was Major R. R. L. Peters. I regret that I cannot remember when Major Peters' tour started or finished, but he was there throughout my stay.

Yours faithfully,

G. F. HAWKER.

Major F. W. E. Fursdon, MBE, RE
38 Engineer Regiment,
Claro Barracks,
Ripon, Yorks.
Ripon 2301

15 July 1966

The Editor,
RE Journal

Dear Sir,

WEST AFRICAN ENGINEERS

Colonel Lawrie's article "The Part Played by the Royal Engineers in the Development of Ghana" in the *RE Journal* of June 1966 gave full reference to the excellent work of those Divisional engineer units serving in Burma which had been raised in the Gold Coast. He did not, however, mention the more numerous non-Divisional West African engineer units many of which also served both in India and Burma between 1943 and 1946 and a proportion of which were Gold Coast raised. Royal Engineer officers from the UK, a number of whom are still serving today, were seconded to these units as well.

According to my own personal records, the overall non-divisional engineer orbat in the Far East during World War II was as follows, though I regret I no longer have a record of from which Colony each unit was raised:

HQ 1st and 2nd Artisan Works Groups West African Engineers.

10th, 12th, 14th, 15th, 16th, 17th, 18th, 26th, 27th, 28th, 29th, 30th, 31st, 32nd, 33rd and 35th Artisan Works Companies, West African Engineers.

1st and 3rd Road Construction Sections, West African Engineers.

892nd Mechanical Equipment Company, West African Engineers.

Yours faithfully,

F. W. E. FURSDON
ex 26 AW Company WAE (Gold Coast raised).

Colonel J. R. E. Hamilton-Baillie, MC,
Engineer 2 (A)
Northumberland House,
Northumberland Avenue.
London WC2

18 July 1966

The Editor,
RE Journal

AIRFIELD PAVEMENT DESIGN

Dear Sir,

Major Donaldson's article in the June 1966 volume of the *Journal* makes an interesting comparison of differing airfield design systems, from which it can be seen that, despite their different approach, different systems give very approximately the same results.

I am anxious, however, that false lessons should not be deduced. The US curves published by Major Donaldson should not be used for airfield design in place of the LCN system. The curves are for one thing not the latest published by the Federal Aviation Agency. The latest series are calibrated in terms of Aircraft Gross Weight instead of Single Wheel Load, and separate curves are given for various main undercarriage wheel arrangements. The FAA system does not allow for differing tyre pressures, which do have a significant effect, and is in this respect inferior to the LCN system. The LCN system is widely used throughout the world, and is published by the ICAO as well as the MPBW. The FAA system is not used by the US Corps of Engineers.

The FAA system of allowing lighter construction in the centre section of a runway is difficult to justify as it is common experience that aircraft often stop not far beyond the centre point of a runway, make a U turn and back track to a link taxiway usually provided there. It must be admitted that the US Army system also allows this reduction, but the LCN system does not.

The LCN curves at Major Donaldson's Fig. 3 are the correct curves for Flexible Pavement Designs. For Forward Airfields the minimum thickness line may be reduced to 6 in. If only limited use is expected, the LCN requirement must be adjusted accordingly.

The suggestion that ordinary bituminous macadam is satisfactory for airfield surfacing is very dangerous. Our experience at Crown airfield in Thailand has shown how difficult it is to make such a surface waterproof. A thin skin, as suggested by Major Donaldson, produced by two or three surface dressings may well give a more waterproof seal, but is unpopular with airmen because of the danger from loose chippings. Heavy braking by aircraft may also tear it up. Rolled Asphalt is the minimum quality construction to ensure a waterproof seal. In two course surfacing the base course may however be of bituminous macadam. For aircraft with high tyre pressures, Rolled Asphalt by the Marshall method is required, but this is seldom likely to be required in Field Construction.

Suitable specification for Airfield Pavements are given in the MPBW General Specification No 201, CU(CE)6 of October 1965.

Yours faithfully,

J. R. E. HAMILTON-BAILLIE.

Colonel R H S Hounsell OBE

Memoirs

COLONEL R. H. S. HOUNSELL, OBE

RANDALL HENRY STRANGWAYS HOUNSELL was born at Weobley, Herefordshire, on 1 March 1890, where his father, Frederick Hounsell practised medicine. His mother being an Irish Catholic he was brought up in that faith, and was educated at the Benedictine Monastery School at Downside, Somerset. From there he passed into the Shop in July, 1908; and was commissioned as a 2nd Lieutenant in the Royal Engineers on 27 July 1910.

From the beginning of his career in the Army, Hounsell's interests lay in the direction of civil engineering as opposed to military engineering as such. Whilst a young officer at Chatham he became the centre of a group interested in classical music, the taste for which remained with him all his life.

On passing out of Chatham he selected India as his choice and, in consequence, underwent a course in Railway Locomotive Mechanical Engineering at the LSW Railway Workshops at Eastleigh. This course he shared with C. W. S. King of his batch (now Lieut-General Sir Charles King) who had selected Indian Railways as his choice on leaving Chatham. It was evidently considered by the War Office at that time that a course in Mechanical Engineering in England was a suitable preparation for service in the Engineering or Traffic branches of the Indian State Railways!

In 1913 Hounsell arrived in India as a Lieutenant, and found himself posted to Ambala as a Garrison Engineer in the Military Works Services, as it was then called. On the outbreak of war in August 1914 he made strenuous efforts to be sent overseas; but in spite of these efforts he was retained in Works Services in India until January 1918, when he was posted to Basra as Assistant Director of Works, Mesopotamian Expeditionary Force.

On the cessation of hostilities Hounsell returned to India, where he joined the RE HQ in Simla in 1920. Shortly afterwards he was posted as Adjutant to the CRE Wana Column, and eventually became Garrison Engineer Landi Kotal at the head of the Khyber Pass. After a period of leave in England he returned to India, where he continued to serve in the Military Works Service in various parts of that country and in Waziristan.

In 1928 Hounsell, now a Major, was posted to Army HQ Simla, and later served as SORE 1, Eastern Command at Naini Tal until January 1933. By then, Hounsell decided he had served long enough in India, and at the termination of his leave in England in July 1933, he reverted to the home establishment, and was appointed DCRE South Aldershot.

On his promotion to Lieut-Colonel in July 1934 he became CRE Home Counties Area (East) with his HQ at Dover. Here he remained until his retirement on 13 March, 1938.

Hounsell had the misfortune to be one of those unfortunates who was caught by the Hore-Belisha reforms of 1938, which laid down that no Lieut-Colonel on the completion of his tenure in that rank could remain longer than six months on half pay. If, at the termination of that period, there was no suitable vacancy in the rank of Colonel available, he was automatically retired—whether or not he had been recommended for promotion! Previous to 1938, a Lieut-Colonel recommended for promotion could, if he wished, remain on half-pay up to three years pending a suitable vacancy.

Hounsell decided on retirement to accept civilian employment in Works Services, and remained in Dover as DCRE.

On the outbreak of war in September 1939, he was recalled from the Reserve and resumed his previous employment as CRE Home Counties (East). During the first three years of the war he was kept extremely busy on the construction of anti-invasion works and of heavy coastal batteries near St Margaret's Bay near Dover, and elsewhere. One of these latter had the honour of a personal visit by the Prime Minister, Mr Winston Churchill.

In August 1942, Hounsell became a temporary Colonel, and was made Chief Engineer, East Kent District, South East Command; in which capacity he remained until 1947, when he retired for the second time.

He was mentioned in Despatches for his services in Mesopotamia 1918, and again for his work in Wazaristan in 1919–21. In 1929 he was made an MBE; and in 1941 he received the OBE for special services in connexion with coast defences.

On retiring in 1938, Hounsell bought a house at St Margaret's Bay, from where he was able daily to travel to his work in Dover. He continued to live in this house up to his death on 18 April this year.

For the last few years of his life Hounsell was compelled to live very quietly for medical reasons, although he found time to visit Italy on several occasions with his wife, Sheelagh O'Sullivan, whom he married in 1926. He leaves a daughter, Ann, who is married.

Ray Hounsell was a most efficient and capable engineer, and throughout his service in "Works" he invariably maintained a high standard of engineering wherever he was in charge.

Although quiet and somewhat retiring, he made a host of friends throughout his life, and was always most popular with those who had the good fortune to serve under him.

In his retirement at St Margaret's Bay he devoted much of his time to helping in local church activities. He also taught himself to become a very efficient clock and watch repairer.

H. A. J. de L.

MAJOR E. J. D. DREW

TED DREW, who died on 21 May last, was in my Regiment in Germany for about three years. He was large, very likeable and at times cheerfully untidy. Barrack Square soldiering was not for him. He was much more at home at the bottom of a collapsed rugger scrum and he knew exactly what to do there.

He knew his Sappers too, and knew them really well. Their home histories, their little domestic worries, their money troubles. He knew these because they told him about them, and they told him about them because they trusted him.

He was essentially a practical man, never happier than when trying to make some reluctant engine go again, or some bent piece of equipment do what it should. And if a truck went in the ditch in the early hours of the morning it was a safe bet that Ted would be there helping to pull it out. Not directing operations from the road, but "up to the armpits" in it, heaving on a rope. His heave was worth something too, for he was as strong as a horse. It wouldn't have mattered in the least to him if he had had nothing to eat for hours. He would only have worried if he had had a meal and his Sappers had not.

One little non-military incident seemed typical of him. Three or four of us were out after geese and duck on an old river channel in North West Germany. When the morning flight was over we all met near where Ted had stood. One of his birds—he was no mean shot—had dropped far out on the mud left by the ebbing tide. It was a horrible place. The mud looked bottomless, the reeds surrounding it were taller than a man. We had no dog, but even if we had it was no place to put one in. It never occurred to the rest of us that there was anything to do but leave the bird where it was. Not so Ted. He muttered something, put his gun down and before we could stop him had plunged in. Every step took him above the knees of his waders and must have nearly wrenched his legs out. But somehow he fought his way on, picked his bird and struggled back, happy and covered in evil-smelling mud.

He was a good companion, staunch and true. The way he liked to live meant that his hands were sometimes dirty—his mind never was. He was a soldier's man.

P.A.W.

MAJOR L. B. PROCTOR, MC

MAJOR LESLIE BROWNSWORD PROCTOR died after a short illness in Reading on 29 May 1966.

His association with the Corps started when he became Mess Secretary at Ripon in March 1949. He moved with the School to Chatham, and started the Mess at Gordon Barracks in March 1950. He was with the RSME for some eleven years, and saw YO batches numbers 2 to 24 go through the Mess during their young officer training. Once a batch had been in the RSME Leslie's interest in every member of it was such that they were all remembered, their careers were followed with interest, and they were assured of instant recognition with names, never forgotten, and a warm welcome whenever they met him again. His warmth of character, his kindness and generosity, his never-failing humour and sense of fun won him immense numbers of friends.

After he retired from being Mess Secretary the Corps remained his great interest until he died. Not long ago, when asked what career he would like to see a son of his follow, his reply was immediate—"A young man can ask no greater privilege than to be a Sapper officer".

His own military record may not be well known. He was commissioned in the Northumberland Fusiliers in 1914. He was wounded three times (once very seriously in the Battle of the Somme which is commemorated this year) in the 1914–18 War, and he was awarded the MC and Belgian Croix de Guerre. He gets special mention in Conan Doyle's *The British Campaign in France and Flanders* for his gallant and skilful handling of his company in retreat in the Second Battle of the Somme in 1918. His wounds caused his retirement in 1919. He served again in the Second World War in the RASC, finishing the war as Lieut-Colonel.

Many Sappers will feel personally the loss of a valued friend. The Corps has lost a man who devoted to it his energy, his interest and his affection to a remarkable degree.

R.W.M.L.

Book Reviews

GORDON—MARTYR AND MISFIT

By ANTHONY NUTTING

(Published by Constable. Price 35s net)

All Sapper officers ought to read this book on the life and death of Charles George Gordon, Royal Engineers, Companion of the Bath, Major-General in the British Army, Mandarin of China, Pasha of Turkey, Governor-General of the Sudan. It is doubtful, however, if any will agree with the theme running through it.

The book covers the whole fifty-two years of Gordon's remarkable life story. The early days at Woolwich and his first taste of battle in the saps and rifle pits before Sebastopol are lightly touched upon. Four chapters are devoted to the Taiping Revolt, Chinese Gordon and his Ever Victorious Army. The chapter describing his five year tour of duty as CRE Gravesend, the Freezes and his "scuttlers", entitled Faith and Charity, is a most moving one. The rest of the book, almost three-quarters of it, deals practically exclusively with Gordon in Equatoria, Egypt and the Sudan culminating in his death at Khartoum on 26 January 1885. Queen Victoria in a letter of condolence to his sister after Gordon's death referred to him as "your dear, noble, heroic brother". Even Gladstone, of all men, called him "a hero of heroes". Many biographies have echoed those attributes of nobility of purpose and steadfast courage. To the general public he was indeed a soldier saint and Christian martyr, a legendary knight in shining armour even if he went into battle armed with no other weapon than his "Magic Wand". But, as was inevitable, detractors came to smear that unblemished image. In this book the author has rightly dismissed those who pictured a besotted Gordon with a Bible in one hand and a brandy bottle in the other. Throughout his book, however, runs another theme to explain the enigma of Gordon Martyr and Misfit which he says previous biographers had elected either to conceal or to dismiss as being of no account. He hints that his deeply-religious inconsistent hero suffered from a sting of the flesh and might have been a sublimated homosexual, and that, throughout his life, he was motivated by an urge to suffer martyrdom without incurring the guilt of suicide and a longing for the glorious hereafter by death in battle, fortified by his fervent Christian faith. This the author maintains accounted for Gordon's total disregard of personal danger and his last stubborn stand alone at Khartoum selfishly refusing to become the rescued lamb and thereby sacrificing thousands of men, women and children to death or slavery as a price for his martyr's crown.

This is a new and more subtle form of denigration. The suggestion that Charles Gordon had homosexual tendencies cannot possibly be substantiated. Much has been written about Gordon's last mission to the Sudan, the conflicting directives he received and the 317 day's siege of Khartoum, nearly as long as that of Sebastopol. The country was vast; the garrisons to be evacuated far flung and the Berber–Suakin route was not available to him. The only means of evacuation was by armed river-steamers, his "Penny Steamers", navigating the difficult water of the Nile. As the waters of the river fell, and as the Mahdi's soldiers closed in, that escape route became more and more hazardous. In answer to a communication, stiff with displeasure, demanding him to state "cause and intention of staying in Khartoum", Gordon, with great simplicity, replied: "I stay at Khartoum because Arabs have shut us up and will not let us out." Here was the true answer; there was no death wish, it was no suicidal stand, sacrificing in his craving for martyrdom the hapless inhabitants of the beleaguered city. "If you send out a soldier to run away from those at whose head you have placed him you must not send a Gordon", wrote J. L. Gavin. Gordon, himself, closed his famous Khartoum Journal with the simple words: "I have done my best for my country—Good-bye."

On a pedestal of a statue, erected in his honour by the will of the people, the cardinal virtues of Charity, Justice, Fortitude and Faith are depicted. It was surely these that were Gordon's constant inspiration rather than the motives suggested by Mr Nutting.

A photograph of this statue is reproduced in the book with the caption: "Bible in hand—Gordon's statue in Trafalgar Square." This of course is inaccurate. Although originally erected there in 1886, the statue now stands in Whitehall Gardens. On 26 January each year, the anniversary of his death, the boys of the Gordon Boys' School—the National Memorial to Gordon—lay a wreath at its foot. This living instrument for Youth was founded in memory of "a man simple and heroic, loving righteousness and hating iniquity, born to be a soldier and a ruler he gave his heart to the young, the poor and the outcast. Accepting the hardest duties but refusing wealth and honours and counting his life as nothing if by any means he might lessen the miseries of mankind, in all loneliness, danger and perplexity he endured as seeing Him who is invisible." *Semper Fidelis.*

THE GREEK CIVIL WAR 1944-9

By EDGAR O'BALLANCE

(Published by Faber and Faber. Price 36*s* net)

Unemotional studies of irregular warfare during the Second World War, of its contribution towards victory, of its cost and, in particular, of its aftermaths, are still being published. Some even now are considered premature and unpalatable, if not positively indiscreet.

A recent such publication is *SOE in France* by M. R. D. Foot, an officially inspired justification of the Special Operations Executive, the wartime organization responsible for encouraging and directing resistance in enemy occupied territories. This book was reviewed in the June 1966 issue of this *Journal*. It has obviously hurt the feelings of General de Gaulle as much as those of the admirers of Odette. Another recent publication is *Baker Street Irregular*, by B. A. Sweet-Escott, which is a comprehensive review of SOE's global activities throughout the Second World War and the personalities and inter-departmental conflicts involved, written by one of the very few people qualified to undertake such a review, the publication of which has been awaiting official permission for many years and which is a long overdue "best seller".

The Second World War did not end for Greece—as it did not for Malaya—with the defeat of the Axis Powers concerned. In both countries several years of Civil War, the direct outcome of the opportunities provided by enemy occupation, were required to defeat Communism. In his book now under review, Major O'Ballance, who has already completed studies of Communist military strategy in China and Viet-Nam, provides us with a carefully reasoned study of previously published material on Greece during and after the end of the War proper, which enables the reader to understand how and why the repeated attempts by the Communists to seize power in that country were defeated, and incidentally, how we ever came to support and arm their resistance movement, ELAS.

He explains how, by the summer of 1943, the Communists had obtained by far the largest armed Resistance Force in Greece, which the Germans actually encouraged to fight against political rivals in the mountains in order to minimize guerilla interference with their own lines of communication. The timing of the Communists' first all-out attempt to seize power was based upon the erroneous belief that the collapse of Italy and the Allied landings in Southern Europe foreshadowed the early liberation of Greece. Having failed to seize power by violence early in 1944 the Communists changed their strategy and tried to overpower their political rivals by infiltration and subversion. But the Greek Government on its return to Greece, backed up by British Regular Forces, proved a more difficult obstacle than had been anticipated, and the Communists decided once again to resort to force.

This brought about the second all-out attempt to seize power, the rising in Athens in December 1944, which, after some anxious weeks, was put down by ill-spared British reinforcements from the main battle-front in Italy.

Whilst some of the left-wing leaders of ELAS thereafter resorted to legal activities, others, including some Communist extremists avoiding arrest for atrocities, scattered into the Greek mountains and to Yugoslavia, whence a year later they re-opened the Civil War. Thus in 1946 began the third and most costly attempt, which was not defeated until three years later, only after extensive American military aid had been received by the Greek National Army.

When at first sight there were so many similarities, why and how did Tito succeed in Yugoslavia while the Communists failed in Greece? Briefly it can be stated here that Tito's decision to support the military requirements of the Allies remained unaltered throughout the war and contributed largely towards the defeat of his only serious anti-Communist rival, Mihailovitch; whereas the Greek Communists, first under Siantos, and later under Zakhariadis, when he returned from German captivity, kept on changing their strategy. But for the presence of the British Military Mission and their support to all the Greek Resistance Movements, there is every reason to believe that the Communists would have confined their overt activities throughout the war to overpowering their political rivals and their activities against the Axis to covert and civil resistance; and that, as a result, when the Germans eventually withdrew from Greece, they would have been in sole power all over the country.

Major O'Ballance perhaps confines himself too rigidly to the subject of his study, and even omits important factors arising from the contemporary post-war Greek political scene in Athens, which affected the conduct of the fight against the Communists. He clearly describes the divisions of opinion on strategy within the Greek Communist leadership. But he glosses over one other important factor, the effect of the many terrible atrocities by ELAS against and on their own country folk.

His description of the third and most serious attempt by the Communists to seize power is excellent, and he rightly concludes that the main reason why they failed was because of their neglect of the primary principle of insurgent warfare, their failure to win the hearts and the minds of the people. The Greek national spirit, intensely proud of its democratic origins, and intensely individualistic, provides its people with an unsurpassed will to survive and ultimately to defeat tyranny; even if it does make democratic Government difficult when there is no unifying national emergency.

Major O'Ballance is to be congratulated on having produced a lucid, interesting and valuable study of how a victory over Communism was achieved. It is a balanced study which is almost ready for the history books. Some of it is by no means irrelevant to the war against the Communists in the Far East today.

E.C.W.M.

ERITREA 1941

By A. J. BARKER

(Published by Faber and Faber. Price 36*s*)

General Sir William Platt, Commander of the Allied Forces operating from the Sudan in 1940 and 1941, has written a forward to this account of the fighting in Italian Eritrea from the time that Mussolini declared war on 10 June 1940 in the hopes of easy spoils from a defeated France and a supposedly-defeated Great Britain to 16 April the following year when the Duke of Aosta surrendered all the Italian forces in Mussolini's East African Empire.

Colonel Barker, the author of *The March on Delhi* and *Suez—The Seven Days War*, has established himself as a military historian, and this his latest work fully lives up to the standard set in his two previous books. The Eritrean story gives a graphic account of operations carried out by the Sudan Defence Force and the three British Infantry

Battalions stationed in the Sudan, the 5th, and later the 4th, Indian Divisions and a battalion of the French Foreign Legion and Senegalese troops against Italian Regular and Colonial troops who greatly outnumbered them. After an initial reverse and a desperate struggle for the lofty heights of Keren, which was the decisive battle of the campaign, the whole of Eritrea and northern Ethiopia fell into our hands. This, linked with the operations under Emperor Haile Selassi and those of General Cunningham's through Italian Somaliland, caused the whole Italian East African Empire to crumble. It was the first successful British campaign of the war.

Victory, however, was not achieved easily. At times the Italians and their Colonial Troops fought tenaciously; distances to be covered were vast and the terrain mountainous and inhospitable making maintenance of the force a nightmare. The author states that the fighting at Keren was even more savage than that at Monte Cassino although the strength of the forces engaged was not as great. An officer of the Royal Fusiliers wrote: "Physically, by World War Two standards, it was sheer Hell. Nothing I met in nine months as a Company Commander in NW Europe compared to it."

APPLIED MATHEMATICS FOR A-LEVEL STUDENTS VOLUME I—DYNAMICS

By J. G. SWEETENHAM, BSc and D. M. ESTERTON, MSc
Senior Lecturers in Mathematics, Medway College of Technology

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 7*s* 6*d*)

This soft-covered book is one of the *Commonwealth Series of Model Answers* which form a section of the Commonwealth and International Library published by Pergamon Press. It is intended as an aid to revision for students preparing for the GCE Advanced Level Examinations in Applied Mathematics.

The questions used were taken, with the permission of the examining boards, from past examination papers set by London University, Southern Universities, Associated Examining Board and Welsh Joint Education Board. The solutions are those supplied by the authors.

The majority of the eighty-six questions utilized are hypothetical in nature and require the derivation of solving formulae. A lesser number are specific questions employing numerical values which demand numerical answers. The answers given to both types of question vary. In some cases complete solutions illustrated with diagrams are given, in others just the correct answers without further qualification.

The questions cover a range of problems dealing with elasticity, velocity, motion and kinetic energy.

F.T.S.

ADVANCED CALCULUS AND VECTOR FIELD THEORY

By KATHLEEN M. URWIN, MSc, FRAS, AFIMA
Mathematics Dept, Battersea College of Technology

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 37*s* 6*d*)

This book is included in the *Higher Mathematics for Scientists and Engineers Division* of The Commonwealth and International Library of Pergamon Press Ltd.

The book falls naturally into two parts. Chapters 1–5 give the basic ideas and techniques of partial differentiation; and line, multiple and surface integrals. Chapters 6 and 7 give the elements of vector field theory, taking the integral definitions of the divergence and curl of a vector field as their starting points. The last chapter surveys very briefly some of the immediate applications of vector field theory to five branches of applied mathematics: hydrodynamics; Newtonian gravitational attraction; electrostatics, magnetostatics and electromagnetism.

Numerous worked examples are included in the text and a number of student

exercises are given at each section end for practice in the basic techniques discussed. In addition some more varied miscellaneous exercises containing many past BSc (Eng), BSc (Spec), and BSc (Gen) questions are provided—with answers.

F.T.S.

METAL TRANSFER AND BUILD UP IN FRICTION AND CUTTING

By V. D. KUZNETSOV

Translation from the Russian, edited by E. H. FREITAG

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

The purpose of this book is to arrange the knowledge of metal build-up; explain a number of phenomena in the cutting, scratching and sliding processes from the point of view of metal transfer theory; and describe some of the investigations akin that have been carried out by the Siberian Institute for Technical Physics at Tomsk.

For the purpose of the text "build-up" is defined as the formations on the surface of one body composed of particles transferred from another body. These vary in appearance and name (adhesions, smears, deposits, etc) and effect machinery processes, friction and seizure.

The text deals with these phenomena in considerable detail and examines avenues of information hitherto unexplored. The author, therefore, is anxious that readers should realize that some of his theories need further substantiation by laboratory experiments and practical tests.

Separate chapters deal with: Friction and Surface Temperature; Seizure of Metals; The Built-up Edge in Scratching and Cutting; Metal Transfer in Friction; Investigations of the formation of a build-up of transferred metal in the sliding between Carbide and Zinc and Aluminium; Friction between Steel and Cast Iron. Each chapter is illustrated with photographs, drawings and diagrams in support of the text. A four-page summary of the author's conclusions is given at the end of the book.

The text would be of interest mainly to metallurgists, designers of machine tools, and others concerned with lubrication and braking.

F.T.S.

ELECTRONICS, RELIABILITY—CALCULATION AND DESIGN

By G. W. A. DUMMER MBE, MIEE, MIEEE, MIERE and N. B. GRIFFEN, AMIRE

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

This book, which is included in the *Electrical Engineering Division* of The Commonwealth and International Library of Pergamon Press Ltd, has been published with the permission of the Controller, HM Stationery Office.

Its purpose is to present the basic theory of reliability and describe the present day design of electronic components, assemblies, equipments and systems in order to prevent undue failure under working conditions. The text is, therefore, divided into two parts, theory and practice, in approximately equal proportions.

The first half of the book expounds the units and definitions used in the science of statistical research to collect, tabulate and interpret data from which predictions of reliability can be calculated at component, equipment and system level. Because one of the main objects of all designers of electronic equipment is to ensure that components are not overstressed a complete chapter is devoted to safety and derating factors.

The second half of the text outlines the principles of construction and covers: design, materials, wiring, cooling, sealing and the effects of extremes of temperature and humidity. The modern practice of endeavouring to obtain high reliability by using micro-electronic techniques is explained, and a comprehensive series of proven failure statistics are provided in the last chapter.

More and more service equipment is being designed to utilize electronic components and systems, so this book is obviously worthy of study by military engineers.

F.T.S.

Technical Notes

CIVIL ENGINEERING

Notes from *Civil Engineering and Public Works Review*, February 1966

A short article for planning engineers in the February issue describes the use of a card network for building up a CPM type diagram. Its basis is that each activity is printed on a card together with the information relative to that activity, eg LET, EET, Float etc. The cards are then set out on a planning board and linked according to their network inter-relationship. Since adjustment and card changes are quick and easy the network grows rapidly without the usual rubbing out associated with drawing the normal CPM levelled diagram. The final card plan is then photographed as a permanent record. By using a colour code for differing trades several planners, each an expert in a particular field or trade, can work on the plan at the same time. This system is being taught in the Industrial Administration Department of the Heriot-Watt University, Edinburgh.

Reporting the formation of a new Company to develop, build and operate submersible work chambers, a short feature describes a new form of diving bell. The chamber is designed to convey divers rapidly to and from the seabed which, when used in conjunction with a surface decompression chamber and oxy-helium breathing apparatus, will increase the range of diving operations at depths below 200 ft. Chambers at present under construction are for use down to depths of 600 ft. The usual drawback of nine hours decompression for a diver who has worked for 30 minutes at 600 ft is overcome by bringing the diver to the surface in 15 minutes at constant pressure within the chamber and then transferring him immediately to a surface decompression chamber. Thus the maximum use can be made of the work chamber using shifts or relays of divers. The submersible work chamber contains two compartments separated by a pressure tight door. The upper compartment is occupied by a technician and a stand-by diver and is normally maintained at surface pressure. The lower compartment is occupied by the working diver who passes in and out via a hatch. The work chamber is produced by Constructors John Brown Ltd and Divers International (UK) Ltd.

Two articles, one dealing with the flexibility of straight built-up beams subjected to transverse loads and the other dealing with the response characteristics of a miniature earth pressure cell, are of interest mainly to the research worker rather than the practical engineer. The latter, however, may find a paper by Prof. T. M. Charlton of Queen's University Belfast on the Development of Modern Structural Analysis of more general interest.

Well worth reading is a very descriptive article discussing the Tidal Generating Station on the River Rance which is situated just to the west of the Cherbourg penninsular in Northern France. The generation of electricity using energy provided by the tide is at present only feasible where there is a considerable range between high and low water. This particular area of the French coast has a tidal rise and fall of 11 metres compared to the Britsol Channel range of 13.8 metres. The potential energy of this head of water is further increased by pumping water upstream at high tide against a very small head and releasing this same water back through the turbines at low tide when its increased potential energy can be utilized. This article is mainly concerned with a general description of the works and a more detailed discussion of the construction of the barrage and the attendant machinery will be given in the March issue. See *RE Journal*, June 1966.

B.O.B.

Notes from *Civil Engineering and Public Works Review*, April 1966

ENGINEERING ECONOMY AND THE CONSTRUCTION ENGINEER. This article, which is the first of three devoted to the subject, is by a Senior Lecturer in Construction Management at Loughborough. It deals with modern ideas on costing and economics generally in the construction industry, and is concerned with the ways in which economic factors influence engineering decisions. Much of the discussion might be thought to exclude the military case, where money is not invariably a critical factor, but the point emerges clearly that a financial evaluation between several possible solutions will often indicate the best answer from an engineering point of view. In so many cases "time is money".

The article is well worth reading for its indication of the increasingly scientific approach to management problems.

WATER FEATURE. This is another in the valuable series of special features presented by *Civil Engineering*. It forms a review of the civil engineer's contribution to the location, development and transport of potable water supplies. There are thirteen articles, ranging from a review of the World Water Situation ("water, the supply of which seemed inexhaustible, is in the process of becoming a scarce commodity") to the use of TV cameras for the internal inspection of pipelines. One point which emerges clearly is the rapidly growing use of plastics in water engineering, both as pipes and as waterproofing membranes.

C.F.R.

Notes from *Civil Engineering & Public Works Review*, May 1966.

In the May edition of the *Civil Engineering* the leader draws attention to the rules for membership of the new Council of Engineering Institutions, in particular the subjects required for the Part I Examination which is due to be held for the first time in October 1967. Details of the Part II Examination will be published later this year in preparation for the first examination in April 1968.

Not only in England are we plagued by industrial disputes. The construction of the Toronto Dominion Centre in down town Toronto was threatened by one of the "who puts the windows in" type of interunion dispute.

A short article describes how this problem was side-stepped using a temporary cladding which enabled the construction to proceed while the matter was settled. This was important as from a design standpoint all cladding had to be in place before construction could proceed beyond the thirtieth floor level.

In the second of three articles dealing with Engineering Economy and the Construction Engineer, Mr R. Pilcher, a Senior Lecturer at Loughborough University of Technology describing current methods of economic appraisal within construction, deals with the discount cash flow method. Simple examples are used to illustrate the method and this method used to show how a choice can be made between alternative schemes taking into account rate of return and yield of investment.

The Estimation of Creep in RC and PC Design is the subject of an article by Professor R. H. Evans. A straightforward method is presented for estimating the values of creep taking into account various factors. Thus this is an article of immediate use to the practising engineer and not a pure research paper. The articles take into account standard mixes, the type and duration of load, the affects of age at first loading, temperature and humidity as well as the analysis of the mix and its constituents. A very full bibliography completes the article.

The description of two new elevated road structures, the Mancurian Way and the Chester Inner Ring Road Viaduct, make interesting reading and show the great strides made in the design of prestressed concrete for this purpose. Of particular note is the basic frame segment section of the Mancurian Way elements which in some ways resemble the deck section of the new Severn bridge which are of course fabricated in steel.

Other articles describe the progress of tunnelling machines on the Victoria line,

and Site Investigation for Estuary Barrages, while two theoretical papers discuss the Analysis of Partially Constrained joints and a First Element Solution to Skew Slab Problems. For those more concerned with practical construction and estimating this issue contains the latest "Measured Rates".

B.O.B.

Notes from *Civil Engineering and Public Works Review*, June 1966

Engineering Developments in the USSR. A note on the use of timber for highway bridges in the USSR appears in the June issue. Current designs employ a laminated glued timber construction in the form of three-pin arches, triangular frames or laminated girders. American experience has shown that where timber is freely available the cost of a timber bridge, with an expected useful life of fifty years, is half that of a similar precast concrete bridge. In six years the length of timber bridges constructed in the USSR aggregated to about 40 miles; further construction at the rate of about 17 miles per year is expected.

Classification Test for Shrinking and Swelling Soils. A recently developed test is described which enables a soil to be classified according to its potential to expand or contract, resultant foundation movements being graded from "negligible" to "very serious". Tables, which give a guide to the economic design of foundations for brittle structures, are provided. The test, which the author prefers to index tests and particle size distributions, employs an undisturbed sample and this preserves three very important properties—soil structure, stress history and moisture history. The sampling equipment is light and readily portable and the test equipment—a type of oedometer—is equally suitable for use in the laboratory or in the field. Design recommendations are based on results obtained in Victoria, Australia, and take into account severe effects of climate, vegetation and drainage; if suitable regard is paid to local climatic conditions and experience the method should prove to be of general appplication.

Tidal Barrages. An interesting article discusses the construction of tidal barrages and the purposes for which they have been built. These are listed as: Protection of low-lying land from the sea; land reclamation; provision of communication links by bridging; fresh water storage reservoirs; harbour construction; tidal energy for electrical power generation; improvement of navigation.

The article concludes by considering a number of possible sites for barrages around the coast of the British Isles and discusses the advantages to be derived from each.

Load-Factor Design of Beams and Slabs. A brief article adequately outlines a straightforward design method applicable to any permissible steel stress in accordance with the requirements of the February 1965 amendment to the British Standard Code of Practice CP114 (1957). The author considers four cases: tensile reinforcement only. Compression reinforcement. T-beams and L-beams. Combined bending and direct force.

The article should be read in conjunction with CP114 as the symbols used are not otherwise explained.

J.D.W.

THE MILITARY ENGINEER

March–April 1966

A National Materials Policy by Franklin Pierce Huddle. The author served for many years in the Office of the Secretary of Defence dealing primarily with strategic materials and later on in the Executive Office of the President working on a study of national materials policy. In this interesting article he describes the methods used by the US to ensure that the supply of essential materials was maintained. It is interesting to read how expected shortages were often successfully met by the development of substitute materials and by improvements in design which produced economies in their use.

CENTRIFUGE FOR SPACEMEN by Brig-General A. P. Rollins Jnr and Major H. E. Emig, Corps of Engineers. A new trainer in the Flight Acceleration Facility at the NASA Manned Spacecraft Center near Houston, Texas, has just been completed. It will take a team of Apollo astronauts on a dynamic ride into space and bring them back to earth again without leaving the ground. This short well illustrated article enumerates the technical problems which had to be solved and indicates the way in which this has been done as fully as possible within the limits of a short article. Basically the apparatus is a gondola which can carry three astronauts in a vacuum and which can be rotated in two dimensions while itself is being rotated at the end of a 50-ft long arm. The technical problems which have been surmounted are formidable. Once again the immensity of the space programme is emphasized by the magnitude of what is only a training device.

DEFENCE MANAGEMENT EDUCATION by Lieut-General August Schomberg, United States Army. This is a description of the organization of and courses of instruction at the Industrial College of the Armed Forces. The college developed from the Army Industrial College founded in 1924 to conduct studies in problems of industrial mobilization for officers who might fill important posts in war-time procurement. The present college is now for senior officers of all arms and civilians and covers a wider scope but with the same basic ideas. Much detail of the various courses is given and a good idea is given of the range of subjects with which it is considered that a body of officers who are concerned with military logistics should be familiar.

WHAT VALUE, VALUE ENGINEERING, by Comdr B. S. Merrill Jnr, Civil Engineer Corps US Navy. Value Engineering is a technique to ensure sound, economical solutions to engineering construction problems through the employment of engineers who have extensive knowledge of conventional and new materials and construction techniques and who are called value engineers. A description of how these value engineers work and examples of savings realized through their co-operation are given.

PRECISE CONTINUOUS POWER SYSTEMS by Lieutenant Orelan R. Carden Jnr, Civil Engineer Corps US Navy. Precise continuous power is a requirement for all cryptographic equipment, message routing and processing equipment, computors and other highly sensitive electronic devices in communications and operations control centres. In this clear and well illustrated article will be found descriptions of systems in use in the US Navy with suggestions on the probable new developments which are on the way.

THE SHIP THAT COMES APART by F. C. Livingstone. This is a short description of the "Multipacket" a vessel built so that the aft section, containing the propulsion unit, may be rapidly disconnected from the cargo sections, and freshly loaded hull sections can be linked in for movement to the next port. The vessel was designed by Hay and Smart Ltd, Liverpool, and following further extensive tests, the Ministry of Transport is expected to approve it for an International Load Line Certificate.

CHEMICAL PROBLEMS ON THE MOON by Richard A. Cini. The special conditions on the moon, absence of atmosphere, low gravity, extremes of temperature range, produce problems for the chemical engineer concerned with supporting life on the moon. The factors are described in this interesting short article which, among other things, discusses ways of producing water from the rock of the moon.

CORROSION—CAUSE AND CURE by Lieut-Comdr Willard E. Edwards, US Navy Reserve, Retd. Common corrosion is a wasting away process which destroys metals through an electrochemical surface action in the presence of moisture. The author elaborates this theme and describes the best ways of overcoming this tendency by means of cathodic protection. This means creating a direct current equal and opposite to the destructive current set up by the electrochemical effect in metal surfaces in contact with moisture. Various methods of creating this opposing current are described with details.

Military Engineer Field Notes

The Squad Test by Captain Thomas E. Kersher, Corps of Engineers. A brief description, with photographs, of tests set by a company commander to find out the potentialities of his unit. The tests were exhaustive and exacting and it is interesting to see the high standard of training expected.

Turbines for Precise Electrical Power by Captain Jack R. Tate, Corps of Engineers. This note is complementary to the article in this number reviewed above. It describes the power units developed by the Engineer Research and Development Laboratory to provide precise electrical power at intercontinental missile sites.

Hydraulic Dredge. There is a picture and brief note on page 129 of a new hydraulic dredge for operation along the East Coast and the Gulf of Mexico. The dredger is semi-automatically controlled and there is a note on its design and operation.

May-June 1966

Mapping Evolution in the Next Decade by Major-General T. J. Hayes, US Army. The author of this article is the Director of the Typography and Military Engineering in the Office of the Chief of Engineers and he writes with authority on the problems facing the map-makers of the future. Eighty per cent of the earth's surface lacks adequate map coverage at scales for general planning or military needs which are more various than ever before. The magnitude and scope of world-wide requirements calls for the fullest use of computors and other aids including satellites. In this article an outline of the equipments available and under development is given with some information on how the map requirements of the Vietnam War are being met.

Salvage of the 602 by Lieut-Colonel L. W. Norton II, Corps of Engineers. After Hurricane Betsy which struck Louisiana in 1965 a barge loaded with 600 tons of chlorine was reported missing believed sunk. This articles describes the location and recovery of the barge and its contents, fortunately undamaged. There are good photographs and sufficient technical detail to make the methods employed clear.

Navy Operation of the PM-3A by Lieut-Comdr Stephen D. Lowe and Lieutenant Charles E. Fegley III, Civil Engineer Corps, US Navy. The PM-3A Nuclear Power Plant was installed at McMurdo Station Antarctica between November 1961 and February 1962. It was intended to do three things. Evaluate the effectiveness of nuclear power plants at remote stations, to develop the ability to apply and operate a nuclear shore power plant in Antarctica and to use nuclear energy to improve the habitability and reduce the logistics requirements of McMurdo Station. These objects have been achieved and a further requirement has been defined, to provide the primary source of electrical power for McMurdo Station. This article describes the teething troubles encountered during the first year of running and maintaining the plant. There are good photographs and diagrams.

Industrial Waste Isolation. A New Concept to Preserve Fresh Water by Malcolm S. Crawford and Clark A. Ritchie. Both the authors of this article are concerned with the problems of water polution in their work in the Oklahama Air Material Area. The pressing nature of the problem is emphasized by the fact that Lake Erie one of the five largest bodies of fresh water in the world is now poluted to the point where fish and aquatic life are extinct and it is doubtful if the water is fit for human use. The article summarizes the various elements causing polution and describes the measures which can be taken to eliminate them. Their conclusion is that a project to meet current criteria would have to include the separation of storm water from sewage and the separation of both from industrial waste. The latter would need a separate collection system plus the equipment to concentrate, recover and finally dispose of the residue. The cost of an overall scheme for the US would be immense

but in the opinion of the authors the alternative of doing nothing will be disastrous. A considerable amount of detail of the methods proposed for dealing with industrial waste is given.

COAST GUARD RESCUE CRAFT by Lieut-Comdr Robert W. Witter, US Coast Guard. This is virtually a catalogue with photographs of the various sea rescue craft in service and under development in the US Coast Guard Service. Broad specifications of design and performance are given.

PROPOSED UNDERSEA AQUEDUCT by Lewis B. McCammon. The author is director of the Engineering Department of the National Engineering Science Company and is engaged in the design and development of off-shore structures and petroleum production systems. There is water shortage in Southern California and it will grow steadily more acute. Two previous articles in the *Military Engineer* in March–April Number 1964 and May–June Number 1965 describe the development of plans to tap the great resources of the rivers in the North of the state and deliver the water to where it is needed by means of overland aqueducts and pumping lifts. The author outlines in this article an alternative scheme whereby the overland aqueducts would be replaced by an undersea aqueduct system which, it is claimed, would be far less costly and more efficient as much pumping would be saved. A great deal of detail of methods of construction and maintenance are given and further study in greater detail appears to be fully justified.

THE SKY HIGH RADARS by Frank King. A common radar surveillance system is in course of being established covering the US. To be as effective as possible the radar stations are sited on the highest possible ground often above the snow line. This article describes the problems which have been set by the requirement but only in general terms. There are good illustrations. Evidence of the effectiveness of a radar air traffic control system is reflected in the proportional decrease in mid-air collisions and near misses.

LASER GUIDE FOR BORING MACHINE. A note on page 203 with illustrations of a "Hard-rock Boring Machine Directed by a Laser Beam Guidance System" that can cut tunnels 21 ft in diameter.

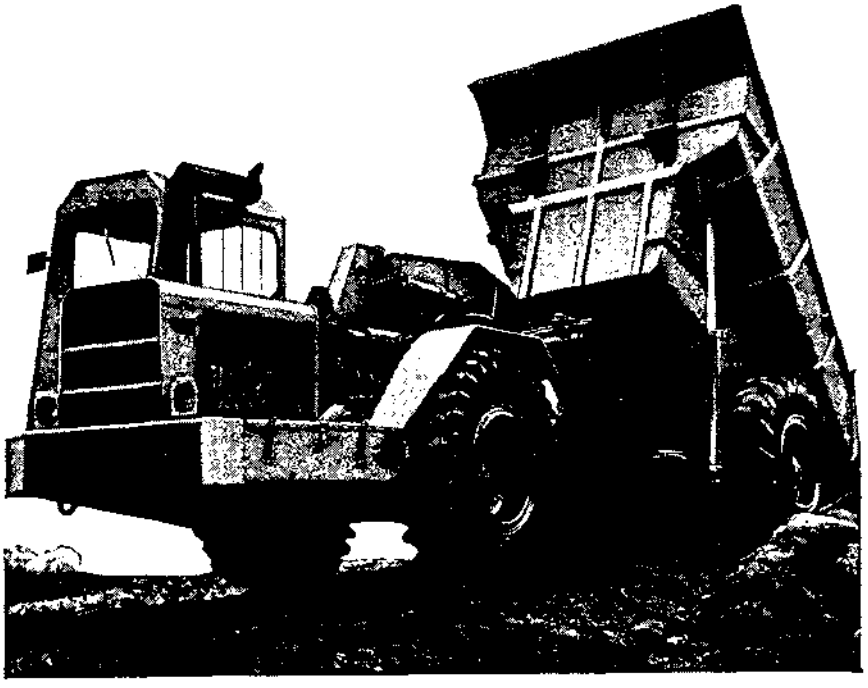
MILITARY ENGINEER FIELD NOTES

EXPEDIENT BRIDGE FOR VIETNAM. A 30-ft span launching bridge helping to solve the gap-crossing problems of the M-113 armoured personnel carrier and the M-41 tank constructed from M-4 balk and materials available in the field has been designed by the Army Engineer and Research Laboratory Fort Belvoir. It is described with clear photographic illustrations.

VIETNAM WATER SUPPLY EQUIPMENT. An illustrated note on a light weight field water purification unit for the air mobile divisions in Vietnam.

FIELD-FABRICATED PILE DRIVER, VIETNAM. An illustrated note on an extemporized pile driver assembled in Vietnam using a 10-ton mobile crane, ½-in sheet piling and a variety of scrap materials.

SOIL COLOUR by Captain James A. West, Corps of Engineers. Although colour has little direct influence on soil behaviour it does give a guide to its composition. A summary of the inferences to be drawn from a range of soil colours is given in this article. J.S.W.S.



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