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Finance, Foundations, Frame and Fabric

AT the Annual General Meeting of the Institution, held on 27 June 1973 the recommendation of the Council to increase subscriptions by 50% all round was accepted.

From 1 January 1974 the new subscriptions will be:

Rank, etc	Annual Subscription
Serving RE Officers of the Active Army	
Combatant	
Lieut-Colonel and above	7·50
Majors	6·60
Captains	5·65
Lieutenants	4·65
2/Lieutenants	3·75
Quartermasters	
Lieut-Colonels	6·60
Majors	5·65
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Other Full Members	
Lieut-Colonel and above	4·50
Majors	4·00
Captains	3·40
Lieutenants	2·85
2/Lieutenants	2·25
Quartermasters	2·25
Retired Officer Rates	
Lieut-Colonel and above	3·75
Majors	3·30
Captains	2·85
Subalterns	2·35
Quartermasters	1·90
Associate Members	2·25

Members who subscribe through Bankers' Orders, either directly to the Institution or through the CBO Scheme, need take no action as their banks will be notified of the change in accordance with the existing signed Bankers' Orders. Members who pay their subscriptions directly to the Institution by means other than Bankers' Order will be reminded of the new rates by letter.

The Council have for the past few years been concerned with the problem of maintaining the standard of Institution publications in the face of ever-rising costs. A number of measures have been introduced to tailor the service provided to the money available. These include:

a Reducing the *RE Journal* to seventy-two pages per issue, limiting the number of illustrations and restricting memoirs to one page;
b Reducing the *Supplement*, whenever possible, to twelve pages, by limiting the coverage given to club and sporting activities;
c Issuing the *RE List* annually instead of twice a year.

The Council felt that to go any further would reduce the standard of Institution publications to an unacceptable level, and it was mainly for this reason that the increases in subscription rates were recommended.

The additional income to the Institution, as a result of the increased subscriptions, will enable us to maintain a credit balance of income over expenditure for the next few years on the present level of service to Members.

The financial foundations have therefore been redesigned and approved. They will be executed in 1974.

The time to look at the frame and fabric to be erected on the foundations has arrived. The new structure must be similar to the existing. Indeed why not? The existing structure is of sound design. It could possibly be improved by moving some partitions, by modernization of some of the interior and by regrouping some of the functions of the rooms. Before these changes can be incorporated into the redesign it is essential that the present structure be carefully assessed and the needs and suggestions of the clients studied. The planning of the new structure should be started now and be ready for incorporation as soon as the new foundations are completed.

We have an opportunity not only to assess the service provided by the Institution but to introduce changes, if sufficient Members consider that changes are needed. The Council would welcome the views of Members particularly on publications which absorb the bulk of the income.

Should the format of the *Supplement* be changed? Should it include a "What is going on" feature, highlighting in brief the main items of Corps news? If so, should "Events" come off the front page and be included elsewhere?

For some time now the "Correspondence" in the *Journal* has lacked vitality and the cut and thrust of opinions to stimulate Members. The *Journal* is published quarterly and at best the Correspondence is at three-monthly intervals. It is therefore difficult to maintain "pace", and interest soon wanes. Is there a case for Correspondence to be included in the *Monthly Supplement* to minimise this lack of "pace"?

Should accession to the Library and the Museum be published in the *Journal* and not the *Supplement*? The *Supplement* is designed to give up-to-date and topical information; do accessions fall into this category?

In short—what changes in service, if any, would individual Members like to see? This question is important for the future of the Institution and the Editor looks to those Members who have views on the subject to let him have their reactions.

Before rushing to write to the Editor it is worth remembering that:

a To produce a second *RE List* each year will require an additional £1,500 per year, exclusive of postage;
b The *Supplement* must change in four-page increments costing about £50;
c The *Journal* must change in eight-page increments costing about £120.

1973 Corps' Annual General Meeting

ADDRESS BY ENGINEER-IN-CHIEF

AT the Annual General Meeting of the Corps, held on 27 June 1973, the Engineer-in-Chief, Major-General M E Tickell CBE MC, gave a talk on the State of the Corps. He said:—

Any account of Corps activities during the year ought to start with Northern Ireland not only because, in common with the rest of the Army, it has continued to dominate our training and thinking and deployment, but also because to a certain extent our achievements there have gone unsung.

NORTHERN IRELAND

During the past year the Corps has continued to operate in the Province in both the Infantry and Sapper roles, which together have absorbed a high proportion of our available effort. At the beginning of 1971 there was one Field Squadron in the Province. Operations in the Summer of last year, culminating in Operation Motorman in July, raised this to six Field Squadrons, an extra Regimental Headquarters, a Support Squadron, and an Armoured Engineer Troop, all deployed in the Engineer role, just after an Engineer Regiment had completed a tour in the Infantry role. We are now maintaining three Field Squadrons, one from BAOR and two from UKLF, in the Engineer role and a three-Squadron Regiment from BAOR in the Infantry role for about half the time. However, even this is a heavy load when you consider that each squadron doing a four month tour in Northern Ireland is not available for other overseas tasks for about a year, taking into account the training time and the period in baulk on return. Very careful training is needed for an environment when one soldier's ill-judged word or act, perhaps under intense provocation, can have such a serious effect.

Rather than attempt to give a balanced account of the multifarious activities of the Corps in Northern Ireland, I will focus attention on a few points of particular interest.

Defences. Defensive works of all kinds have been an important task and we have had to develop new techniques as well as rake through the text books of the First World War. As an example of the former, we have had to surround all sangars and protected posts with wire-mesh as a defence against rocket attack and some of our accommodation has overhead netting as a burster course against mortar attack. The sand bag is now being replaced with dense concrete blocks, just as quick to lay and just as flexible in a good bricklayers hands; the precise design of embrasures and so on has developed to a fine art against the threat of a sniper who may fire from a window of a derelict house only fifty yards away. Sappers are very vulnerable while improving defences and both we and our infantry protective parties have had a number of casualties on this task. Squadrons in Northern Ireland are ably supported by 325 Engineer Park whose workshops produce in large quantities such items as prefabricated sangars and OPs, and knife-rests. The full resources of the Engineer Support Group are also beamed in whenever needed, and CEP, Long Marston has a large stores and workshop commitment to Northern Ireland.

Barricades. Barrier clearance is another major pre-occupation at intervals, mostly done by wheeled tractors with their fearless operators. Barriers go up at fantastic speed at the drop of a hat and it is not unusual for fifty or more to have gone up overnight. The Bogside/Creggan barriers facing Operation Motorman in Londonderry were particularly formidable and they were likely to be covered by fire. In consequence we mounted a neat little amphibious operation which is worth recalling as a tribute to the Armoured Engineers. A troop of four AVREs from 26 Armoured Engineer Squadron in Germany, after a long period of hiding in various ports in

Great Britain, was moved across to Northern Ireland on *HMS Fearless*, motored up the Foyle in LCMs, landed in Londonderry a few hours before H hour, led the assault and cleared a way through the barricades on all four routes into the Bogside-Creggan, then re-embarked and cleared Northern Ireland within twelve hours of arriving. The haste was essential to thwart a propaganda campaign which would have quickly built up against the use of tanks.

Search Operations. We are also closely involved in search operations, the most successful of which deprive the IRA and Company of valuable resources. Field Squadrons provide both specialist search teams and combat engineer sections for search operations, and as an example of their success, the escape tunnels in Crumlin Jail and Long Kesh were discovered through the vigilance of Sapper search parties. The searching for arms, ammunition, and explosives to be effective must be carried out systematically by properly trained troops who know where and how to look. The RSME is now responsible for the training of search teams of all arms from UK prior to their tours in Northern Ireland, as well as the Sapper teams and dog handlers from the Royal Army Veterinary Corps. Chief Engineer BAOR is responsible for similar training for his units. We are also, of course, deeply interested in the development of search equipment which is becoming more and more sophisticated.

EOD. At this stage I would like to say a word about EOD, (Explosive Ordnance Disposal), in case any of you are wondering why the Corps appears to be taking a back seat behind the RAOC in this dangerous task. In general it can be said that we do the expert searching while the RAOC dispose of the device when found. A great deal of mutual respect exists between us. We, of course, still have the booby trap role in war but the intense sophistication of IRA devices suits the specialized experience of the RAOC ammunition technician, generally a senior NCO or officer. They are very brave men.

Infantry. As already mentioned we are also providing units from BAOR in the Infantry role. I like to think that we do this well as we always have in our history. Certainly the Regiments there have had a very high reputation. They are able, of course, to establish close links with the community not only through living in the area but through the construction of playgrounds and other amenities.

Survey and Postal. A word on the work of the Survey Branch in Northern Ireland. They have produced not only a whole series of updated town plans of the bigger towns but, at very short notice, an excellent series of maps of the border areas. That Service too has a very high reputation in the Province. The same applies to RE Postal who have responded quickly to every new commitment. I would mention, for example, the need almost overnight to switch to a full BFPO system for private mail and the tricky problem of guarding against explosive parcels and letter bombs.

WORLD TOUR

I would not like you to think that our heavy commitments in Northern Ireland have prevented the Corps from being spread as usual right across the world. We have continued to undertake project work abroad and for next year we have already planned squadron exercises in Hong Kong, Canada, the Sudan, and Kenya.

In Gibraltar, the Europa Road which was started in 1971 by troops from UKLF on arms plot tours, is now nearing completion. The half mile road cut round the end of the Rock was a delicate task involving difficult excavations, some high retaining walls and a bridge. I hope that Phase 2 of the Europa Point re-development will be completed next year by 111 Engineer Regiment TAVR who are planned to complete the Europa Promenade. During the period of the Gibraltar General Strike last August, 1 Fortress Squadron successfully operated and maintained the Civil Power Station at very short notice as well as running the Service one as usual.

In Cyprus, we are undertaking the reconstruction of the Akrotiri Mole, on behalf of the DOE. The Mole, which encloses the only harbour in the Akrotiri Peninsula, has been severely damaged by storms and is now being remade with 70,000 tons of

up to 4 ton rocks from one of the largest quarries we have opened and worked since the War. 22 Engineer Regiment from 3 Division also initiated a large reinforced concrete swimming pool badly needed in Dhekelia—it is being test filled soon.

TAVR units have also been busy in Cyprus and Gibraltar. One Engineer Regiment, for example, completed twenty-one projects in Cyprus last year.

In the Arabian Gulf, 131 Parachute Squadron TAVR undertook a difficult track improvement task which was then extended by our element of the MAT in Sharjah.

The most exciting of our current overseas commitments is subject to a Security clamp but perhaps I would be allowed to tell one story about it. A large, inaccessible village in the Middle East lacked a school and medical centre, although a local builder had contracted to build them and had had stores on site for two years. In desperation the Squadron Commander flew in Sapper Chambers. I met him last week by the almost completed buildings and asked him what advice he had given them to inspire such high-class work. He answered none as he was a welder by trade and knew nothing about building construction and anyhow he didn't speak the lingo. What then was the secret of his success? He replied that he didn't really understand but he only knew that whenever he was there they built and whenever he went away they stopped. A good illustration of the power of the Sapper!

Turning now to Africa, last summer 51 Squadron were engaged on a project in North West Malawi, where they constructed a difficult section of road and prepared an additional thirty-seven kilometres of road within the period of the exercise to help open up the border area adjacent to Zambia.

In Kenya earlier this year 53 Squadron constructed thirteen kilometres of road to complete the 1972 road project.

Moving to the Far East you will recall that early last year 33 Squadron constructed a 2 mile stretch of jeep track, connecting an existing road-head to an isolated Police Post overlooking Deep Bay in Hong Kong. The Gurkha Engineers and 54 Squadron have been kept fairly busy repairing and maintaining the road following some exceptional flooding. Sappers have also been involved as usual in maintaining and constructing border defences, and in construction tasks for both the military and the Civil Communities. We still retain our Troop with the ANZUK Force in Malaysia.

Across the world in British Honduras elements of 10 Squadron completed priority camp improvements for the garrison late last year, and constructed two camps in support of DOE. We continue to maintain a Sapper Troop on roulement from the UK.

We have also been well represented in North America, where 9 Parachute Squadron, ably supported by fifteen Junior Leaders from the Junior Leaders Regiment at Dover, constructed two improvised bridges and a section of new road in the Valcartier training area North of Quebec as part of a combined task with the Canadian Engineers to open up a ring road through the Northern Part of the training area, and six members of the Squadron also managed to get up to the High Arctic to sample life with the Eskimos. Sappers from BAOR and elements of 24 Squadron, the RSME Support Squadron, have also exercised in Canada and this summer 66 Plant Squadron and elements of 37 Engineer Regiment will be working on a road and bridge construction task to further extend the Valcartier training area.

At present 59 Commando Squadron are exercising in Kansas in the USA, building a rock filled breakwater and undertaking associated tasks including a haul road. You may wonder why we are doing MACC tasks in the USA. The answer is that it is valuable for both armies to see how the other operates, and the US Army is becoming all-regular like us.

In the field of professional engineering the Corps is still very active. Our need to be able to react on a world-wide basis has recently been recognized in the Ministry of Defence by the endorsement of a requirement for a world-wide engineering capability over and above the White Paper priorities which tend to confine our provisioning to the European Commitment. The world-wide deployment of MES personnel and management and specialist teams is now on a firm footing. Their expertise is being

enhanced by the introduction into the Corps of a computer capability. At the RSME there is now an Elliott 803 computer for use in instruction, and we are beginning to get the Hewlett Packard pocket and desk-top calculators.

The RE Assistance Team from 12 Engineer Brigade withdrew from Bangladesh late last July after assisting in the restoration of road communications and in the supervision of bridge construction, using Bailey Bridge equipment provided from ODA funds for relief work. The team also carried out an aerial survey of all road and rail communications for the United Nations Relief Organization.

The STRE returned to Malta last October and they continue to assist the Public Works Department in the planning and execution of projects concerned with marine works, light industry, and the tourist trade.

The Management Team in the Solomon Islands which was due to be withdrawn in March this year, has now been extended for a further two years, although at a slightly reduced strength. The deployment of further management teams to the Gilbert and Ellice Islands is now under consideration to assist in developing air strips in the Islands and to supervise the re-construction of a village damaged by hurricanes.

In Zaire a small team spent most of 1972 supervising the construction of thirteen Bailey Bridges in the North East Province, and we still have the British Army Training Team under Lieut-Colonel Donald Cameron based in Kinshasa and Likasi.

I have not yet mentioned BAOR except for their by no means insignificant contribution to Northern Ireland. The Sappers there continue to play their important role in support of 1 (BR) Corps and their equipment is improving every year. The Barmine Layer and M2 Amphibious Bridge are being following by the Chieftain Bridge Layer system and, at an early prototype stage, by the Combat Engineer Tractor. One of the prototypes was shown at the RE Demonstration at the beginning of this month. When development has been completed we will have a powerful machine which can accompany, and indeed lead, a battle group right into the forward areas. An important event this year was the move of 10 Field Squadron to Laarbruck to support RAF Germany. The Squadron provides the day-to-day support for RAF Germany with particular emphasis on the Harrier.

Both Postal and Survey units have also been busy overseas in the last year. A detachment from the Home Postal Depot was sent to Nepal to support the Army and RAF engaged on famine relief; and Survey, under their new Director, Brigadier John Kelsey, has been heavily involved in overseas work. Field Survey operations and exercises took members of Survey to seventeen different countries and eleven remote islands during the year. One task for an enlarged field troop from 42 Survey Regiment was to spend several months in Northern Kenya, East of Lake Rudolph, fixing new trigonometrical control points. The geodetic satellite survey team based in Washington has been widely deployed and Survey officers and soldiers, working as surveyors and navigators, have also taken part in several major expeditions including the Musandam expedition.

The Adventurous Activities of the Corps continue. As a sequel to the 1972 Trans-American expedition Major John Blashford-Snell will be leading the Stanley Expedition which aims to navigate the Lualaba-Zaire Rivers in West Africa next year. Captain Henry Day and four Sapper climbers are at present in Nepal preparing for the Army attempt on Everest in 1976 when we hope that Captain Day will be the climbing leader. Another of our well-known explorers, Major David Hall, is now an honorary secretary of the Royal Geographical Society, and is himself planning another expedition.

MAPLIN SANDS

The EOD clearance task at Maplin Sands goes on, as whatever the political argument, the Sands have to be cleared of all unexploded ordnance before any construction can start. 71 EOD Squadron was formed last year for this task. They are part of the recently established 33 Engineer Regiment (Explosive Ordnance Disposal).

RECRUITING

Now a word about recruiting. For the Corps, as for the rest of the Army, it can at present only be described as disappointing, and I would like to describe some of the problems.

To look first at the Officer situation: the last batch of Officers to be trained under the old system at Mons Officer Cadet School passed out in August 1972, and the new pattern of Officer Training at Sandhurst has now started. So far in 1973 the RCB attendance figures have fallen, but it is very encouraging to see that the quality of candidate is improving markedly. It is too early yet to judge the effect of this new pattern of training on the Corps, but it is clear that one of the objects of the new system, that of ensuring that all officers receive a high common standard of initial training, is being achieved and can only be to the benefit of all Arms and Services. It is important that we all realize that the majority of the Officer Cadets arriving at Sandhurst have already decided which Arm or Service they wish to join. Under the new system of training those un-committed must all make their firm choice after only a two-month period at the College and this of course greatly increases the importance of Corps Officer recruiting activities and associations with schools, particularly with those schools that are consistently producing officers for the Army. Not enough of the best young men at Sandhurst are at present giving RE as their first choice. Our aim must be to achieve a situation whereby we are over-subscribed, and to this end steps are being taken to improve the knowledge of the Corps in schools as well as universities. Twenty retired regular and serving TAVR, Sapper Officers holding appointments in universities have agreed to act as RE Liaison Officers in their respective universities and they are being kept regularly informed of the activities of the Corps as valuable contacts on matters of joint concern. A similar system, to appoint as RE Liaison Officers, a number of retired Sapper Officers holding teaching or administrative appointments in schools, has now been initiated. I am most grateful to all who have responded.

Finally, although when compared with our considerable success in 1971 we recruited fewer direct entry graduate officers last year, the number of new University Cadets and University Cadets maturing continues to be satisfactory, and 1973 trends so far indicate an improvement in the number of graduates applying for direct entry.

Turning now to soldier recruiting, the centralized system of recruit selection operated fully last year and this, together with an overall decline in Army recruiting generally, led to a sharp decline in the number of RE adult recruits. From our surplus in 1971 we have run into a shortfall below target and this will become steadily worse and may lead to manpower shortages in a year or two. However, the Corps continues to maintain a favourable strength against manpower targets when compared with other Arms and Services, and while this situation remains there is little likelihood of any increase in the percentage of adult recruits allotted to RE through the centralised recruit selection system. In other words we will continue to be rationed.

For junior soldiers, 1972 was a record year for the Corps and showed an increase from the previous year of over 10%. However, September 1972 was the last full intake of junior soldiers that we will receive until May 1974, due to the raising of the school leaving age. 1973 will therefore be a very lean year for junior recruiting, but then we hope that recruiting will pick up again in 1974 when the first 16½ year old boys become available.

Recruiting, both of officers and men, is a subject which affects all of us and we can never as a Corps afford to relax our efforts in this field.

ORGANIZATION

Finally, I would like to say a little about the top organization of the Corps. The great achievement last year was the co-location of all the branches of Headquarters E-in-C, although the Director of Engineer Services continues to be answerable to the QMG. The snag is that we are in the Empress State Building in Earls Court, a rather soul-less

edifice, half an hour from the centre of power.

Two important decisions in our favour have just been made. First, that the Engineer-in-Chief should take under his wing ASD7, the executive branch of the Corps which currently answers to DASD. The second decision is that when this happens the whole of HQ E-in-C, including DES, will move into the Old War Office, I hope by next March. We should then be able to respond quickly to all the demands of the General Staff and QMG, and also be in closer touch with the RAF and DOE. The penalty for this most valuable change is a fairly drastic cut in staff. However, it is well worth our all having to work rather harder.

The Corps as a whole, as I hope I have shown, is at full stretch on a wide and rewarding range of tasks.

A Tour of Duty with Ordnance Survey

MAJOR P F FAGAN MBE RE

HISTORICAL BACKGROUND

THE mapping of most countries is usually closely associated with some form of military involvement, and in this Great Britain is no exception. Unlikely though it may seem the beginnings are associated with Bonnie Prince Charlie, for it was after the 1745 rebellion that Lieutenant (later Major-General) William Roy first started to make a map of the Highlands. Roy's influence later led to the formation of the National Survey in the Tower of London in 1791, under the Board of Ordnance and hence the name Ordnance Survey. At this time, during the Napoleonic Wars, there was considerable anxiety about the threat from the Continent and the early efforts were concentrated on the production of one-inch maps, starting in the south east of the country. The first sheet, that of Kent, was published in 1801.

By 1820 most of the southern part of Britain had been covered by the one-inch series, and the main effort of the survey was then transferred to Ireland in order to make a 6-inch to the mile map of the whole of that country for valuation purposes. Later a further 6-inch survey was started in England and Scotland, and shortly after this it was decided to increase the scale of the general survey to 1:2500 (approximately 25 inches to 1 mile) which then became the primary task of the Ordnance Survey right up until the outbreak of the First World War.

Between the two World Wars manpower was severely reduced and it became impossible to keep up with the rate of change on the ground. An enquiry was instituted and the investigating committee, reporting in 1938 under the chairmanship of Lord Davidson, recommended far reaching changes to the Ordnance Survey, and laid down a policy which still provides the basis of the current mapping programme. Up until this time the Ordnance Survey had been largely military, in that most of the staff were either serving, or after 21 years service retired, soldiers, but now direct civilian recruitment was embarked upon on a large scale for the first time. The Second World War interrupted the implementation of the recommendations and so it was not until about 1946 that the Ordnance Survey really started to develop in its new form. It is now a Government Department answerable to the Minister for Local Government and Development in the Department of the Environment.

PRESENT POLICY AND STRUCTURE

The Ordnance Survey is currently tasked with the responsibility for the official surveying and mapping of Great Britain, together with geodetic surveys and the associated scientific work. The public as a whole probably identify the Ordnance Survey with the one-inch map but in fact this series, and the other small scales series such as the 1:25 000 and 1:250 000, take a relatively small proportion of the total effort. By far the greater part of the staff work on the three large scale surveys at

1:1250, 1:2500 and 1:10 000 and it is these that local authorities, developers and engineers need for their work. The total task is enormous with around 18 000 different maps being published each year—that is on average some 75 every working day. The surveys at 1:1250 (limited to urban areas only) and 1:10 000 are entirely new, but the 1:2500 series, which covers the whole country apart from major towns and the mountain and moorland areas, is in fact a revision of an earlier series at the same scale. It is with these three large scale series that the surveyor in the Ordnance Survey is concerned, as the popular smaller scale maps are not surveyed as such but are derived from the larger by cartographic techniques.

The technical work of the department is divided into two Directorates responsible for all surveys and for the various stages in map production respectively (see Fig 1). The types of work covered by the staff (totalling about 4600) is extremely wide ranging, and this article can only attempt to cover a small fraction of the whole. I have therefore concentrated on the job on which I personally was employed, mentioning other parts of the organization only to round off the story. My task was to run the Air Survey Branch, (Fig 2), which includes everything from the flying of the necessary photography to the plotting of a map, complete in most essentials and virtually ready for the drawing office. Thus, fortunately, something of the work of the Ordnance Survey as a whole can be seen in this microcosm.

It was in the latter part of 1969 that I was posted, on a normal tour of duty, to the Ordnance Survey headquarters at Southampton, a few months after Her Majesty the Queen had officially opened the magnificent new buildings. Some 1500 of the department's total strength, however, spend most of their working lives well away from Southampton, scattered thinly over the whole of Great Britain under the local direction of six Region headquarters. Three of the six Regions are at present commanded by Majors and they and their three civilian equivalents have very considerable autonomy in their areas. These Region Controllers, as they are called, maintain continual contact with local authorities in order to obtain intelligence of change and to anticipate future requirements of maps in every part of their Region. They have then to balance conflicting requirements in preparing their future surveying programme within totals for each scale laid down by the Field Directorate headquarters; these overall totals will have been earlier agreed as a planned annual input to the drawing and printing stages in the Map Publication Directorate. The Region Controllers have other responsibilities, which include the carrying out of surveys at short notice for the Land Registry, by which correct title to land ownership in England and Wales is gradually being recorded. These, which now number over 20 000 cases each year, have to be done at very short notice in order that no additional delays should take place during conveyancing. The average time is eight days from receipt of task to completion of survey.

PLANNING

Production planning in a large organization is necessarily complex. The Ordnance Survey has for some time been using a mathematical model of its large scale programme in order to cope with the problem and it is now introducing budgetary control. Sophisticated computer based information and accounting systems enable managers to quantify problem areas so that the most economic method can be chosen for a particular task. In most cases an air survey method will prove cheapest but small surveys urgently required, such as those for the Land Registry, are typical of those best suited to ground methods. The overall programme is confirmed in the autumn of each year and it is soon after this that Air Survey Branch first becomes involved with the arrival of the following seasons flying programme.

THE FLYING PROGRAMME

As soon as the flying programme is received a rapid assessment is made of the overall requirement in order to decide on how many aircraft will be needed, and where they

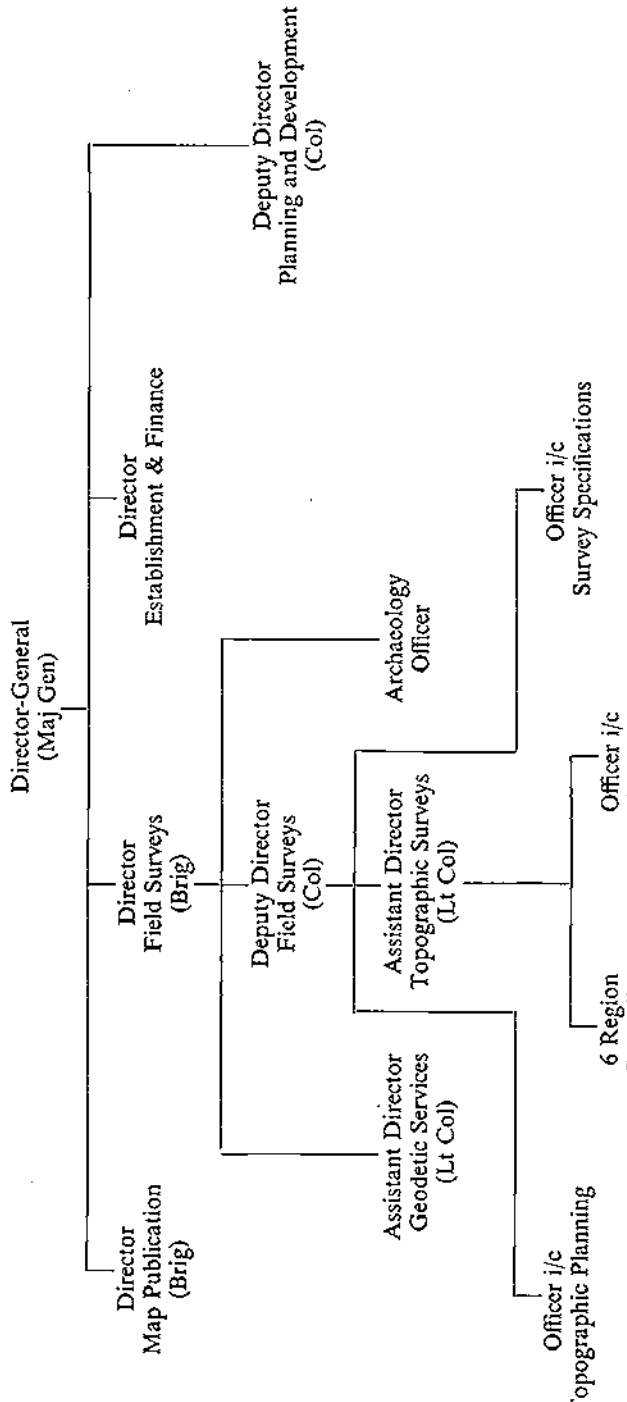


Fig 1. Ordnance Survey functional organization.
Posts currently filled by Serving Officers are as shown. A total of 16 officers are at present serving with the Ordnance Survey.

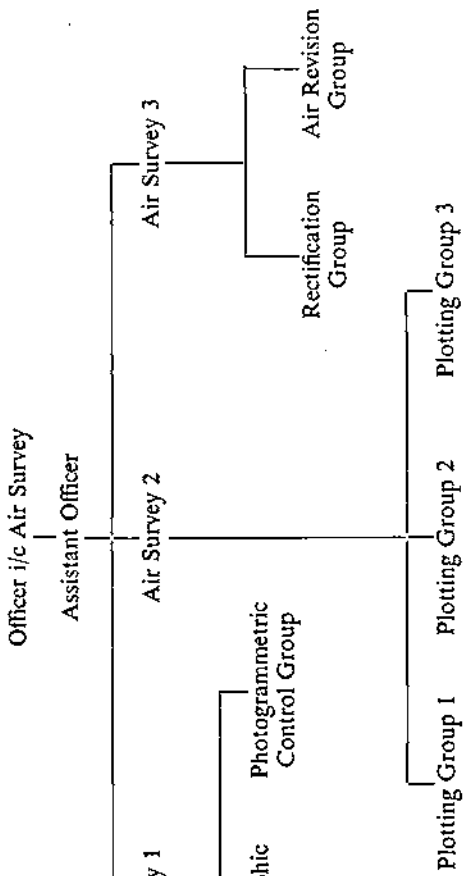


Fig 2. Air Survey Branch organization.

are best based. The Ordnance Survey does not own its own aircraft, but prefers to engage them from private companies as required. The contractor undertakes to provide the aircraft continuously every day between agreed dates (normally 1 March to 30 September) and is responsible for providing a pilot, navigator and maintenance facilities, while the Ordnance Survey supplies the camera, the operator and office space at the chosen airfield. In recent years 5 aircraft have been employed on one or three-year contracts.

Quite a number of different aircraft may be offered, from the continental market as well as the UK, and the cost-effectiveness of each has to be determined bearing in mind that, thanks to British weather, only some 220 suitable hours will be available to each aircraft each year. This evaluation is a very interesting task and leads to some very pleasant assignments—the occasional business lunch, the odd quick trip to the continent and on one occasion a pub crawl by helicopter along the River Hamble with a glamorous mini-skirted blonde as pilot/escort.

Well before the end of the year the contracts are agreed and detailed planning begins. By the middle of February everything must be complete and dark room, teleprinter (for meteorological information) etc properly established at each base. Flight planning of all the targets to be flown (approximately 500 of these) has to show the exact tracking lane that the aircraft is required to follow, and the switch-on and switch-off positions for the camera. This is not always a straightforward task as it is important to take only the minimum number of photographs to complete the area if maximum economy is to be obtained at the subsequent plotting stages, and complex coastlines, the relief of the country and the disposition of Ordnance Survey trig stations on the ground have all to be taken into account. The overlap is arranged to be 60% in the fore and aft direction along a strip and a minimum of 15% (it will vary in hilly terrain) laterally between strips. The flying height is well established for each form of survey: basically a balance has to be struck between flying as high as possible for economy (fewer photographs) and as low as possible for accuracy (larger scale photography), but Air Traffic Control restrictions provide a further constraint in only permitting flying at intervals of 1000 feet—referred to a standard atmosphere of 1013 millibars. This last factor can be a considerable nuisance as the actual photographic scale obtained is subject to the barometric pressure on the day that it is flown. All Ordnance Survey flying is done in the zone 5000 to 15 000 feet and different camera lenses are used to widen the range of photographic scales available (for example flying at 5000 feet will produce approximate photo scales of 1:5000 with a 12-inch lens; 1:10 000 with a 6-inch lens and 1:17 000 with a 3½-inch lens). Fig 3 shows details of photographic scales etc.

Before flying starts the cameras have to be calibrated after their winter servicing. These air survey cameras are amazing pieces of work and produce an extremely accurate image (the average is 5–10 micrometres residual distortion in the focal plane) on the 9 inch square format, but they are bulky, weighing over 400 lb with magazine and control unit, and cost £12 000 to £16 000 each. The camera operators spend the whole of the summer with the aircraft, each at its own base, working a 7 day week and taking every possible advantage of the weather to obtain the maximum amount of photography according to his priority list. Some targets will be urgently required while others, perhaps a new motorway, may not be ready for flying until a date later in the season. Further targets may be added from time to time as local requirements change and the system is flexible enough to cope readily with these.

As each film is exposed it is despatched to the Air Survey Branch studios in Southampton where it is developed in a new automatic processor (see Fig 4). This gives first class results, and, most important, does not introduce distortions by stressing the special stable plastic base material used to carry the emulsions for this type of work. Contact prints are produced using electronic printers, which automatically compensate for any uneven illumination, and a check is made to ensure that photographic cover is complete and according to the flight plan. The camera

Area	Map Scale	Type of Survey	Graphical or Instrumental	Photo Scale	Camera	Method of Control
Urban	1 : 1250	Resurvey	Instrumental	1 : 5000	Zeiss RMK 30/23 (12-inch)	Analytical aerial triangulation (AAT)
		Continuous Revision	Instrumental	1 : 5000	Zeiss RMK 30/23	Existing detail or AAT
Rural	1 : 2500	Resurvey	Instrumental	1 : 10 000	Wild RC8 R (6-inch)	AAT
		Revision	Mainly graphical	1 : 7000	Zeiss RMK 30/23	Existing detail
		Continuous Revision	Mainly graphical	1 : 7000 or (1 : 10 000)	Zeiss RMK 30/23 (or Wild RC8 R)	Existing detail
Mountain & Moorland	1 : 10 000	Resurvey	Instrumental	1 : 25 000 approx	Wild RC8 R	AAT
		Continuous Revision	Instrumental	1 : 25 000 approx	Wild RC8 R	AAT or sometimes existing detail
Urban & Rural	1 : 10 000	Contouring on sheets derived from larger scales	Instrumental	1 : 24 000 approx 1 : 31 000 approx	Wild RC8 R Wild RC10 ($3\frac{1}{2}$-inch)	AAT with existing height information
Coastal	All Scales	Surveys of high & low water	Graphical	1 : 5000 to 1 : 30 000	Wild RC8 R	Existing detail

Fig 3. Photographic Details. The Wild RC10 camera is also equipped with a 6-inch lens. This is used for the same tasks as the Wild RC8 R.

Figure 4. A modern automatic film processor. The film is loaded into the other end of the equipment in the darkroom behind the back wall. Speed and temperature may be modified during processing while monitoring the results.

operator can then receive confirmation that this particular target is in the bag. Some 500 films are processed each year and well over 100 000 contact prints produced for all purposes.

GRAPHICAL PLOTTING

The aerial photography is used to produce subsequent mapping in two very different ways. The simplest method is a "graphical" one which uses very little equipment, and which is a development of the very early air survey techniques of 50 years ago. Two problems, however, have to be overcome before a photograph can be used to make a map. Firstly the scale changes and distortions due to the tilting of the camera out of the vertical at the moment of exposure have to be corrected for, and secondly the image displacements and scale changes due to height differences on the ground have to be overcome.

An instrument called a rectifier is used to remove the effects of the tilts in the photograph which are nowadays always small and rarely more than 2°. It is similar to a very large photographic enlarger with a tilting base board and built-in analogue computers to maintain correct geometry between negative plane, lens and the base board,—which can also be raised and lowered to change scale. The amounts of tilt

and the scale factor for enlargement are computed by a separate process and the equipment can then be set to produce what is called a rectified enlargement, a photograph from which the effects of tilt have been removed.

The effect of image displacement due to height is apparent on any photograph of an urban area where, unless it is directly beneath the camera, the top of a building will not appear on the photograph in the same position as the bottom. It is in fact displaced radially outwards from the plumb point and precisely the same thing will occur due to changes in the height of the ground above sea level, though these are not normally so immediately apparent to the eye. The problem can be readily overcome by intersecting the same point of detail from successive photographs during plotting, but over extensive areas this becomes rather cumbersome and the technique is, therefore, best suited to relatively flat country.

In the Ordnance Survey very considerable use is made of graphical techniques for the purpose of revising the 1:2500 map. The problem was originally one of bringing the 170 000 sheets at this scale up to date in a reasonable time and at reasonable cost. Most of the area to be surveyed had been mapped at the same scale in the last century, but these were produced on projections centred on many different origins around the country and did not tie up very well. However, it was decided that as much use as possible should be made of this and the old sheets were cut up and the detail re-oriented onto 1 km² sheet lines based on the National Grid. Once this adjustment was done the provisional (unrevised) sheet could be printed down on a stable transparent plastic ready for up-dating.

The surveyor can now revise this provisional sheet by superimposing it on the rectified enlargement and tracing off the changes that have taken place. Errors are kept to a minimum by only fitting small parts of the photograph to the map detail at any one time, ie by fitting to the perimeter of a garden in order to plot the position of a new garage. In more difficult areas where the changes are more significant, it will be necessary to intersect the position of new detail by drawing rays to it from the plumb points of two successive photographs in the same way that the height displacement problem is overcome. This method of survey would not now be used by most survey organizations, but it is suitable for revision and has been extremely useful in the Ordnance Survey: it will continue to be so until the programme of revising the old 1:2500 maps is completed in about 6 years time. One of the advantages of the system is that as it involves no expensive equipment for plotting, the work of revising can therefore be done in any part of the country, preferably near the area being mapped. The surveyor can then utilize bad weather by plotting from the photograph in his office and when it clears visit the actual spot on the ground to resolve queries, add changes that have taken place since the date of photography and generally complete the map.

INSTRUMENTAL PLOTTING

For the new surveys at 1:1250 and 1:10 000, however, something much more rigorous is required, and these are performed using modern plotting instruments such as the Wild A10 shown in Fig 5. A total of 33 such instruments of all types are employed and the current prices of each lie in the band £15 000 to £24 000. (Fig 6)

In setting up such an instrument, the first problem is to rotate the carriers of the two photographs (shown at the top of the instrument in Fig 5) about 3 mutually perpendicular axes (representing tip, tilt and swing) until the relative positions of each equate to the attitudes of the air camera at the moment of exposure. It is then possible to look through the binocular viewing system and see the ground stereoscopically. The two hand wheels together control the carriage movement in a horizontal plane, and a foot disc provides for vertical movement. A small dot is built into the centre of each optical system (the left and right parts of the binoculars) and the operator uses his three controls to simultaneously cause these two aiming marks to "fuse" stereoscopically, and place them on the ground as he sees it through the

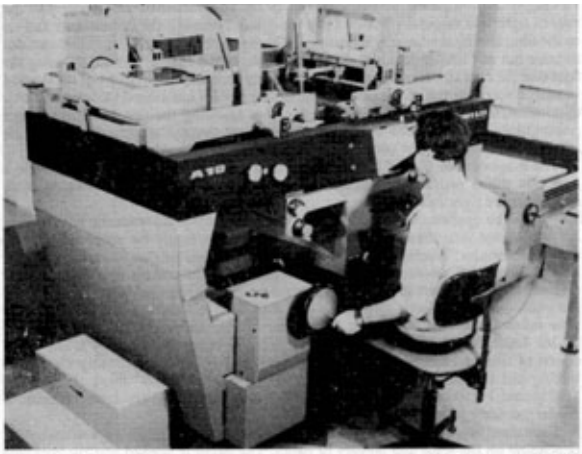


Figure 5. Wild A10 plotting instrument. The principal advantage of this instrument is the fact that photography of all normal focal lengths (3½–12 ins) can be readily accommodated. The effect of the curvature of the earth is taken account of continuously during plotting.

Figure 6. General view of one of the plotting instrument rooms. The instruments shown are Wild A8s with a Wild A10 in the foreground. These instruments are made in Switzerland.

viewing system. When he has achieved this he has re-established the geometry of the rays of light that originally passed from the ground through the camera lens and on to the film, and by continually adjusting the three controls he can cause the fused dot to trace out any line of detail on the photograph, eg the edge of a road. By using the foot disc the operator is in fact continually taking account of the height of the ground in such a way that the radial height displacement effect mentioned earlier is entirely eliminated, and the other problem, that of not knowing the tips and tilts of each photograph, has also been overcome as these are derived empirically during the relative orientation of the two camera carriers.

The movement of the dot is taken off mechanically or through a servo system to a gear box which provides for an appropriate scale, and thence to a drawing table shown on the right in Fig 5.

Before the operator can actually start to plot the map, however, he has to bring his instrument into harmony with the drawing table, firstly by providing correct scale and then by "levelling" his instrumentally measured heights to accord with the known heights of the same points on the ground. This process is called absolute orientation and at least three known control points are required to be identified on the photography so that a reference plane may be established. The total setting up time takes about two hours, but once achieved the operator can rapidly plot all visible detail to a very high precision with account being continuously taken of the effects of tilts and height displacement. Contours may also be precisely plotted by tracing out a continuous line at a fixed height of the "fused" mark. In fact the 1:1250 and 1:2500 maps are not provided with contours and the 1:10 000 series is the largest scale to have them.

Each sheet is plotted by one operator and takes from two to ten days to complete, depending on the scale and density of detail. The detail is penned and the contours when applicable are scribed on an overlay to this, located by a pin register system. (Scribing is the process of cutting a line on a wax coated sheet using a steel stylus: it provides a smooth line of even width which needs no further fair drawing before being used to make the final printing plate.) Once complete the sheets are passed to the local office where the field surveyor adds any information that was not visible from the air and includes details that have changed since the date of photography.

When the sheet returns to Southampton it is passed to other sections who will plot Mean Low Water, archaeological sites, local boundaries and so on, where applicable, and also compute the areas of fields to be shown on the 1:2500 series. It is then ready for fair drawing according to the specification. Most sheets are scribed with different elements being taken off separately, for example the names and the detail are drawn separately and are only combined later. The contours on the 1:10 000 scale maps will appear in brown and will therefore form a further sheet at the drawing stage, and in mountainous 1:10 000 areas the draughtsman's artistic bent comes out strongly in adding the rock interpretation for cliff features. For this purpose the draughtsman has a photo enlargement of the area and he uses this to portray the actual nature of the piece of ground concerned which amplifies the information provided by the contours.

Subsequently printing plates are produced for each of the colours involved in each type of map, and eventually the sheet is printed (Fig. 7) and becomes available to the public through the department's own Publication Division. These brief notes on the drawing and printing apply primarily to the scales mentioned, the work for the smaller scales being very much more complex. Space unfortunately precludes further discussion of these in this article.

AERIAL TRIANGULATION

There remains one large aspect of Air Survey which has not yet been mentioned and that is aerial triangulation. Before the operator can plot detail usefully he has to relate his plotting instrument in some way to the National Grid system of coordinates.

Figure 7. A general view of part of the large print shop with a 2 colour machine in the foreground.

The familiar Ordnance Survey trig pillars are scattered widely over the countryside and may often be seen in the photograph, but their density is not sufficient to control every photographic overlap. Extra control points could be provided by field methods such as fixing the position of suitable fence posts etc and identifying these on the photographs, but this would be prohibitively expensive. The answer lies in aerial triangulation by which further points may be coordinated as required off the photograph. It is a fascinating subject and there are several methods of doing it, but after years of experiment the air survey world has largely settled for one of two different systems. The Ordnance Survey uses that known as analytical aerial triangulation which would not be possible without the use of the high speed computer. Very precise measurements are made on an instrument called a stereocomparator of which the Ordnance Survey has three (see Fig 8). These measurements are made to both coordinated control points and to those points whose coordinates are now required (normally about 15 points altogether per overlap). The readings are recorded automatically on punched tape and from the known stations the computer deduces iteratively the attitude of every photograph at the moment of exposure. Once the mathematical adjustment of the complete block of photography has been done the coordinates of any measured point may be printed out, and in this way a very large number of points may be provided for control very rapidly and very cheaply. Further points may be coordinated at any time in the future if required. The accuracy of these fixations will depend on the photographic scale but the current standard error, for example, of points fixed in this way off 1:5000 photography is ±0.15 metres in plan, and this is more than good enough for the operator to set up his plotting instrument.

Figure 8. The Hilger and Watts Stereocomparator. The electronic control unit is shown on the right of the instrument.

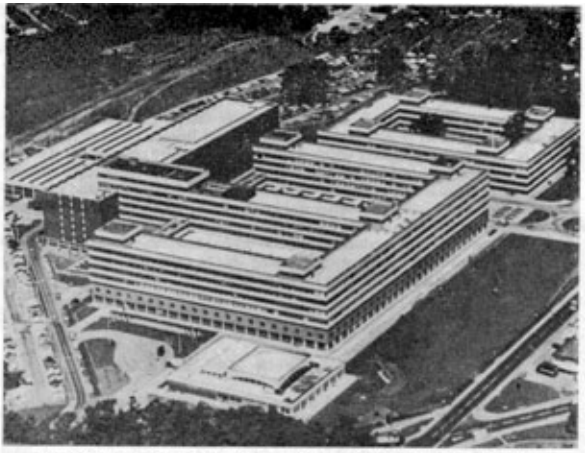


Figure 9. An aerial view of the Ordnance Survey Headquarters in Southampton.

GENERAL

Once a sheet is published it is kept up-to-date by a system known as Continuous Revision. A master copy of each sheet is held in the local Ordnance Survey office and changes are surveyed onto this master as they occur. At a certain point, depending partly on age and partly on the amount of change that has taken place, this sheet will be sent forward to the Map Publication Directorate in Southampton and a new edition will be made, with a new master sheet for the local office. In this way the map can never become badly out of date, and anyone wanting the latest information may obtain it by asking for a copy off the master sheet. The new detail is not of course fair drawn in these instances but it will be neat and accurate and this service is of great assistance to local authorities, engineers and developers.

The rapid rate of change nowadays has led to much reappraisal in the Ordnance Survey in the past few years and the recently established Planning & Development Division has made great strides in the field of automated cartography. A pilot production scheme is now in being with the survey detail being directly digitised rather than being fair drawn, and the fair drawn map is then produced automatically, complete with names and symbols, on a computer-controlled Ferranti Master Plotter. One of the advantages of the system is that the age old problem of having the point of interest at the junction of four sheets can be overcome, for the computer can centre the map sheet at any point of interest. In addition once the detail is stored it can be played back at different scales (there are problems of interpretation if this is carried too far), and extraneous detail can be removed at will; for example some organizations are only interested in roads and/or house frontages (electricity boards; companies engaged in distributive trades) and all else can be deleted leaving space for further information to be added by them as they wish.

These things are happening now but many other developments are under

consideration. Certainly the large scale maps of the future will increasingly be on a reel of magnetic tape (80 maps can be stored on one tape) and perhaps microfilm slides for copying, rather than the conventionally understood map, fair drawn and published on high quality paper and revised necessarily at longish intervals. Of course the popular smaller scale maps will continue to be published as at present for as long as can be foreseen.

The intention of this article has been to cover the principal activities of the Ordnance Survey in its programme of mapping Great Britain, concentrating particularly on the air survey aspects which were my own primary concern. By the time this article appears I will have left the Ordnance Survey and returned to military duties after 3½ years in this extremely interesting post. It is not often that one finds oneself in a job which includes involvement in negotiating contracts with commercial companies (in the fields of aviation, instrument manufacturing and photo-chemicals), quality and cost control of production work on several flowlines employing some 160 men, and, perhaps most satisfying of all, being able to enjoy the use of equipment shortly after making the justification for its purchase.

The Medicine Line

COLONEL T A GIBSON MBE late DERR

"On the Canadian frontiers in 1787 the important people were the army officers. They were imperious, able, resolute men, well drilled, and with a high standard of honour. They upheld with jealous pride the reputation of an army which in that century proved again and again that on stricken field no soldiery of Continental Europe could stand against it. They wore a uniform which for the last two hundred years has been better known than any other wherever the pioneers of civilization tread the world's waste places, or fight their way to the overlordship of barbarous empires. Subalterns wearing this uniform have fronted dangers and responsibilities such as in most other services only grey-headed generals are called on to face; and at the head of handfuls of troops have won for the British Crown realms as large, and often as populous, as European Kingdoms."[1]

HEADY stuff this, especially when written by an American who became President of the United States. Perhaps chivalrous too, for in that period the same British officers must have been smarting from defeat in the American War of Independence. It could have been little consolation that this conflict had been lost not by any lack of valour in the regimental officers and soldiers but by pusillanimous political and strategic direction and, also, the old enemies, France and Spain, coming in for the kill.

But if the Seven Years War, 1756–63, laid the foundations of Empire, with British supremacy assured in India, Canada and the West Indies, it was the Victorian soldier of the next century, after the climacteric struggle against Napoleon, who consolidated the gains. Moreover, his achievement was not solely ensured through a succession of victorious small wars against savage foes. While conquest and domination were obviously first steps in the game of empire, what made the Imperial infant thrive and grow strong was the later civilizing and development process. Here the British officer of the nineteenth century, in his many distant garrisons, played a great peacetime role. This was especially so in areas that attracted the British, in their own dynamic expansion, to land settlement through a temperate climate, suitable terrain and challenging emptiness. In the rudimentary early societies of Canada, South Africa, Australia and New Zealand, the British Army officer had much to contribute, and not only socially and culturally.

Foremost in value, by the virtues of scientific knowledge and practical application, were the officers of the Royal Engineers. In the development phase after conquest,

or discovery and exploration, came the urgent needs for roads (and later railways), bridges, town planning, water supply to support population and irrigation. The demand for survey and construction expertise was heavy and constant. In Canada, Lieut-Colonel John By RE and two companies of Sappers organized and supervised the construction of the Rideau Canal during 1826–32 to connect the Ottawa River with Lake Ontario. After the War of 1812, a safer military route between Montreal and Lake Ontario than the St Lawrence was deemed necessary and the 123 miles-long Canal with its 47 locks, now a modern scenic attraction, has been described as "the greatest work of British military engineers to be carried out in eastern North America". Bytown, the settlement that grew up to support the project, was selected by Queen Victoria in 1857 to be the site of the new capital, Ottawa. In South Australia today, Colonel William Light is honoured for his siting and superb layout of the capital, Adelaide in 1836; strangely, Light despite being the Colony's Surveyor-General, was not a Sapper, an exception to the general rule. In nearby New Zealand, during the Second Maori War, Colonel Mould, though also a field force commander, constructed the Great South Road in 1861 from the farmlands on the outskirts of Auckland through miles of forest to the Waikato River to open up the Maori heartland to European penetration.

It could be said with some probability that the Industrial Revolution, with its rapid development of science and an infant technology, led, in most Armies, to the best brains bent on a military career entering the Engineers. This was certainly so in nations such as Great Britain and the United States, concerned with the opening-up of underdeveloped territories and where the role of the Engineer officer, primarily, was, for want of a better term, aid to a struggling and elementary civil power in those territories. It is interesting to note that in the United States Army, the great Robert E Lee was an Engineer and at the other end of the century, Douglas Macarthur, when he graduated brilliantly from West Point in 1903, went into the Corps of Engineers as it was considered that this is where the elite went. Regarding the British Army, perhaps eccentric and flamboyant personalities, as well as mental candlepower, could be added when "Chinese" Gordon and Herbert Kitchener are considered! However, as observant map-users during IS operations in Cyprus 1955–58 will have noted, Lieut Kitchener RE surveyed that island between 1878–82 before he gravitated to less civil-orientated projects, such as becoming a trainer of Egyptian cavalry and a genuine cloak and dagger intelligence agent, wandering dangerously about bazaars in disguise.

In the British Empire of that great century of achievement overseas and Pax Britannica, it is probably in Canada where the Royal Engineers made their greatest impact and in conditions of some latent urgency. This was due, on one hand, to the sheer size of the country, its rugged and variable terrain and severe extremes of climate and on the other, pressure from the bustling expansionist United States, with all its energies bent, after the bloody Civil War, on opening up its West, and, indeed, anybody else's West that was lying open and unoccupied by default. The Canada of the mid-nineteenth century had the extraordinary situation that whereas Quebec Province and the Maritimes had an old history going back beyond Wolfe and Montcalm, the American War of Independence and the Loyalists, and latterly Ontario too, the Canadian West with its Plains Indians was as distant and primeval to the citizens of Toronto and Quebec City as the Mongolian desert and its Tartars were to the citizens of Moscow and St Petersburg. Even more relevant, it was just as difficult to get to each place. Before the Canadian Pacific Railway thrust westward in the early Eighties,[2] the determined traveller from eastern Canada usually crossed from Ontario over the border into Minnesota and journeyed westward by a mixture of early U.S. railroad, steamboat on the Missouri, stage coach and horse before turning north to enter the Canadian prairies; the wilderness of vast forests, racing rivers, rapids and large lakes in Manitoba barred the way.

But across the nebulously defined border with the United States, tough adventurous men were looking hard for lucrative openings. Gold was rumoured in

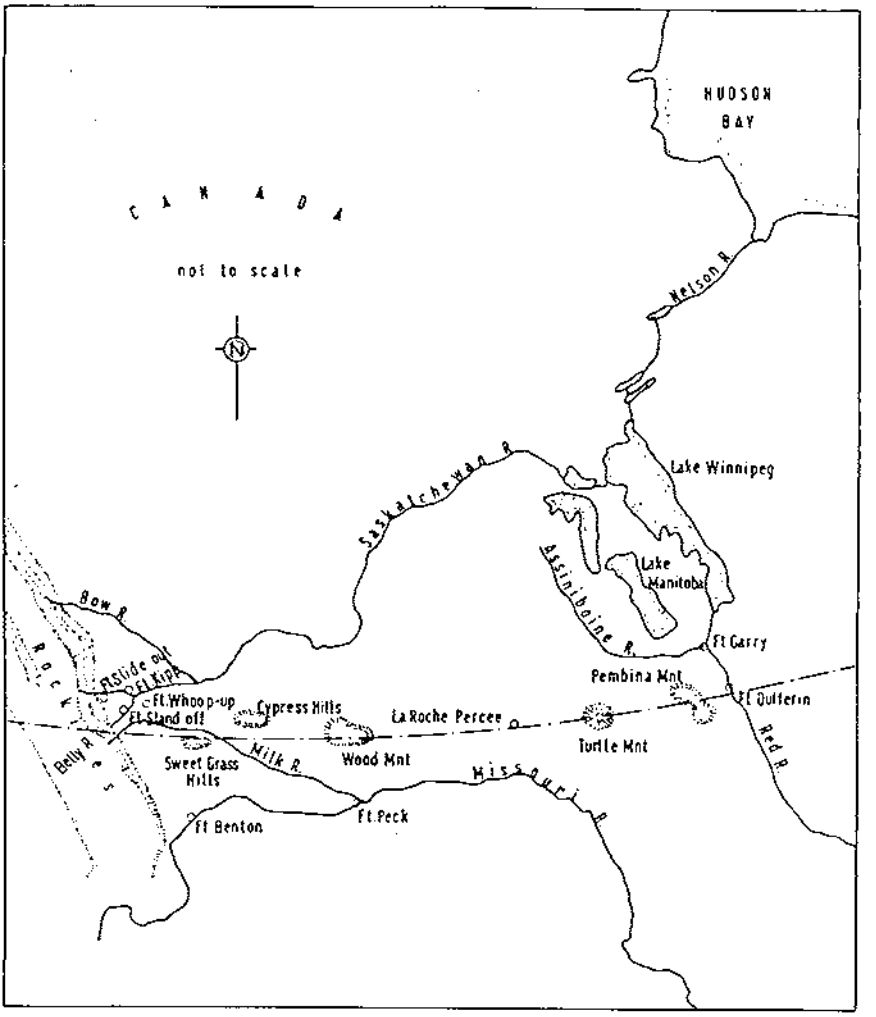
Saskatchewan, the rich fur trade of the North West Territories was enticing, as well as the rolling prairie grazing land of what is now called Alberta, and across the Rockies, gold and timber were in abundance in British Columbia. To that Canadian West, where the British and Canadian presence was signified only by the trading posts of the Hudson's Bay Company, now an anachronism after its great pioneering era, the traders, buffalo hunters, gold miners, land grabbers and adventurers of all kinds across the U.S. border looked askance. It became clear to the new Dominion Government, self-governing in 1867 after the Federation of Ontario, Quebec, Nova Scotia and New Brunswick, that if they wished to hold on to the great land mass vaguely termed Canada, they must, in the rough legal parlance of the frontier, "stake a claim". A joint survey of the international border was a priority task to enforce the protocols of legality between Ottawa and Washington.

The task was made even more pressing by the impending withdrawal in 1871 of all British garrisons, reinforced during the American Civil War, by an Imperial Government determined that her white Colonies overseas should bear their own defence burden. The only exceptions in Canada were historic, fortified Halifax on the Atlantic seaboard and Esquimalt on the Pacific, where jurisdiction with the Americans over the islands and channels about Vancouver Island was proving difficult. The reason for a physical definition of the vast border was that the Convention of London, signed in 1818 between Great Britain and the United States, depended ominously on a parallel of latitude to define the territorial division. Its Article 2 said:

". . . that a line drawn from the northwestern point of the Lake of the Woods, along the forty-ninth parallel of north latitude, or, if the said point shall not be in the forty-ninth parallel of latitude, then that a line drawn from the said point due north or south as the case may be, until the said line should intersect the said parallel of north latitude, and from the point of such intersection due west along and with the said parallel, shall be the line of demarcation between the territories of the United States, and those of His Britannic Majesty, and that the said line shall form the northern boundary of the said territories of the United States, and the southern boundary of the territories of his Britannic Majesty, from the Lake of the Woods to the Stony Mountains".

A particularly serious situation had developed during the Fifties in the territory west of the Rockies, then vaguely known as New Caledonia. For the first half of the century, this splendid region of snowy mountain peaks, alpine lakes, mighty rivers and great timbered tracts was known, apart from the native Pacific Coast Indian tribes, only to about 50 Hudson Bay Company traders. In 1858, placer gold was discovered in the Fraser Valley and in the districts of the wild Cariboo, and some 25,000 American miners poured in by sea and overland from Oregon. What had been a placid Hudson Bay Company trading preserve, visited by the occasional R.N. man-o'-war, was transformed into seething boom conditions of inflated prices and lawlessness. Vancouver Island was rapidly declared a Crown Colony with James Douglas, the Company's Agent, as a notable early Governor, but as all the gold was on the mainland and drawing the population, the need to establish order and control there was paramount.

In Whitehall, the Secretary of State for the Colonies was Sir Edward Bulwer Lytton, author of *The Last Days of Pompeii*. Lytton was to prove no literary dilettante in his decisive and effective dealings in transforming the Hudson Bay Company's vast western fief into a ocean-to-ocean Canada. In 1858, he was instrumental in despatching 150 Sappers and Miners from England under Colonel Richard Moody RE to the whole new area of Vancouver Island and the mainland, now named by Queen Victoria herself as "British Columbia". Land survey, town sites, road construction, and the enforcement of law and order were urgent. Moody was not only to be Commissioner of Lands and Works but also Lieutenant-Governor under Douglas. Moreover, his men were all picked men from the forty Regular sapper companies in the Army.



Moody's path was not to be an easy one, due to strained relations with Douglas. An early clash of policy occurred when Moody wished to concentrate on organizing town sites whereas Douglas was adamant that a road must be driven through to the Cariboo where the miners were paying famine prices for food and other basic necessaries. Douglas was determined that the trade of the Cariboo should go to the merchants of Vancouver and nearby infant New Westminster to get the colony on its financial feet and not lost via the Okanagan Valley to Oregon. Douglas was also concerned with the cost of the surveys, which the Imperial Government said bluntly the new colony must pay for out of its land sales.

However, ignoring the high level bickering, Moody's junior officers, NCOs and sappers accomplished much before they sailed home in November, 1863, less a goodly proportion who elected to time-expire and accept a gift of 150 acres. Road building to gold rush areas had been their main occupation as other big strikes occurred at Wild Horse Creek in the Kootenay Mountains and Big Bend district of the Columbia River.

Among all this hectic period of road and bridge building and town planning,

British sappers under Lieut-Colonel John Hawkins RE also carried out a survey of the 49th Parallel with the Americans and Hawkins completed his part, from tidewater to the crest of the Rockies, in early 1862. However, in the east, 2000 miles away to the nearest main settlements, the 49th Parallel was a line drawn piously on a small scale map. From the Atlantic, a 1826 survey had taken it physically westwards to the Lake of the Woods on the western Ontario border, but there it disappeared into the abstract. What ultimately precipitated the Dominion and Imperial Governments into some positive action was Louis Riel's Red River Rebellion of Metis, or half-breeds, in 1870 near the Manitoba-North Dakota border.

The rebellion was suppressed bloodlessly by a certain Lieut-Colonel Garnet Wolseley, 90th Regiment, with a half-battalion of the 60th Rifles, detachments of the ubiquitous Royal Artillery and Royal Engineers, and two weak battalions of Ontario militia. However, the progression of the force from Toronto to their objective, Fort Garry, Manitoba, by an old canoe route from Lake Superior to Lake Winnipeg was a minor triumph of logistic endeavour; certainly of endurance, as some 47 portages, dragging the heavy boats along hastily cleared forest tracks over rollers of felled poplar trees for distances varying between a few hundred yards to over a mile, had to be undertaken to by-pass rapids and waterfalls. When the British field force marched away in September 1870 from the grey stone fort at the junction of the Red and Assiniboine Rivers to return to the East to embark for England, an uneasy void was left as the rebellion had stirred up sympathetic Fenian Brotherhood activity across the Dakota and Minnesota borders and Riel himself had fled to the States.

Even so, it took another two years of political discussion to arrange a joint British-US border survey and then it had to be stirred into life by a sudden US claim that the Hudson Bay Company trading post at Pembina on the Red River was on American soil. On 18 September, 1872, the British, consisting of a Commissioner, 4 officers and 45 NCOs and Sappers of the Royal Engineers, and a Canadian civilian survey team which included a geologist, surgeon and veterinarian, met at Pembina the American Commissioner, 4 officers of the Corps of Engineers and a party of civilian surveyors, with Company K of the 20th US Infantry as escort. The British Commissioner was a Gunner, Capt Donald Cameron RA, and his RE officers were Lieut Samuel Anderson, Chief Astronomer, Lieuts Albany Featherstonhaugh and William Galwey were assistant astronomers, and Lieut Arthur Ward, secretary; Lieut Valentine Rowe was to join the Commission in the Spring of 1873. On the American Commission, the mark of West Point figured as strongly as the Royal Engineers with the British. Arthur Campbell, the Commissioner who had been with Lieut-Colonel Hawkins on the 1861–62 British Columbia border survey, was a graduate and all his astronomers except one were serving officers.

"Their first act was to determine just where the 49th Parallel did cross the Red River. The disputed Hudson's Bay post was demonstrated to be a few hundred feet north of the line, but the Canadian customs house was south of it. When the American and British surveyors came up with a discrepancy of thirty-two feet in locating the line, the Joint Commission set a precedent in international relations by amicably halving it."[3]

An equinoctial snowstorm greeted the surveyors but then a fine month of Indian summer allowed them to tackle the daunting baptism of their work: to survey sixteen miles of swamp and close timber from the north-west corner of the Lake of the Woods, where the 1826 survey gave up at a submerged post in a crib of logs, and then ten miles across the Lake where the elusive 49th Parallel was located on the open ice. Thankfully, on the west shore of the Lake, after the cold slime, quagmires and sodden, miserable camps of their exhausting introduction, they established their first astronomic station.

With only the first station established, the American contingent had to fall out back to St Paul for lack of funds. The British, however, once the freeze came to ease

Photo 1. British and Canadian Officers of the North American Boundary Commission 1872–76.
Left to right; Standing. Sub-Asst Astronomers Burpee, King and Coster, Commissary Captain Herchmer, Chief Astronomer Captain Anderson RE, Geologist Prof Dawson, Surveyor Russell, Sub-Astronomer Ashe.
Sitting. Asst-Astronomer Captain Galwey RE, Secretary Captain Ward RE, Commissioner Captain Cameron RA, Asst-Astronomer Captain Featherstonhaugh RE, Doctor Burgess, Vet Surgeon Boswell.
By Courtesy of Public Archives of Canada

movement in their swampy environment, were determined to press on and this they did with great fortitude and vigour, aided by Saulteaux and Woods Cree Indians and hardy, adaptable Metis. Transport varied between horses, mules and dog teams with sleds; shelter was Indian skin lodges or brush lean-tos.

"Sometimes in the still cold their spirit thermometers dropped to forty-five, fifty, fifty-one below. In their icy camps they lay and heard the gunshot reports of willows bursting as the sap froze, and on those nights of windless cold they saw the Northern Lights in their greatest splendour. . . . They learned how eyelashes could freeze together on a trail, and how a muffler moistened by breathing could freeze fast to a man's beard and threaten to smother him. . . . The eyes of all the surveyors were painful from the constant dangerous contact with the eyepieces of their instruments, whose lurking frost could seize an eyelid and hold it fast. After long exposure the eye would leak tears that froze instantly into beaded ice on the lashes."[4]

After another 90 miles of woodlands, they came into the Red River Valley and the Plains country where they were to sight a beeline for eight hundred miles. During April and May, in the boggy conditions of the thaw, the British party rested up on the Red River but were back in the field when the American Commission rejoined with the company of 20th Infantry reinforced by two squadrons of the 7th Cavalry under Major Marcus Reno. The Indian menace on the American side was real as the Woodland Sioux under Little Crow had risen in bloody massacre in Minnesota in 1862 (a certain Sitting Bull of the Plains Sioux, as a young man, had visited Little Crow and thought his Woods cousins rather wet for suffering the

depredations of the white man for so long), and since 1864, the United States Army had been fighting a running small war further south in Wyoming and Colorado against the Cheyennes, Arapohos and Sioux under the splendidly named Black Kettle, Roman Nose, Lean Bear and Red Cloud, who were aided by war parties from the Kiowas and Comanches. The Plains Indians were determined to resist the torrent of settler wagon trains allegedly heading for the El Dorado of California and Oregon but in fact many were turning aside en route when desirable land was seen. It was ironic that Major Reno should later impress on the survey party when, further west, its escort had grown to the formidable force of not only his two cavalry squadrons but also five companies of the 6th US Infantry, that there must be no division of the force to dissipate its strength and deterrent power. Sitting Bull and Crazy Horse of the Sioux, who in 1872 were already preparing to defend their ancient tribal territory of the Black Hills of Dakota (the real name of the Sioux was the Dakotas) against incursions of gold miners, were to inflict a crushing defeat three years later on the 7th US Cavalry at the Little Big Horn River, Montana, under the flamboyant Custer who did divide his command and the unfortunate Major Reno, the other column commander, was to become a controversial figure for not riding to Custer's relief.

The Joint Survey worked alternate stations, each Commission dividing into several parties. As far as the western border of Manitoba, ie, two thirds across North Dakota, 8 ft hollow iron pillars, dug 4 ft in the ground, were erected at 1 mile intervals. Once in the empty Plains country, cairns of stones were used. Ahead of the British survey went an officer with 30 mounted Metis to scout out the land and select camp sites, and these armed Metis, lightly known as the "49th Rangers", were the sole protection, apart from the personally armed working sappers, the British considered their expedition needed; this is an interesting insight into the differing relations with the Indians on each side of the border. The summer of '73 in the fertile prairie valley of the Red River was unpleasant as clouds of mosquitoes and voracious bulldog flies attacked both man and beast and the horses particularly became very thin.

Photo 2. Ox train of the Boundary Commission crossing Dead Horse Creek on their way West in the early days before they met the treeless, dry Plains country.
By Courtesy of Public Archives of Canada

From the Red River Valley the survey entered the Plains proper and headed for buffalo country, with its short dry brown grass on which this magnificent beast, a walking department store of all the Plains Indians' needs, throve. Tragically, like his natural predator, the Indian, the buffalo was to succumb appallingly to the advance of the white man; the repeating rifle, the insatiable demand by Eastern manufacturers for hides while carcasses rotted on the ground, the squander by well-armed Meti hunters who shot to take only the delicacy of the tongue and hump ribs, all contributed to the summary departure of a superb animal who had roamed in his countless thousands but, by 1878, had almost vanished from the vast prairies.

From Pembina Mountain, the surveyors emerged to traverse a burning open 70 miles to the Turtle Mountains, where shade and water lay, and then they pressed on across 138 miles of more flat plain to the foothills about the Missouri. They were now entering the real arid prairie country of alkaline lakes and streams and violent fluctuations of climate; snowstorms could well come in September. Fortuitously, as the weather roughened drastically in October and the advanced British survey party was looking desperately for a Meti camp at Wood Mountain for shelter, they came across a Sioux hunting party who directed them. The whole survey was now strung over 400 miles in various parties and with the onset of winter, they all rode back to the Red River to hibernate and consolidate their paper work.

On May 20, 1874, the British Commission of 11 military and civilian officers and 128 sappers and Canadians left Dufferin on the Red River, and in late June were joined by the Americans, including Major Reno and his small army. By August a considerable concourse of 500 men, horses, wagons and baggage were at the Sweetgrass Hills whose three magnificent buttes towered 3500 feet about the surrounding vista of plains. The survey was now in the territory of the warlike Blackfoot confederacy, consisting of Blackfoot, Piegans and Bloods, who ranged from central Alberta to northern Montana and were old enemies of the Sioux. However, the Blackfoot were not to trouble the survey, perhaps deterred by Reno's show of strength, but any euphoria was soon sobered by the discovery of the bodies of a war party of 20 Crow Indians near the depot camp, mummified in the dry heat and having been scalped by the Blackfoot.

Captain Featherstonhaugh located his final astronomic station at the Belly River crossing, 748 miles west of the Red River. On 18 August, Samuel Anderson reached the most easterly monument of the Hawkins-Campbell survey of the BC boundary and so the great project was accomplished. By the end of August, all parties of the Commission turned east again for the long trek back and the main British party reached Dufferin on 11 October. All that remained now was the considerable paper work of writing reports and completing maps. Out on the ground, along the parallel, 388 monuments and marks had been established by the two Commissions, as well as 40 astronomic stations.

What was the effect of these lonely iron pillars and stone cairns on the ground where such real problems lay? The newly-arrived North West Mounted Police now had an effective line of demarcation to enforce action against rotgut whisky bootlegging, gunrunning and horse stealing (the latter being an honoured Indian pastime). The Indian nations, the Blackfoot, Sioux, Crow, Assiniboine, Cree, Nez Perce and Gros Ventre, came to look on it as a safe refuge from the blue-coated cavalry squadrons who operated on the simple thesis propounded in 1868 by that thrusting cavalry general of the Civil War, Philip Sheridan, who was then commanding in Kansas during the Indian wars. When Tosawi brought his Comanches in to surrender, he uttered two words of English, "Tosawi, good Indian". Sheridan's reply: "The only good Indians I saw were dead",[5] became through repetition that classic phrase, "The only good Indian is a dead Indian". But the scarlet uniforms of the North West Mounted Police, patterned on the British soldier's red coat because the Indians had trusted him, stood for justice and respect for a man's dignity and the Land of the Grandmother was a haven from the ruthless European domination and Indian misery in the Great Father's domain. The inanimate series of stone cairns

along the vast, unguarded frontier became powerful medicine. After Little Big Horn, Sitting Bull and 4000 Sioux moved across "the Medicine Line" to escape the vengeance of the United States Army and settled in the Cypress Hills, watched by Superintendent Walsh and a handful of Mounties, and they lived peacefully there for four years, much to the embarrassment and worry of the Canadian Government. Chief Joseph and his gallant remnants of the Nez Perces were not so fortunate; they were caught by the combined forces of Generals Miles and Howard at Bear Paw Mountain, after a 1300 miles fighting march from their tribal grounds in what is now Washington State, when only one day's long march from the Medicine Line.

To move from those tragic, bitter days for the Plains Indians into the next century, Wallace Stegner puts a modern, light touch to the Medicine Line; recalling his boyhood during the Great War:

"The 49th Parallel ran directly through my childhood, dividing me in two. In winter, in the town on the Whitemud, we were almost totally Canadian. The textbooks we used in school were published in Toronto and made by Canadians or Englishmen; the geography we studied was focused on the Empire and the Dominion . . . The songs we sang were "Tipperary" and "We'll never left the Old Flag Fall" and "The Maple Leaf Forever" and "God Save the King"; the flag we saluted was the Union Jack, the heroes we most revered belonged to a Canadian regiment called the Princess Pats . . . But if winter and town made Canadians of us, summer and the homestead restored us to something nearly, if not quite, American. We could not be remarkably impressed with the physical differences between Canada and the United States, for our lives stepped over the international boundary every summer day. Our plowshares bit into Montana sod every time we made the turn at the South end of the field. We collected stones from our fields and stone-boated them down into Montana to dump them. I trapped Saskatchewan and Montana flickertails indiscriminately, and spread strychnine-soaked wheat without prejudice over two nations."[6]

Perhaps the last word should be left to a surveyor about surveyors:
"The heroic deeds of explorer-surveyors, men of the calibre of Champlain, Mackenzie, Thompson and Fraser, are the stuff of legend and rightfully enjoy prominence in the story of Canada's development. But the work of pioneer land, railway and boundary surveyors, which helped to transform a vast wilderness into ordered growth, has seldom stirred public imagination. Yet these men, too, subdued the unknown and replaced ignorance with knowledge. The lives of frontier scouts, of cowboys, soldiers and mounties have become invested with a glamor not bestowed upon surveyors working by celestial and terrestrial rules applied through the expert use of their modest, unspectacular instruments. The bold advances of the Wolseley expedition of 1870 and of Canadian mounted police in their famous trek from Dufferin to Fort Macleod in 1874 have become part of Canadian folklore. Yet, whether in treacherous muskeg west of the Lake of the Woods or on the seemingly limitless plains in the vicinity of Red River or hundreds of miles to the west of that waterway, men in uniform found that dauntless surveyors had been there before them. It was, in fact, at the Wood Mountain survey depot, 430 miles west of Red River and 22 miles north of the 49th parallel of latitude, a provisioning point of the international boundary-marking project, that Commissioner Macleod and his weary mounties obtained essential supplies that enabled them to continue their journey to the foothills of the Rockies. By that time the boundary surveyors had nearly completed their allotted task. Perhaps if their relatively mundane mission had been less well-performed or less practical in its uses, their accomplishments might have been gloriously enshrined in the national story as an exciting, epic chapter of achievement."[7]

[1] *The Winning of the West*, by Theodore Roosevelt, (New York and London 1894).

[2] Medicine Hat, on the border of Alberta and Saskatchewan and the nearest city to British Army Training Unit Suffield, was only founded in 1883 as a water point for the CPR pushing west.

[3] *Wolf Willow*, by Wallace Stegner (The Viking Press, New York, 1962).

[4] Ibid.

[5] *Bury My Heart at Wounded Knee*, by Dee Brown (Holt, Rinehart & Winston, New York., 1971).

[6] *Wolf Willow*.

[7] *Men and Meridians, Vol 2*, by Don W. Thomson (Queen's Printer, Ottawa 1967).

The Solomons Specialist Team

MAJOR M G HUNTER RE BSc (Eng) MICE AM INST HE

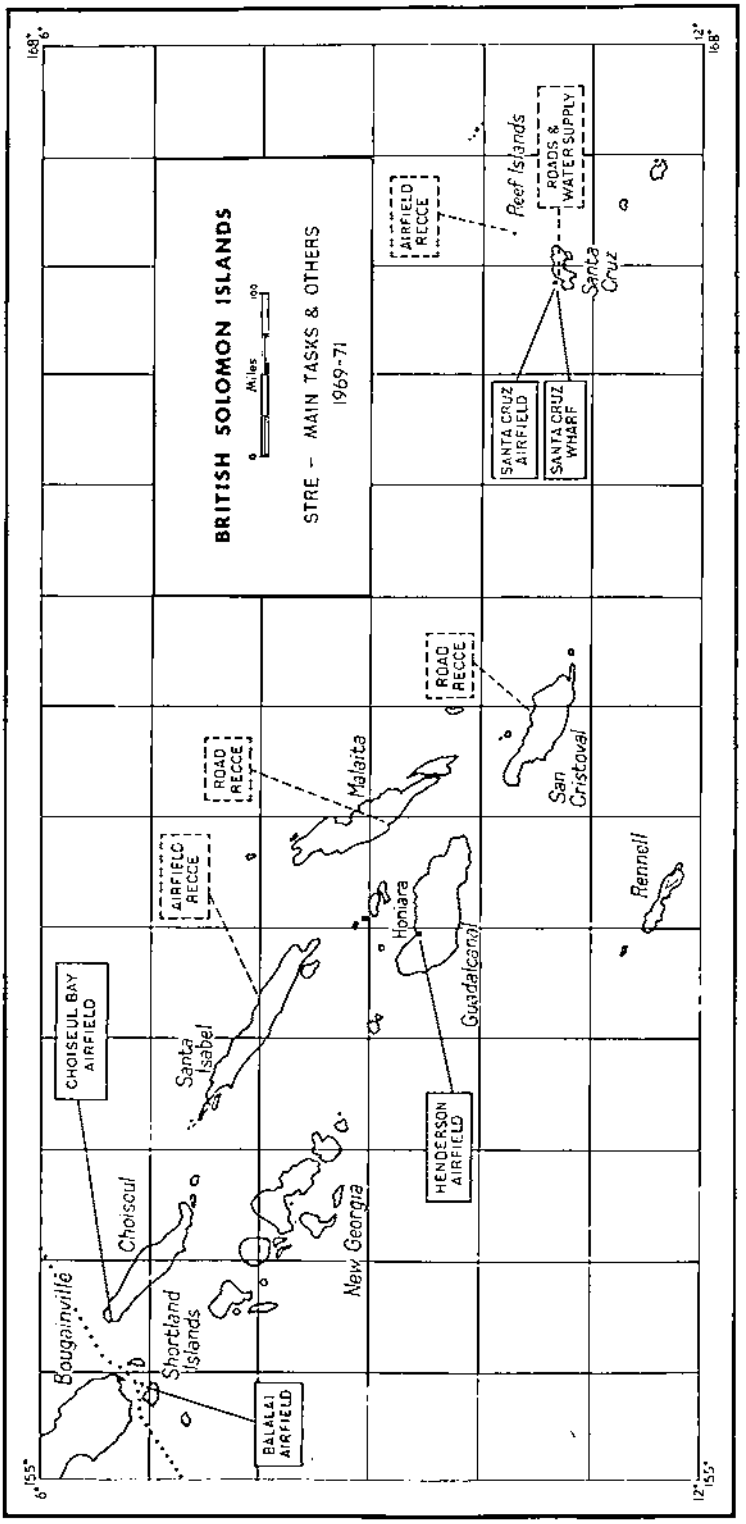
INTRODUCTION

SOME readers will have heard or read of the Specialist Team RE (Solomon Islands). Brief glimpses of it have appeared in *Soldier Magazine* and *Sapper*. The team was also introduced at the end of the article "Henderson Field, Guadalcanal" by Lieut-Colonel F J Otten published in the *Journal* in June 1969. I do not consider it desirable to repeat any of his article which is the background to my story.

Undoubtedly influenced by the very favourable impression created by Colonel Otten the British Solomon Islands Protectorate (BSIP) Government requested additional MOD assistance during a routine courtesy visit of the C-in-C Far East. As a result the STRE (Solomon Islands) was formed up some five months after I reached the Solomons. My team was not the only MOD assistance resulting from the C-in-Cs visit, two Survey NCOs (Photo Technician & Print Technician) were seconded to the BSIP Lands & Surveys Department where they installed a camera and a printing machine and trained Solomon Islanders to use the equipments. As a result the BSIP can, and does, now produce and print its own maps. Also seconded to the Public Works Department was a WO I Ammunition Technician. During his two years, apart from a very large number of callouts for the great range of American & Japanese ammunition still being discovered, he cleared a very large American dump known as Hell's Point which had exploded during the war—and had been virtually abandoned ever since! His over 2,000 tons of ammunition sea-dumped considerably boosted RAOC statistics.

The composition of the Team and its tasks had been established during a follow-up visit before my arrival. Briefly the Team was to plan and supervise the construction of two airfields and a wharf in the Eastern Outer Islands. Separate Commonwealth Development and Welfare (CD & W) project funds had been earmarked for the airfields and wharf and these were to come from within the BSIP overall allocation. The Team was to work directly for the Public Works Department (PWD) using PWD plant and local and PWD specialist labour. The Team was also to give on job training to PWD Tradesmen and Operators. The Team had an establishment of 12, OC, Admin WO, MPF, CW (C), Sgt RAMC, Cpl REME (VM), Cpl POM, Cpl Cbt Engr (Admin), Cpl Svyr Engr, and 3 Plant Fitters. One Plant Fitter and the Cpl REME were to work in the main PWD mechanical workshops until suitable "expatriates" could be recruited and the remainder were on site. The Admin WO was the vital base link. He was procurement, resources, pay, spares, rations, etc, and at times had a very difficult and busy job with infrequent shipping to very remote detachments. Experience proved that the Team was too large for the tasks and was subsequently reduced. The tasks were also altered as a result of a Transport Survey by a pair of UK Specialists.

It would be possible for me to write an article about each of the major tasks undertaken by the Team during my 2½ years as all the tasks were of some engineering and general interest. I believe I could even have written an amusing, though it


BRITISH SOLOMON ISLANDS
STRE – MAIN TASKS & OTHERS
1969-71
Miles
100
0
CHOISEUL BAY AIRFIELD
BALALAI AIRFIELD
HENDERSON AIRFIELD
SANTA CRUZ AIRFIELD
SANTA CRUZ WHARF
ROADS & WATER SUPPLY
AIRFIELD RECCE
ROAD RECCE
Bougainville
Choiseul
Shortland Islands
Santa Isabel
New Georgia
Guadalcanal
Honiara
Malaita
San Cristoval
Rennell
Reef Islands
Santa Cruz
168°
6°
12°
155°

seldom seemed so at the time, article on the problems of travelling in the BSIP. For a non-sailing Sapper I got in an awful lot of "seatime"—about 150 days—less than Chay Blyth but at about his average speed (and our boats had engines!). The BSIP Marine Dept and local "fleets" were definitely of the "bring your own pillow and sandwiches" variety and journeys could last 72 hours. I was twice caught in minor cyclones and lived in semi-permanent fear of finishing on a reef—which wasn't too uncommon.

The map shows the locations of the tasks undertaken by the Team. Logistics were the biggest problem because of infrequent and unsatisfactory shipping to outlying detachments. Fresh rations were a particular headache as few ships had freezers and those that did invariably had temperamental ones. It was not only internally that problems occurred and items ex-UK took at least a year. Air freight, which of course one didn't demand as lightheartedly as normally in the Army as one's own project funds were being used, could still take three months. Spares were a very real problem and quite obviously serviceability rates were not always satisfactory. Plant availability and correct and efficient utilization of plant were equally difficult problems because of the very limited quantity and range of equipments available within PWD. These and other "difficulties", which included the limitations of the PWD tradesmen and operators, were always with us and will not be referred to again.

AIM

I have set a limited two-fold aim. Firstly, to give a very brief description of the main tasks, the engineering problems in them, and the lessons learnt, (many of which do not only apply to a "tropical" setting), and secondly, to give my views on the value and limitations of this type of Specialist Team.

THE MAIN TASKS

Henderson Airfield

As I mentioned in the Introduction, Lieut-Colonel F J Otten's article "Henderson Field, Guadalcanal" was a detailed report on the planning and execution of the project until the time Colonel Otten left the Solomons. At that stage the earthworks for the runway were largely complete, the granulator and screen had started production, the proof roller had most satisfactorily proved the completed parts of the runway, and some of the primecoat of cutback bitumen had been sprayed. The project was increased in scope after some months by the inclusion of a new phase which included surface treatment for taxiways and apron, about 3,500 metres of new access roads (coral surface), and improvements to the terminal area including a large car park with surface treatment, some building extensions, new drainage, water supply, and a new terminal for the Internal Airline.

Progress on the "second half" of the task was not as good as it had been before my arrival but the airfield was satisfactorily completed as can be seen in Photo 1. There were a number of reasons for this slower progress—the main one being that the ruling factor on progress was the rate of production of crushed stone. The engineering problems of interest are discussed in subsequent paragraphs.

The rate of production of crushed stone was most discouraging. The obvious snag of this setup, dictated by the unavailability of any conveyor belts, was that the failure of either the granulator or screen brought both units to a halt. Most things that could go wrong went wrong; hammers broke, piston rings broke and later two pistons broke up, a cylinder cracked and the screen vibrated itself through three engines—its own plus the engines taken from a concrete mixer and later a waterpump. In all serviceability, despite liberal use of airfreight, was little better than 60%. It had been my experience from two projects in Aden that, in terms of usable stone, a small crusher will normally only produce in a day what it is rated at per hour. On this project production was under half this rate. Most of the obvious things were tried in an effort to improve productivity like prewashing, screening, varying

Photo 1. Henderson Airfield Guadalcanal.

hammer clearance and number of hammers. The percentage reject from the screen remained high, at about 40%, and naturally the screen never produced the ¾ in and ⅜ in in the correct ratios which in effect meant over 50% of output required re-circulation. Despite all this the 2,050 tons of crushed stone required were finally produced—but it was most frustrating.

The surface dressing consisted of a primecoat of cutback bitumen (MCO) followed by two coats of 85/100 straight run bitumen with ¾ in and ⅜ in crushed stone. The first problem was the preparation of the coral surface. At first we brushed with a rotary broom, hand swept, wetted the coral, and then sprayed the cutback. This was not entirely satisfactory as it resulted in patches of MCO lifting to release water vapour trapped underneath. Later we cut out the rotary broom, (as coral can be brushed for ever), and the wetting of the coral. This slightly improved penetration but did not eliminate surface deterioration. For about a month this surface "skin" retained sufficient flexibility to absorb temperature change but after that cracks started appearing and the surface "blistered" and spalled. The primecoat did produce a very reasonable temporary waterproof surface but required a lot of maintenance because of the delays with the first coat of surface treatment.

The laying of the surface dressing was the most interesting technical part of this project. RETN No 16—"A Guide to Surface Dressing" gives, in detail, notes on the theory and practice of surface dressing and is strongly recommended as a very useful guide. As the Henderson Airfield project was more than twice the size of the project on which the practical notes were based I feel qualified to make three comments.

Firstly, because of aggregate variations there can be no absolute method of design and the RETN correctly advises obtaining advice from any source available. I designed the surface dressing for the project using the US Asphalt Institute method for double surface treatment (MS—13). This method employs the theory of absolute volumes which seems logical, it works, and is recommended where there is no existing specification available. Secondly, the RETN makes no mention of the use of

The Solomons Specialist Team.

building paper to obtain "clean joints". This is very desirable at pavement edges for neatness and essential at transverse "joints". Spray jets do not operate instantaneously and ridges or gaps are inevitable at each end of each run if building paper or something similar is not used. The paper should be removed after the spraying and before the application of chippings. Finally, the spray jets must operate from the correct height to apply a uniform spray.

The equipment we had available is of interest if only for its lack of match. The controlling factor affecting the speed of laying was the time taken to heat the bitumen. We had three bitumen heaters, one 500 gallon and two 200 gallon giving a total usable capacity of about 700 gallons. The "Kettle gang" started at 0400 hrs but one "fill" per day was the normal limit from each boiler. The filling and transferring (400°F) arrangements were very improvised. The towed distributor had a usable capacity of 300 gallons, a burner for maintaining temperature in case of delays, and an ex-Land Rover engine operating the circulating and spraying pump (which made it look strange). The towing tractor for the distributor was fitted with a fifth wheel tachometer and an improvised sighting device, with these two aids the driver became most proficient. The aggregate was spread from two tippers fitted with Hornsy gritters. These gave a surprisingly good result. The gate opening and speed for the required spread had to be found by trials. The speed of the tipper was fixed by using the slow running adjustment so that the driver reversed with "feet off". This worked well but needed constant checking. The effective capacity of the tipper was used as the factor dictating the length of a run. We were fortunate enough to have a self-propelled rubber tyred roller for initial compaction and this was followed up 24 hours later by a medium smooth wheel roller.

Some small points to complete the comments on this project. Firstly, I would add my entire agreement to Colonel Otten's remarks on the value of the proof roller. For the natural surface strip, whether surface dressed or not, the approach seems ideal. It gives physical proof of the complete runway which must be more satisfactory than random soil tests. Secondly, we found the runway marking more difficult than perhaps it should have been. The paint (emulsion) was as specified for bituminous runways and was applied by spray gun. Two points worth noting are that with the open texture of surface dressing one needs considerably more paint than the makers advocate, and, to achieve a good job one requires many more windbreaks and much more masking than one might imagine.'

Bituminous surfaces are susceptible to fuel and oil spillage and the thin coating of a double surface treatment is particularly vulnerable. Some damage was done on this project mainly by the heavier oils on the apron. The high ambient temperature quickly dissipated the more volatile fuels. It is worth noting that asphalt sealants are commercially available, (we did a trial with one), but they have disadvantages. Cement slurry is another possible alternative where the high cost of PQ concrete cannot be justified. One small final point, commercial aircraft require earthing during fuelling and designed earth points are essential at each parking bay.

Santa Cruz Airfield

This was a natural surface airstrip with a runway 3,000 ft × 80 ft within a flightstrip 3,400 ft × 150 ft. Although it took 13½ months to complete against a planned time of 12 months, at least it was completed within the original cost estimate. As can be seen from the map a major problem was the distance from any support facilities. We had a mobile workshop on site but as mentioned in the introduction were very dependent on infrequent shipping (averaging two or three visits per month). The government landing craft was very small, 60 tons dw capacity, which meant the build up and exchange of plant and equipment was slow and this vessel had to do over 20 trips during the project. Despite the logistic problems the project would have been completed on time but for a dock strike in Australia which considerably delayed the arrival of explosives.

Site selection on volcanic islands with little usable ground produces as many

problems as in more sophisticated areas and land acquisition in the Solomons is surrounded by difficulties largely because ownership is confused. The site finally selected had a large area of swamp at one end and a coral hill at the other. Trials following the original site investigation had shown that the coral hill would be very difficult if not impossible to rip. Because of the need to blast the hill the provisional design was not "balanced cut and fill" and assumed a quantity of imported fill. Imported fill from within the purchased boundary proved harder to obtain than expected—but so did winning the rock from the coral hill! The final profile, after many trials, was a compromise and was surprisingly close to the provisional design.

The two main constructional problems have already been mentioned—the reclaiming of the swamp and the reduction of the hill. Santa Cruz has a rainfall of over 200 inches a year. The swamp, about 15,000 square yards, normally had the water table a few inches below the average ground level but flooded following heavy rain. It was essential to clean out this swamp down to a coral base a few feet below normal ground level. As it was not possible to drain the area the operation was very dependant on weather but it was achieved with no great technical difficulty.

The other main problem was the reduction of the coral hill, maximum cut 30 ft. The coral hill was fissured, was not homogeneous and varied considerably in hardness. Most of the coral was re-crystalized (of marble appearance) but there were pockets of relatively soft material. The two D6s with rippers (the maximum capacity of the landing craft was a D6) came in for considerable punishment largely because of the inconsistency of the material. Rippers are designed to a "rock strength capacity" (strength based on seismic velocity) and we confirmed, (the hard way!) that most of the coral could not be ripped out.

The hill was therefore very largely taken out by drilling and blasting. Drilling was difficult because of the varying conditions of the coral, in addition a drilling pattern was impossible to establish or maintain because of surface irregularities and the large

Photo 2. Santa Cruz Airfield. Reclaimed swamp area at far end of airfield with coral hill in foreground.

number of faults and fractures. Fragmentation was poor, partly because of the inability to produce a drilling pattern, but mainly because the pressure waves from a blast naturally followed the planes of weakness or discontinuity between the hard crystallized coral.

We had a small wagon drill and a number of normal hand drills for the actual drilling. The wagon drill, see Photo 2, had some limitations on this site. It took some time to manoeuvre into position because we could never clear the site to a reasonable level and we were unable to use its drilling depth capacity. With the very varying material the drill rod tended to be forced off line and jam at a depth of more than about 6 ft. Hand drilling was often quicker, because of the ease of moving to each drilling point, though was more liable to jam. Two smaller problems found with drilling the coral were that, first, coral dust and moisture often produced a very sticky 'paste' which built up behind the bit making progress slow because of the need to frequently withdraw, (a lesson only learnt after having to dig out two or three bits), and secondly, resupply of tungsten carbide bits, which were absolutely essential, was very difficult.

The drilling and blasting were the ruling factors governing the progress on this job. We worked shifts all the time, I introduced an incentive scheme, and for many months we had a night-shift working under crude floodlights or the light of the moon. An earlier appreciation of the slow progress of the drilling could have speeded the job but the main limitation was availability of compressors and drills. In total we used 48,800 lbs of explosive on the task and the "yield" was almost exactly 1 cu yd/lb of explosive. A more normal yield would be at least 1·5 cu yd/lb which indicates the loss in efficiency which can be expected when blasting a material which is heterogeneous.

The surface finish of the runway was also a problem. The grid roller was most effective in crushing the fill but the variations in the nature of the fill made it difficult to grade. We finally used coral from the reef (finger coral) as a surfacing material and this proved most effective. It bound well, having some self-cementing properties, and from experience gained in other areas should prove durable.

Santa Cruz Wharf

It had been intended that this task be undertaken at the same time as the airfield and other smaller jobs at Santa Cruz. The airfield and wharf were needed to improve communications to the Eastern Outer Islands and a small District Station was established at this time. The smaller jobs included the supervision of the housing contract, road construction and assistance with a water supply project sponsored by UNICEF. Unfortunately the supply of steel, ex-UK, for the wharf was delayed and this task did not really start until after the "airfield team" had moved on. This overstretched our support resources, for example we only had the one mobile workshop, and increased our administrative overheads.

The wharf consisted of a piled T-head at the reef edge connected to the shore by a stone jetty or mole. The piles and bracing were steel and the deck was concrete, precast in sections with protruding reinforcement. After placing the sections were welded together for continuity and the infills poured *in situ*. The main design problem was lack of knowledge of the likely penetration of the piles because of the impracticability of a trial. The Geology Department did a few trial bores which indicated small penetrations and the design had to be based on this. A lot of bracing was therefore assumed to be necessary.

The main construction problems stemmed from the limitation that the only available piledriving combination was a 19 RB and drophammer. This resulted in many headaches including the manufacture of improvised brackets to adjust the angle of the leaders. The main problem was that the 19 RB was heavier than the design live load for the wharf. This made progress very slow as, after driving, each pair of piles had to be braced and a temporary timber deck constructed before the 19 RB could move forward to drive the next pair. The 19 RB rigged as a piledriver,

has a very limited "reach". The final concrete deck could not be started until all piling was completed and the 19 RB withdrawn.

The piles, 8 in × 8 in × 31 lb UC, and all the bracing steel was sandblasted on receipt and given three coats of epoxyresin paint. Piling over the sea with a 19 RB is never very satisfactory as it is not a rigid piling frame. On land the bottom of the leaders can be supported but over the sea this is not possible—and there was up to 25 ft of pile unsupported hanging below the bottom of the leaders. The correct positioning of the pile therefore became rather chancy and we had no means of extracting a pile. By using normal survey methods the pile would begin in the right place but once driving had started it was rather a question of luck. The coral was not homogeneous and the toe of the pile tended to wander and corkscrew. The unsupported length of pile, which was surprisingly flexible, followed and tended to pull the piling leaders out of position.

Penetrations to design set varied from 6 ft to 35 ft. As mentioned earlier the design had to assume small penetrations, ie under 10 ft. Fortunately we had a good reserve of piles but the large penetrations could involve up to two splices which were very time consuming. *In situ* welding, for the cross girders and bracing following the piling, was by far the biggest factor delaying progress and was very slow. Apart from equipment the main problems were, firstly limited and difficult access over the water, some welding could only be done at low tide, and secondly, quite a lot of extra brackets and cutting was needed because some piles finished a few inches out of position. As mentioned earlier further piling could not take place until all this welding and the temporary decking, had been completed.

The precasting of the deck slabs went well after a few initial problems with the shutters, because of the projecting reinforcement and lack of experience of the local carpenters, and the aggregate. The only available aggregate source was a river gravel which had an excess of coarse sand taking it outside the normal grading bands, however a design based on a refinement of Road Note 4, which takes into account actual grading and shape of aggregate, gave satisfactory strength and workability.

This was not a big job but was made most interesting by the remoteness of the site and the limitations of equipment. Photo 3 shows the wharf near completion.

Choiseul Bay Airfield

This was a natural surface airstrip with a runway 680 m × 25 m within a flight-strip 800 m × 90 m. (SI units were used for this airfield because of the later design date). Choiseul Bay had been chosen by the BSIP Government as the most suitable centre for the development of Choiseul/Shortland Islands. It was proposed to establish a small Government Station to be the focal point for this development. Again land acquisition problems were considerable and the original proposal for the airfield proved impractical and effectively we were restricted to the land owned freehold by an Australian Company. This land, including the four islands of the bay, had been a coconut plantation before the war but the company had not subsequently returned. The Japanese had used Choiseul Bay as a seaplane base during the war.

Site selection within this limitation was very restricted. There was no suitable land on shore and it was finally agreed to build the airfield, small jetty and government station on one of the islands which I had selected as offering the best airfield site. All the islands in Choiseul Bay had swamps and were plagued with mosquitoes which made them most unpleasant by day and impossible out of doors by night. Considerable clearance of undergrowth and the filling of part of the swamp did however make it habitable after a short time.

As can be seen from the map Choiseul Bay is some distance from Santa Cruz and the one landing craft made for a very slow build up. Fortunately the task was simple and the earthworks involved were small. The only constructional problem was the soil which was a poorly graded sand with virtually no clay. It compacted well when the m/c was reasonably high, which is normal, and lab tests gave good CBRs at OMC (about 20%). The poor grading and lack of cohesion meant that when dry the

Photo 3. Santa Cruz Wharf. Precast deck sections can be seen at nearest corner of T—head.

surface would be liable to rut and during heavy rain would be liable to erode. Stabilization was considered but rejected as being impractical because of lack of suitable material for mechanical stabilization and money for cement stabilization. Eventually it was decided to plant suitable grasses and once established they should largely overcome both rutting and erosion problems.

We did a series of cone penetrometer tests over the runway and these showed that very satisfactory compaction had been achieved but clearly some maintenance may be necessary until the grass is firmly established.

SPECIALIST TEAMS

The composition of the original Team, which is given in the Introduction, had been decided upon as the result of a brief visit, before my arrival, and without any visits to actual sites. The Admin WO and I were on 2½ years accompanied tours for continuity and the remainder on 9 months tours. The original team was overstrength, could not be fully employed, and was subsequently reduced by underimplementing the first and second reliefs. Together with the recruitment of "expatriates", (two men in the main PWD workshops), our strength was reduced from 12 to 7. This, in fact, rather overstretched our manpower when for a short period we had three remote detachments operating simultaneously.

All our tasks were small, the outlying airfields each employed an average of 40 Solomon Islanders and the jetty about 25. Each job only justified one expatriate "foreman" and this of course is all the PWD would have sent—if they could have recruited/persuaded anyone to go! With the right type of man this would undoubtedly have been the most economical way of running these tasks. However, the sites were extremely remote, two were on completely uninhabited islands, one site was plagued with mosquitoes, and none offered anything remotely resembling a travel agency's

"tropical paradise". There was absolutely nothing to do in the evenings. It therefore became very desirable to increase the "expatriate" strength for companionship which only produced very small improvement in efficiency and beyond a certain, quickly reached, point produced under-employment and gross boredom.

One of the main problems is that the Army is apparently "tied" to a 9 month tour for this sort of posting. This I believe is quite unrealistic. A task with a unit in the West Indies with cinemas, canteens, excursions and even possibly girls cannot be equated with a CW (C) stuck on a remote island with a Cpl 16 years his junior and the only contact, apart from myself, being an occasional meeting with the District Officer. In my experience the young men, in particular, were limited in their ability to entertain themselves and morale did drop, to varying extents, with all on detachment once the novelty of the setting had worn off.

I believe that other Teams in similar situations should be at absolute minimum strength and the length of tour should not be greater than six months. The reduction in strength would compensate for increased travelling costs and continuity is not so vital as might be imagined for this type of task provided there is an adequate administrative anchor. From a Corps point of view the main disadvantage of a very small team using direct labour, or supervising contractors, is that the excellent experience available is very thinly spread. The real full costs for a similar task carried out by a unit using imported military equipment are of course astronomic but more experience is far more widely gained. It all depends on who pays what in the cost calculations!

I am certain that all those who served with the Team gained considerably in technical experience and the younger ones in additional matureness (an acquisition not necessarily fully appreciated at the time). For example, each of the three Engineer Surveyors, surveyed, calculated, draughted, set out and controlled their own airfield —an experience not normally found beyond the RSME classroom and, even then, certainly not for a Sapper.

While giving excellent experience to individuals it is my view that the Team was not particularly good value for money in the overall aspect of field management of plant. I believe there were two reasons for this. Firstly, what I would call "the operational attitude" and, secondly, lack of experience (and in some cases lack of sound basic knowledge). The PWD was a small organization with obvious support limitations; replacement equipments were usually not available and spares had both financial and logistic difficulties. The "operational attitude" correctly aims, as in any large commercial undertaking, to keep downtime to a minimum by replacing components or assembles immediately or by producing replacement equipments. This approach is only economic with a large organization and simply does not apply in BSIP. Some of the Team were unable to appreciate the rather different circumstances—machines were misused, spares were carelessly handled or even lost, spares orders were incorrect, and the general attitude was rather casual. The lack of experience was explainable but unfortunate—for example one young fitter arrived as an A1 (at 19!) having spent all the time since qualifying as a driver—the lack of basic knowledge was discouraging.

Despite these criticisms, and I think it only fair to point out the limitations, I believe the Team did well. Certainly the BSIP Government were sufficiently satisfied to ask for, and obtain, a two year extension for the Team.

COMPUTERS

A net curtain was cut into strips and fed into a computer. The Director of Music emphatically denies that the resulting print-out was played as a waltz at the RE Summer Ball. It was played as a quickstep.

A computer was programmed to solve a series of calculations. The solutions could be in either SI or Imperial Units. The first answer appeared as "37". The operator kicked the machine, keyed-in "37 what?". The reply "37-Sir".

Desert Waters of the Middle East and the Role of the Royal Engineers

F MOSELEY ERD DSc PhD MA

A MAJOR and fundamental problem of any desert region is the availability of fresh water. The refined techniques and equipment of the present day can only be used by those with sufficient money to pay for them, and although the oil industry has locally introduced the wealth necessary to overcome some of the difficulties, oilfields cover but a fraction of the Middle Eastern deserts, and many regions continue to languish in a mediaeval environment. It is in the context of the latter that the Royal Engineers have played an important part, their contribution essentially beginning during the Western Desert campaigns of the second World War, and then continuing to the present day. During this period there have been significant hydrogeological investigations in Egypt, Libya, Jordan, Iraq, Persia and various parts of Arabia, but because publication has been mostly in confidential reports, or in journals not normally consulted by geologists and hydrogeologists, there has been little appreciation of its content. It is the object of this article to outline some of the conclusions derived from these investigations and also to portray some of the geological and human problems encountered.

There is no doubt that prospecting for water in deserts can be immediately satisfying and useful in a manner perhaps rare today. Pure university research has its personal fascination, but often is not of immediate value and to contribute to the progress of a giant oil or mining company may give a sense of achievement to some, even should they be the smallest cog. Desert water surveys on the other hand can still permit small groups or even individuals to contribute materially and obviously to the well being of many, and it it is in this field that the RE with rapid organization and mobility has proved that it can be superior to many commercial companies for whom security and a guaranteed profit is paramount.

It is true that the subject of water supply, or more fashionably ground water hydrology, has become increasingly complex, especially in the highly developed countries of Western Europe and America. Application of mathematics in electrical analogue techniques is the rule and computation and trend surface analysis is increasingly necessary. The question is no longer where to find water, but what are the flow rates, permeabilities and the most efficient development and conservation of the water resources. Geological maps, numerous borehole records and well outputs will already have been analysed and more refined techniques will be sought, such as the geophysical methods now pursued by Professor Griffiths of Birmingham University and his colleagues, endeavouring to improve supplies from the Bunter Sandstones beneath the Fylde of Lancashire. Notwithstanding these advances there are the vast undeveloped regions indicated above where water exploitation remains as it was 2,000 years ago, when the gods were largely responsible. This is the paradox of most deserts, the greatest need yet the least development. One may reflect that not many years ago water diviners held sway. For example in the British Army the species tended to be self perpetuating since those professed of the faith were often of high rank, and in the early 1940's the fate of armies in the Western Desert was almost at the mercy of dedicated dowsing. Indeed it was not until a War Office directive prohibited divining, stating that results had proved "inferior to chance", that Major (later Professor) Shotton and his geological methods prevailed. Quite recently a highly regarded water prophet of Fadhli, Southern Yemen was known as the "dreamer" because of his method, and he may well be the only geological advisor at present in the country. Other inhibiting influences exist and may be experienced by dowser, dreamer and geologist alike. One such was the sheik who, delighted with a water survey of his territory, nevertheless insisted that the water

must be discovered beneath his fort, and not very different, if one is to avoid discrimination, was the army commander who explained that all wells must be within the camp for security reasons.

In describing some water surveys undertaken by the Royal Engineers a variety of examples will be referred to, but I hope to be excused if I mention mostly those with which I am immediately familiar.

A THE DESERTS OF LIBYA AND EGYPT

(1) *The Miocene Limestones of the north*

These rocks are nearly horizontal, and outcrop over many thousands of square miles. Water occurs in two situations, first as comparatively rare perched water tables, and secondly as the ever present but rather saline sea level (main) water table.

Perhaps the best example of a *Perched Water Table* is the *Fuka Basin*, Egypt (Fig 2, Shotton, 1944, 1945 and 1946B). The presence of two native wells with unusually fresh water and a water table higher than normal led to the discovery of what proved to be a major water point for the Eighth Army during the desert campaigns. The basin consisted of a shallow fold with water held at a high level in the limestone by a thin clay bed, the main water table being beneath the clay and highly saline. The extent and potential were proved by a large number of boreholes and a continuous supply exceeding 25,000 gallons per day was achieved, a considerable amount for this region. It was successfully concealed from the other contestants when they advanced to Alamein and quickly reopened when fortunes changed.

The *Main Water Table* is always to be found in the desert at depths close to sea level, descending to a little less than sea level at inland oases such as Giarabub (Shotton, 1946A), where it is at surface (Fig 3). With this foreknowledge it is very easy to impress by pointing to any locality across the Libyan Plateau and saying "just there at 524 feet" or "467 feet" (or whatever the height above sea level may be). Sadly the hero worship diminishes when the located water tastes like a cross between the Red Sea and Leamington Spa, and one of the objects of surveys such as ours of 1968 (Moseley and Cruse) was to locate slightly less saline spots. Theoretically these are to be found where there are combinations of prominent mudpans and faults (major fractures), since occasional surface floodwater will be concentrated at the mudpans, which are essentially inland drainage areas, with wadis leading to them, and underground flow will be facilitated by the faults, (there are no salt pans since the water sinks into the limestone before it can evaporate) (Fig 3).

The logistics of this survey may be of some interest, mostly as an indication of what not to do in the desert, but this must also be taken as an indication of the spurning of too much security and the desire for some adventure felt by most of those who join the army. Two ancient land rovers and trailers, loaded with petrol and water, were manned by carefree para-troops. After 100 miles the first trailer snapped after being towed up an escarpment of chair sized boulders. The wheels were cannibalized just in case. There followed a succession of punctures with the trailer wheels coming in most useful since none of the party seemed capable of mending punctures successfully, but it must be said that the soldiers seemed little perturbed at the thought of a 200 miles walk back to base.

Moving from one extreme to the other it is worth noting that some years earlier the oil companies had surveyed a comparable region and had drilled quite a few exploratory oil wells. An oil drilling rig requires about 3000 gallons per hour continuous water supply for mud make-up and storage and the known presence of the sea level water table was therefore invaluable. Fresh water for other purposes was produced by portable distillation plant, and it seems certain that various scales and types of plant for producing fresh from saline water will become more important in years to come. It was fortunate that when these matters were being resolved the army had available the expert advice of Major Cruse.

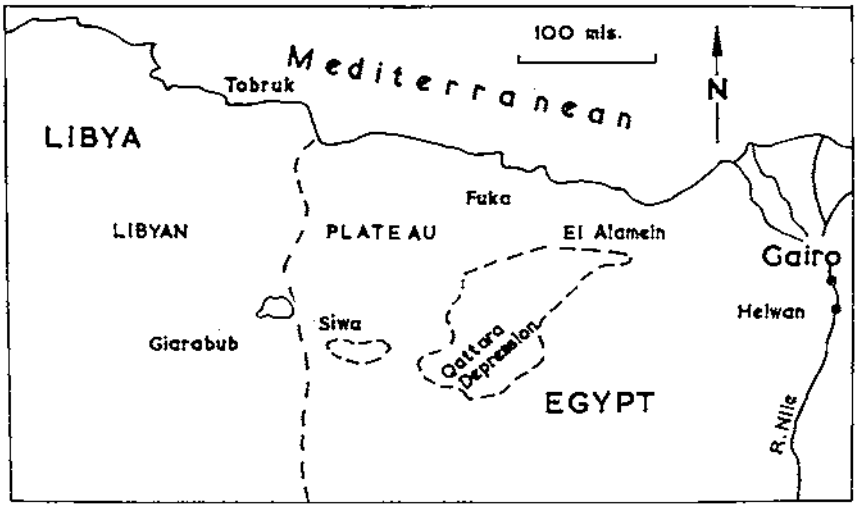


Figure 1. Map of the Western Desert showing some of the localities mentioned.

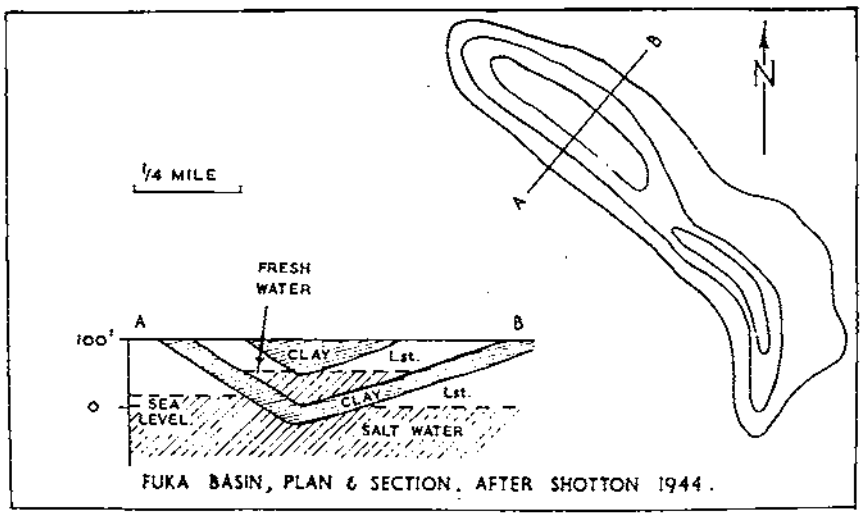


Figure 2. The Fuka Basin, Egypt.

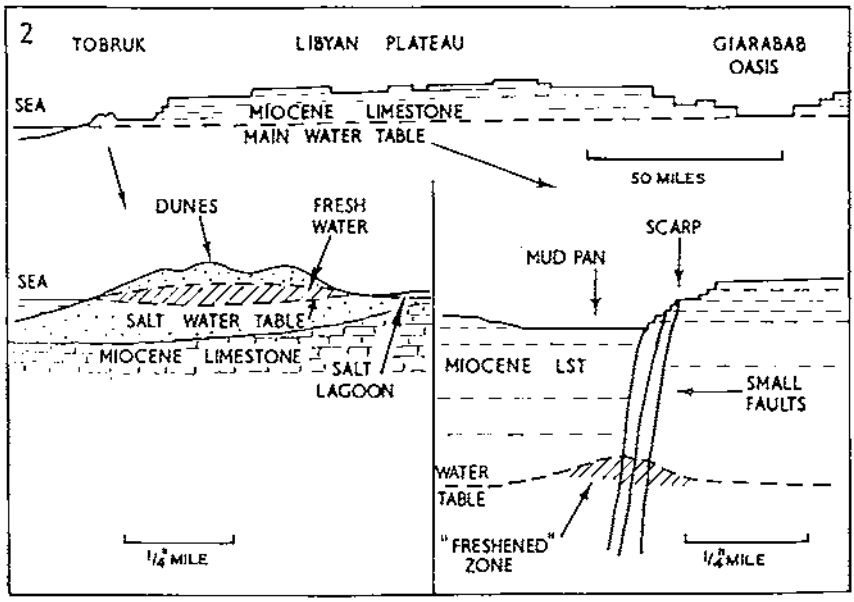


Figure 3. Sketches to show the Main Water Table, and water in coastal dunes, NE Libya.

(2) *Continental Sandstones of the Central Sahara*

It is worth mentioning an unresolved problem from further south in the Sahara where the "Nubian Sandstone" (a much mis-used term) occasionally reaches the surface to give oases such as Kufra and the Fezzan. This water is not an artesian supply deriving from the Sudan as was once thought, but is fossil water, stored during pluvial or rainy periods, when Britain was suffering an ice age and the Sahara was savannah country. Consequently extraction is really a mining process, and there will be no re-charge. New grandiose irrigation schemes therefore need careful watching otherwise hopes will quickly crash. Quite recently, since the opening up of the Libyan oilfields, there have been successful attempts to date this water by the advanced Tritium method. This has confirmed the earlier conclusions about the age of the water and gives an indication that modern scientific resources can aid development of desert water if money is available.

(3) *Superficial Deposits*

Water supplies from superficial deposits can be illustrated by three examples, both going back to the same Major Shotton's experiences during the last encounter (Shotton, 1945, 1946C).

The first is from the *Cairo* region where the *Nile Gravels* pose a two-fold problem of sullage disposal and acquisition of drinking water (Fig 4). The solution adopted could be regarded as the medico's nightmare with sullage discharged down one hole and drinking water taken from another a few feet away. At Darb el Hagg (1) fresh water was obtained from sand, sealed from the surface by clay, and sullage was dispersed into the top layer of sand. At Helwan (2) advantage was taken of calcreted sand layers which sealed off fresh water from saline water. The fresh water was obtained from the higher layer and sullage pumped into the saline layer. Perhaps those concerned with the military camp at Beihan, South Arabia (3), had seen and admired the Cairo set up. At any event sullage and fresh water points were located close together, but out of sight, underground, it was not quite the same, and fresh sullage would have gone to the cook house had there not been objections. The moral for the amateur is to be careful.

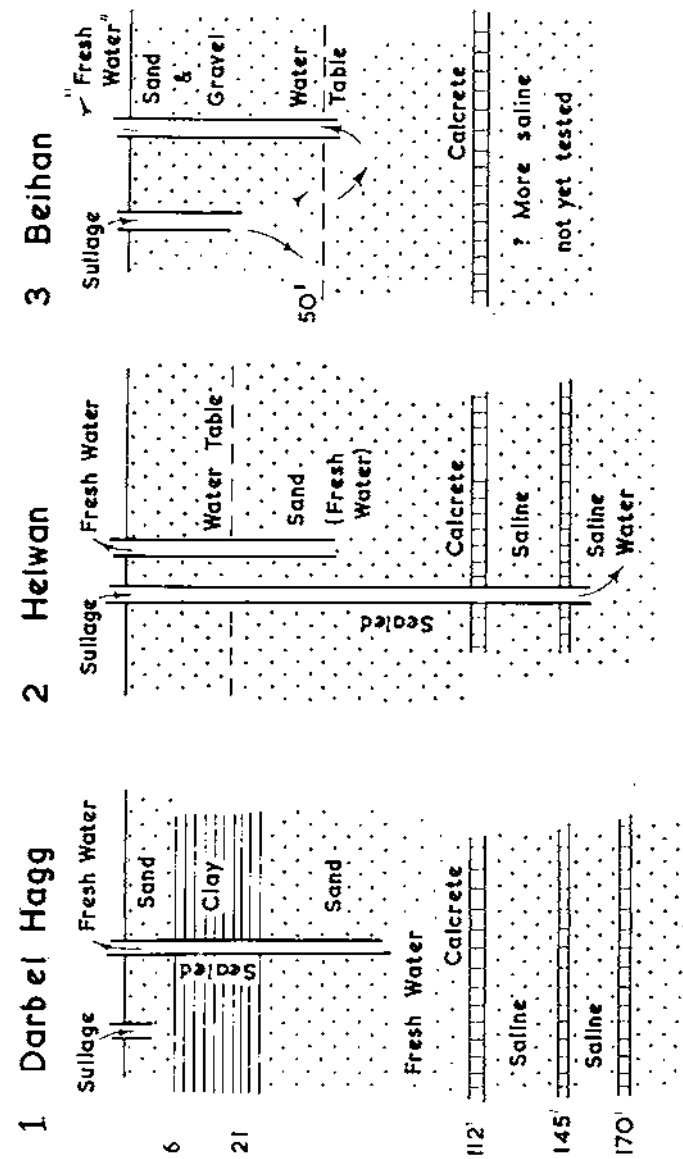


Figure 4. Simplified vertical sections to show derivation of fresh water and disposal of sullage.

A rather different problem is that of water from *Coastal Dunes*, illustrated in figure 3. In these situations there is a shallow layer of fresh water resting abruptly on saline (sea) water, sometimes visible in the field when a fresh water spring is seen only a foot or so above a salt lagoon. Boreholes are an unsatisfactory method of tapping this water since they simply bring up the saline water from below. The method commonly used is to skim off the fresh water by a collecting gallery, essentially a covered trench or series of trenches just below the water table, along which water flows to a collecting point (Addison and Shotton, 1946, Moseley, 1963). Most dunes along the Egyptian and Libyan coasts and indeed all over the world yield supplies of this kind.

The third example comes from the extremely arid *Red Sea Hills* of *SE Egypt* and has been described by Paver (1946). It is chosen for two reasons, first to show how water in wadi gravel can depend on local structures in the bedrock, and second to illustrate the value of geophysics in determining concealed structures. The area is underlain by impervious granite and metamorphic rocks, penetrated by vertical and inclined dykes of impervious basaltic rock, which tend to stand up as low ridges. These rocks are crossed by wadi channels of varying width and with varying thicknesses of gravel, whilst below the gravel the top few feet of bedrock is weathered and porous. Figure 5 shows one such wadi obviously crossed by an impervious dyke, which, acting like a dam in the weathered bedrock, and forming a low ridge across the sub-gravel wadi floor, was found to hold up water on the up-wadi side. In practice the position of the dyke beneath the gravel was located by a magnetometer traverse, and the thickness of gravel by resistivity measurements.

B THE MOUNTAIN DESERTS OF SOUTH ARABIA

Water supply problems in this region are in sharp contrast to most of those just described. This is largely due to the mountainous terrain and to the fact that much run off reaches the country from the higher rainfall region of Yemen. Logistic problems are also different and cross country movement is especially difficult. My surveys were blessed with an enlightened and efficient organization commanded first by Colonel Drake-Wilkes and later by Brigadier Baldwin, which provided the odd helicopter and arranged all other forms of air and ground transport to suit the surveys. Helicopters were particularly useful in remote areas for quick inspection of inaccessible ground, and one can make fascinating first ascents of sharp peaks in next to no time. All ground surveys required military escort because of the traditional South Arabian sport of shooting at all comers, and no tribesman was ever to be seen without his rifle (like a geologist and his hammer). A British escort was not preferred (by me) because this somehow concentrated attention, although to be fair there was no malice intended and nobody was ever (or hardly ever) hit. In fact it was generally conceded (by the tribesmen) that the soldiers enjoyed the game, much as our foxes enjoy being hunted. Better by far to have the bodyguard of the local Naib or Sheik, whose code of honour guaranteed absolute safety, and this also subtly removed the best players from the other side.

It will be as well if I now outline a few specific examples. The first from *Fadhli Province* (Moseley, 1971) reveals one of the problems when boring into highly permeable limestone. The aim was to tap a water zone near an unconformity where permeable Jurassic limestone rested on impervious basement gneiss, some 500 feet down. This particular region is extremely dry, the nearest well 10 miles away only produced 600 gallons per day, the drilling team had one 400 gallon bowser to carry drilling water, there were no roads, and the limestone was so permeable that the whole bowserful disappeared in a few minutes of drilling. I leave the reader to work that one out and to ponder on the difficulties of getting things started with limited resources.

One incident during this survey revealed very clearly the superior perception of the Arab in his desert environment. We were trundling across a broad silty plain near

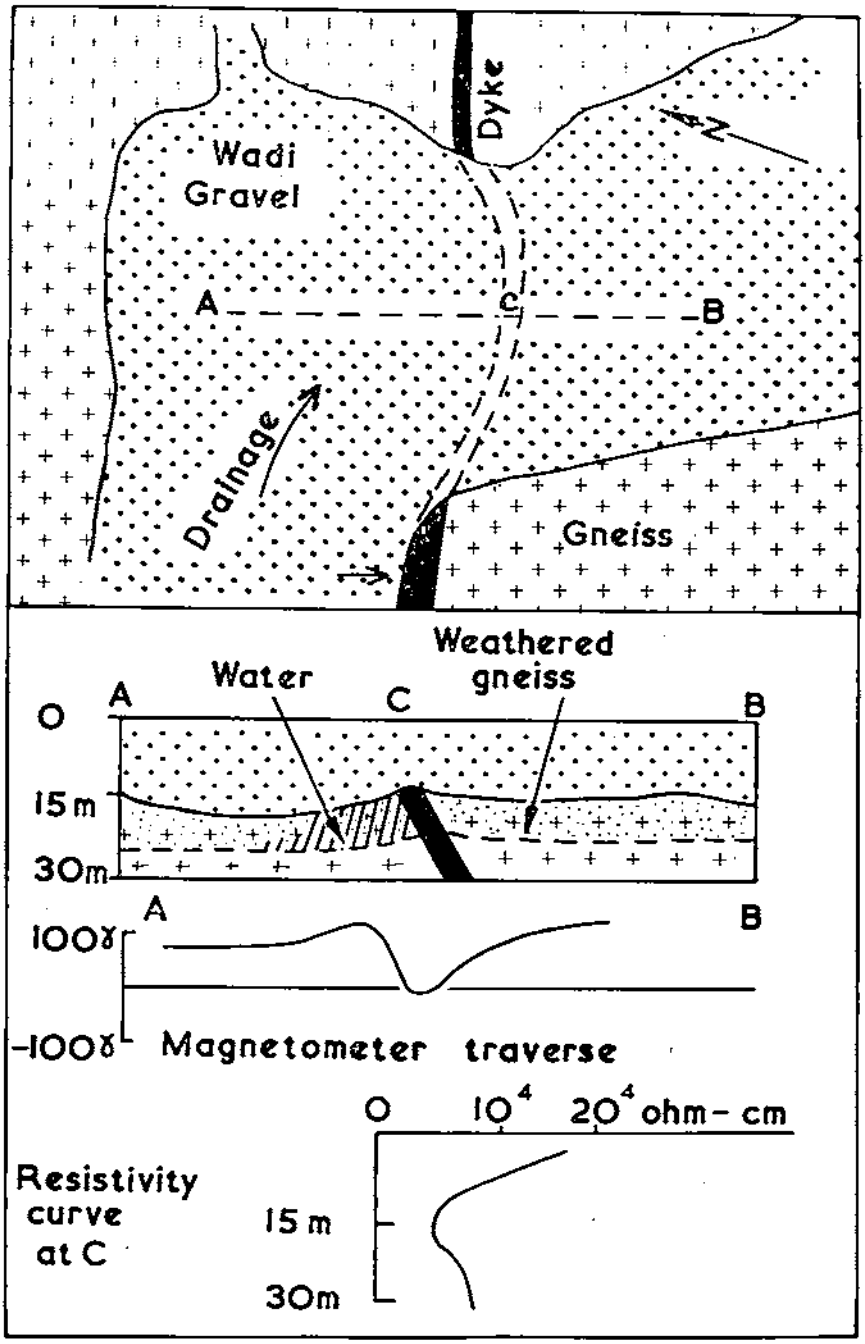


Figure 5. The use of geophysical methods in detecting underground water in the Red Sea Hills, Egypt.

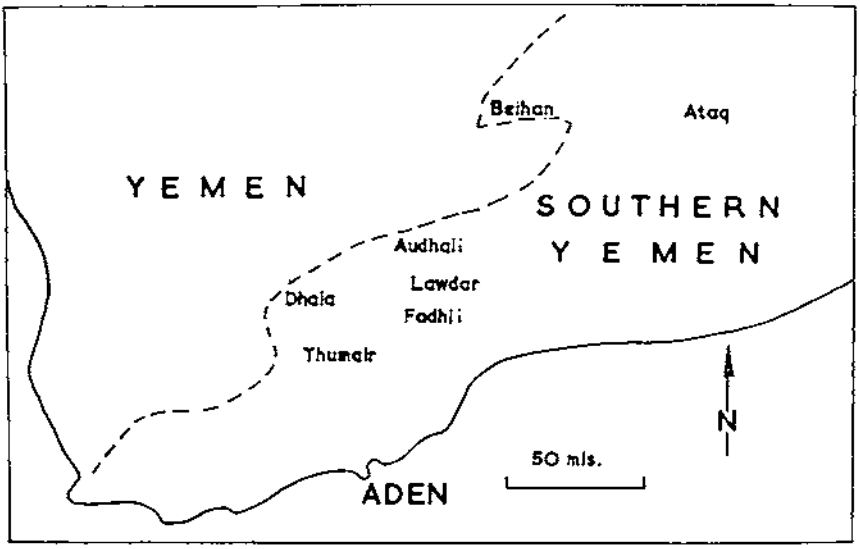


Figure 6. Map of Southern Yemen to show the localities mentioned.

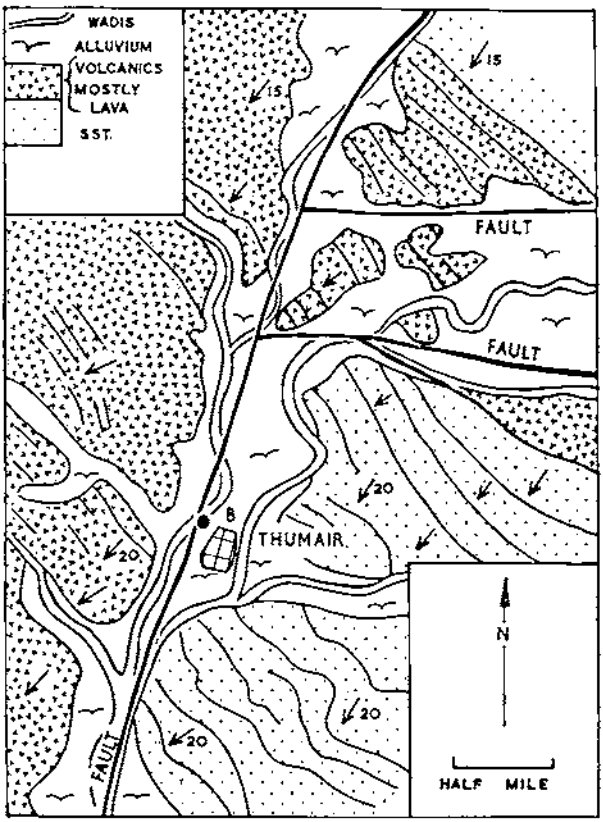


Figure 7. Classical water supply situation from the Radfan Mountains, South Arabia. The water is found in the sandstones and concentrated along the fault plane. The western side of the fault consists of impervious basalt which holds back the water.

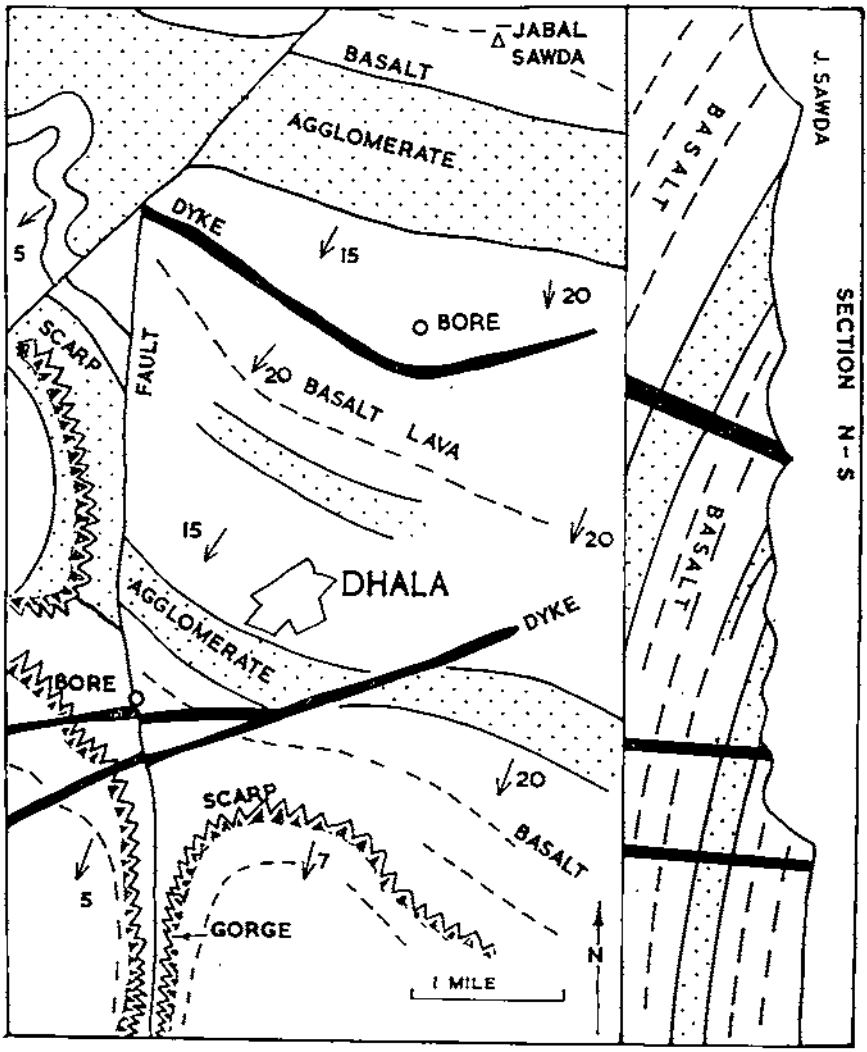


Figure 8. Water points near Dhala, South Yemen. The water is found in agglomerate and ash and held up by dykes.

Lawdar in two land rovers, when an almost invisible, tiny moving speck appeared round a distant rock buttress. The rovers halted in a cloud of dust and the complete Arab escort leapt out as one man "What's wrong?" I asked. "He cocked his rifle", was the reply.

A more successful bore than the last mentioned was near *THUMAIR* later referred to as Habilayn, (Fig 7) where there is a classical situation of a major fault with relatively impermeable basalts to one side and highly permeable sandstones dipping obliquely towards the fault on the other. The fault is beneath alluvium but its position and the estimated 'flood" of water could have been precisely located by magnetometer traverse. Without this equipment to hand a guess had to be made, not too difficult in the circumstances, and a reasonable borehole supply was obtained. However, there were other difficulties graphically described by Colonel Shapland

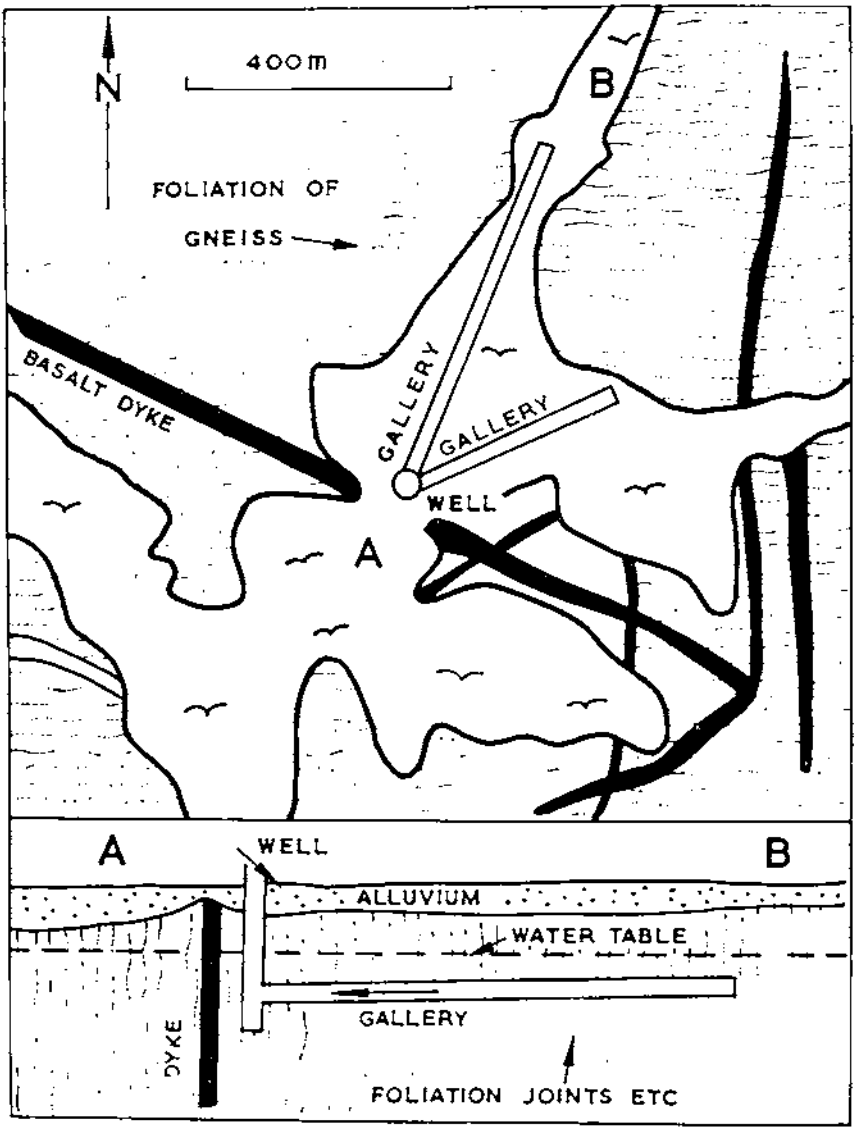
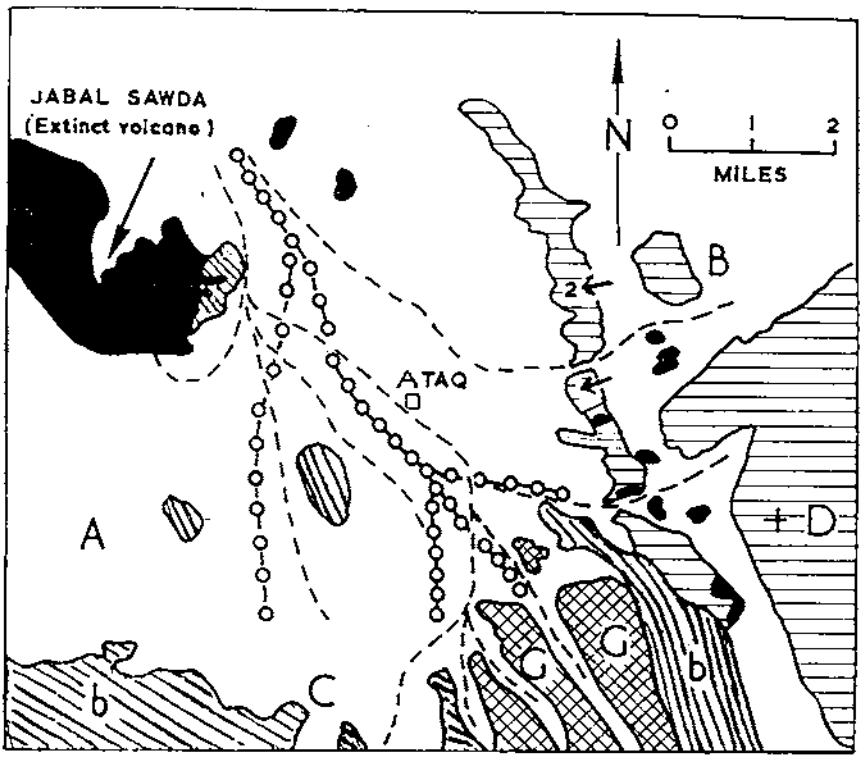


Figure 9. Use of galleries intercepting fissures in otherwise impermeable Basement metamorphic rocks, Audhali Plateau, South Yemen.

(1967). The water point was outside the camp and continuously guarded, but in spite of this dissident tribesmen managed a commendable attempt at its destruction.

Other successful bores were made in the slightly higher rainfall region of *Dhala* near the Yemen frontier (Moseley, 1966) where there is a thick accumulation of Tertiary basaltic lava flows, almost completely impervious, with occasional interbedded agglomerate and ash, the fragmental and permeable products of explosive volcanic action. The problem is simple, almost like predicting pips in apples, or whatever the phrase is. Boreholes had to penetrate into permeable agglomerate and preferably be "up dip" of dykes so that the water would seep down the gradients



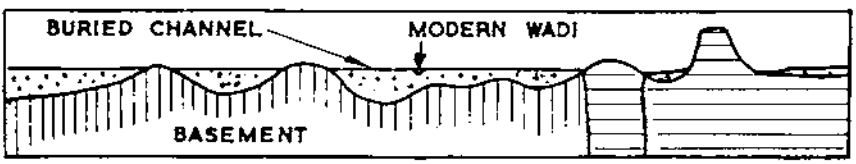


Figure 10. Buried channels at the base of alluvial gravels, Ataq, South Yemen.

indicated by the dip arrows (Fig 8) and be held up by the impermeable dykes (feeder channels for the lava flows), which thus acted as underground dams. The two bores (the only two up to 1968) had high yields for this region (about 4,000 gph.) and gave Dhala its first piped water supply. They replaced a few traditional wells, mostly with only two or three feet of slimy water, and several hundred (no doubt nutritious) frogs.

A final solid rock example may be quoted to reveal the difficulties of obtaining water from Basement metamorphic complexes. The *Audhali Plateau* 6,500 feet above

sea level, has numerous shallow wells each yielding a small quantity of water, which filters into the wells from vertical fissures (mostly foliation or fracture planes and other joints parallel to foliation) (Moseley, 1971). Boreholes are not normally the answer to increased supplies because they would be parallel to the above fissures, which may also be expected to close and become watertight with depth. It is better in such cases to construct gently inclined galleries to intercept as many fissures as possible as shown in Fig 9, but it is more than difficult to convince local dignitaries that this is the method for them when they have only recently been weaned to the concept of tube wells.

One example of water from the *Superficial Deposits* of South Arabia will suffice to illustrate a universal problem. *Ataq* (Moseley, 1966) is typical of many alluvial plains and alluvial fans where the old hill and valley topography is buried beneath several hundred feet of sand and gravel (Fig 10). The water at the base of the deposits will obviously be concentrated along the buried valleys, and the mistake frequently made is to assume that these valleys will be directly beneath the modern wadi channels. This is not necessarily so and surveys really need geophysical assistance (resistivity or seismic) to record more precise locations of water and/or buried channels, although intelligent approximations can be made from conventional geological surveys.

There is one final anecdote from here which to some may reveal the Arabs great concern with water. The keeper of the well at Ataq was so impressed to meet the finder of the water, that he offered his most treasured rifle as a gift. A great honour even though the barrel was so bent that the user would have been in danger of shooting himself, but the finder of the water later discovered that had the gift been accepted the code of conduct would have required the offer of his rifle in return.

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Exercise Latin Field

MAJOR D G KNOTT RE(V) BA CEng MICE

INTRODUCTION

In October 1972, 111 Engr Regt(V) spent its annual camp in Cyprus on Exercise Latin Field. Sappers always experience a particular satisfaction in constructing works of a permanent nature and respond accordingly. To undertake twenty such tasks is a rare opportunity and resulted in one of the more interesting exercises that the unit has undertaken in recent years. It also illustrates a potential role of the Regiment, while the finished products provide evidence of the range of skills and the tasks that can be accomplished.

As the Regiment is perhaps not too well known throughout the Corps a word of introduction may be necessary. 111 Engr Regt(V), a sponsored as opposed to an independent reserve unit, is administered by Central Volunteers Headquarters (CVHQ) based at Cove. The Regiment is organized into two field squadrons, 120 Fd Sqn and 130 Fd Sqn, with an RHQ and a supporting REME workshop. The unit establishment of 28 Officers and 485 OR's is nearly at full strength and enjoys the privilege of a "waiting list" for officers.

The regiment is unique among the TAVR engineer regiments in two respects. Firstly, it is composed entirely of reservists; secondly, the recruiting area of the unit extends over the whole of the UK and the Channel Islands. The training commitment is two compulsory weekends and fifteen days annual camp. This commitment is obviously extremely short and exerts a significant influence on the running of the unit and the pattern of training. Although there is some continuity during the year, the Regiment only assembles as a complete unit for the period of camp. Hence the first priority of camp is to re-establish an effective organization before any training can be carried out. This process usually occupies the first two days of camp, but practice has reduced the time thus spent to a minimum. One advantage, however, arising from the lower training commitment and the wider catchment area is that it permits a high standard of recruitment among professional engineers and skilled tradesmen who, for geographical reasons or pressure of work, could not fulfill the training requirements of other TAVR units.

PRE CAMP PLANNING

In order to add interest to the training and to provide an opportunity for command to be exercised at every level, the tasks set by CRE NEARELF consisted of a number of small construction tasks, which could be executed within a period of ten days under troop or section organization. The recce reports and designs were carried out in advance by the CRE and 525 STRE (Constr) (V). Completed recce reports were sent to RHQ during the summer as they became available. It was appreciated that the successful completion of the project would require a high degree of co-ordinated planning since the schedule was particularly short after allowance was made for the time required for mobilization, deployment, handing back of plant and stores and the return of personnel to the UK. After a reconnaissance in August by the Commanding Officer, Lieut-Colonel G A Leech RE(V), a final list of tasks was drawn up. Tasks were allotted to each squadron on a geographical basis, those in the Episkopi SBA to 120 Sqn and those around Dhekelia SBA to 130 Sqn. This allocation represented an approximately equal division of work. From the reports made available to them in September, troop commanders planned their construction schedules on the basis of continuous working from the time of arrival in Cyprus to the date of departure, with recreational time allowed for on an individual rather than a group basis. In some cases it was found necessary to work on a double shift system for all or part of the construction period. Planned construction times, labour and plant requirements for each task were as shown on Table 1.

TABLE 1

Project Tasks

Task Serial	Location	Description	Troop	Construction Period	Labour Required	Plant Required
1	Goshi	Construction of new schoolroom	2TP (130)	10 days	2 sections	Mixer 3½ T
2	Pergamos	Building demolition and production of crushed stone	4TP (130)	10 days	1 section	D6, Drott B100, Dumper 4½ YC, Stone Crusher
3	Pyla	Construction of mobile A/tank target.	1TP (130)	10 days	1 troop	Crane 6T, Compressor, Drott B100, Tippers
5	Happy Valley	Widen existing bridge in reinforced concrete	2TP (120)	10 days	1 section	Mixer, Compressor
6	Golf Club	Construct concrete golf tees	2TP (120)	10 days	2 sections	
7	Episkopi	Demolish cliff overhang	4TP (120)	4 days	1 section	Wagon Drill, Compressor
8	Limassol	Construct concrete slipway for services sailing club	1TP (120)	10 days	1 section	MWT, Compressor
9	Akrotiri RAF base	Construct Armco culvert under access road	1TP (120)	10 days	1 section	MWT, Vibrating Roller
10(a)	Kingsfield Airstrip	Hangar repairs	4TP (130)	3 days	Tradesmen	
(b)		Resurface sections of runway		6 days	1 section	Paviour, Roller, Drott B100, Tippers
11	Dhekelia School	Earthworks and drainage for new car park and access road	4TP (130)	10 days	Plant Ops	Grader, Drott B100, Roller, Tippers
12	Paramali	Construction of timber and CI hut	3TP (120)	9 days	1 section	
13	Dhekelia Golf Club	Construction of septic tank	2TP (130)	9 days	1 section	Mixer 3½ T, D4, Hymac
14	Rhine Camp	Construction of covered way	3TP (130)	9 days	1 section	
15(a)	Rhine Camp	Construct aggregate storage bins	3TP (130)	10 days	1 section	Compressor
(b)		Construct scrap bays			1 section	Mixer
16	Episkopi Go-Kart Club	Construction of club house and spectator stand	3TP (120)	10 days	2 sections	Mixer, Compressor, Welding Plant
17	Dhekelia Golf Club Hill	Heavy earth moving to level hill	4TP (130)	11 days	Plant Ops	D4, D8, 38RB, Tippers, Hymac
18	Berengeria Officers Club	Support roof on new concrete foundations. Replace roof beams. Recover roof.	1TP (120)	10 days	1 section	
19	Paramali	Grade and level playing field	4TP (120)	8 days	Plant Ops	D8, Drott B100, Grader, Roller

THE MOVE TO CYPRUS

The advance party consisting of 5 Officers and 26 OR's left UK for Cyprus in the early morning of Wednesday, 4 October, 1972, arriving at Dhekelia shortly after lunch. This allowed time for a rapid tour of the sites in the immediate vicinity. The next two and a half days up till 1300 hrs on Saturday 7 October were spent taking

over the barracks and preparing the individual projects. The latter task involved drawing stores, moving plant to sites and ordering of materials, all with the vital objective of permitting an immediate start on the following Monday. The problem of maintaining long shifts at the time that the regular units were working Middle East hours made it necessary to establish a more elaborate stores organization than would otherwise have been required. All stores were drawn in bulk and broken down either on a sqn or task basis as appropriate. These operations were carried out with the assistance of the regular squadron in Cyprus, 62 (NEARELF) Sp Sqn, who, apart from supplying the plant and stores, gave the Regiment unstinted support that contributed in no small measure to the success of the exercise.

On Day 1 of camp, Saturday 7 October, 1972, the remainder of the regiment numbering about 500 steadily mobilized at Brize Norton from all over the country, to be flown in five chalks by RAF Britannias and VC-10's during the Saturday night. A reception centre was established at Akrotiri airfield and as each chalk arrived the men were provided with a meal and despatched by coach to their respective locations on the island. By 1200 hours on Sunday morning all personnel had arrived at their destinations. Recce parties from each troop which had been despatched in Chalk 1 were meanwhile inspecting their sites setting out and checking stores, while the remaining members of the unit settled into their accommodation and carried out recces of another sort.

EXECUTION OF THE TASKS

With the exception of Kingsfield airstrip for which plant was not initially available, work began on all sites on the morning of Day 3. The entire operation was controlled by a Project Office set up and manned by RHQ at Dhekelia. Contact was maintained with each Sqn HQ by telephone, while each squadron established its own radio net. The Project Office served two functions. Firstly it substituted for the operational command network transmitting orders and receiving sitreps. Secondly it enabled all the ordering of materials and movement of plant to be co-ordinated through one channel. This was important in dealing with civilian suppliers and avoided the confusion that would have arisen from eighteen projects individually ordering materials, which could have resulted in deliveries to the wrong site and accounting chaos. It was accepted that the system would be by-passed from time to time in cases of emergency. On balance the Project Office functioned well, and it provided an up-to-date picture of the actual progress on all tasks. A general outline of the camp timetable was as follows:—

CAMP TIMETABLE 1972

Day 1	Sat 7 Oct	Mobilization in UK. Flight to Cyprus
Day 2	Sun 8 Oct	Settle in. Draw stores
Day 3	Mon 9 Oct	Work on sites commenced
Days 4–10	10–16 Oct	Continuous working on tasks
Day 11	Tues 17 Oct	Site work substantially complete
Day 12	Wed 18 Oct	Hand back of plant and stores
Day 13	Thurs 19 Oct	Hand back of plant and stores
Day 14	Fri 20 Oct	Half regiment returns to UK
Day 15	Sat 21 Oct	Remainder of regiment returns to UK

The usual problems were encountered at the beginning due to non-availability of certain pieces of equipment and a general shortage of transport, but within two days work was proceeding smoothly on all sites. On Day 7 the cliff overhang at Episkopi was successfully blown using a "home-made" explosive. The whole overhang slid smoothly down to the foreshore below and only the golf tees being constructed below were showered with debris. The construction schedules proved tight for some of the tasks, but in the event all were completed more or less by the evening of Day 11, and indeed, one or two additional tasks were undertaken in the course of the week. There is no doubt that delays and problems affecting the programme were overcome

mainly by the exceptionally hard work and long hours put in by the sappers. The determination to finish the tasks was prompted to a great extent by the appreciation shown by units or local villages for whom the work was undertaken.

The one failure that must be recorded was the re-surfacing of Kingsfield airstrip, which in any case was an open ended task. For a variety of reasons, mainly technical, the task never really got underway. Experiments with various trial methods of surfacing were carried out until a satisfactory method was finally developed. The scale of the operation, however, was too large for anything to be accomplished in the remaining period although much useful experience was gained which will be invaluable if any opportunity of undertaking an airfield runway presents itself in the future.

The nature of the individual tasks is best illustrated by considering in more detail two of the projects, Goshi School and Happy Valley Bridge.

GOSHI SCHOOL

This task consisted of the erection of a permanent schoolroom as an extension to the existing schoolhouse in the Turkish village of Goshi, about 15 km north of Larnica on the road to Nicosia. The building was presented by the British Government as a gift to the village. Under the existing educational system in Cyprus a community is expected to provide suitable school accommodation and the central government will then pay for teaching staff. Many communities however, cannot afford to pay for their share of the deal and consequently forego the government subsidy. Thus the construction of the schoolroom provided a double benefit to the village.

The structure designed by 525 STRE consisted of a concrete floor slab, previously laid by 73 Engr Regt (V), breeze block walls rendered internally and externally with a 6:1 sand/cement mix and an exterior tyrolean finish. The building was completed with wooden roof trusses and tiled. The floor was finished with a sand cement screed. Cement, sand and blocks were purchased locally, but windows, doors and roof trusses were made up in the workshops of 62 Sqn from material salvaged in the demolition of another building.

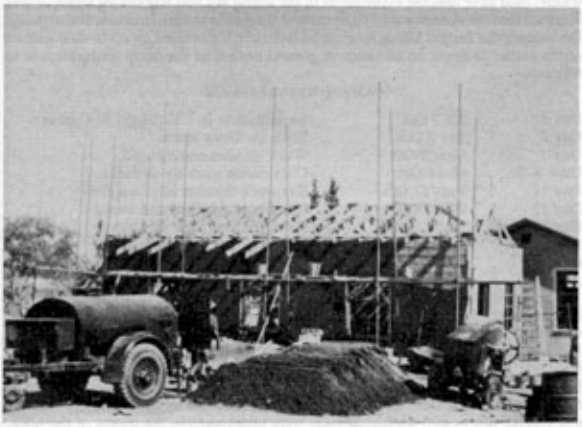

Photo 1. Goshi School—Roof truss in position.

Photo 2. Goshi School—Laying roof tiles.

Of all the tasks undertaken Goshi school probably involved the tightest construction schedule, requiring continuous double shift working for ten days in order to complete within the time available. The sequence of operation is given below and progress illustrated on photos 1 and 2. The labour force shown on the table refer only to the tradesmen and labourers required for the specific activity. Allowing for other site requirements a full section was employed for each shift. Fortunately no unexpected problems were encountered other than unexpected rainstorms on the last two days and the task was completed just in time for a presentation ceremony at 1700 hrs on Day 12 to an admiring assembly of Turkish villagers and government officials, clearly impressed by the speed with which the operation had been carried out. This was followed by a party given for the troops by the village.

GOSHI SCHOOL—CONSTRUCTION SEQUENCE

Activity	Duration (days)	Labour Force	Started Day	Completed Day
1 Setting out	1	Tp Comd Tp Sgt	2	3
2 Lay block walls	4	2+2	3	6
3 Fix window and door frames	2	2	4	6
4 Fix roof trusses	3	1+2	6	8
5 External and internal rendering	6	2+2	6	12
6 Roof felting, tiling and fibreboard ceiling	3	1+2	7	10
7 Lay surface water drains and gulleys	2	3	8	9
8 Extension of concrete slab	2	4	9	10
9 Tidy site	1	All	12	12

HAPPY VALLEY BRIDGE

The task was an interesting exercise in reinforced concrete construction. The existing Happy Valley road bridge had a 16 ft wide RC slab deck spanning 23 ft across a small flood channel. This proved to be a bottleneck under peak traffic conditions, which occurred after athletic events on the nearby sports ground. It was therefore decided to convert it to two way traffic by widening the road deck 4 ft. The work consisted of breaking out the existing wing wall and reconstructing it further down stream, extension of the abutments and central pier, and finally the extension of the road slab itself. For this last operation it was necessary to cut out the existing handrail and recast it in the extended slab. At the same time the steel binders in the existing edge beam were cut and bent to act as shear connectors between the old and new deck slab. Owing to the nature of the task it was only possible to employ one section and consequently the correct sequencing of the operations was an important factor in achieving completion. Progress is illustrated on photos 3 and 4.

BRIDGE WIDENING—SEQUENCE OF OPERATIONS

	Duration Days	Completed on Day
1 Removal of D/S wing walls and tail of pier	4	5
2 Excavation for D/S extension (abutments, new wing wall and apron)	1	5
3 Fixing steel for pier, abutment extension and new wing walls	1	6
	1	6
4 Concrete pour for apron extension	1	6
5 Breaking out edge beam and handrail	2	7
6 Erection of shutters to deck soffit level for pier, abutment and wing walls	2	8
7 Concrete pour for pier, abutment and wing walls	1	9
8 Erection of shutters for bridge deck and edge beam	2	11
9 Fixing of steel for bridge deck and edge beam	1	11
10 Concrete pour for deck and edge beam	1	12

Difficulties were experienced in several aspects of the work, particularly labour, plant and materials. A shortage of skills such as steel fixing and concreting was apparent and furthermore the carpenters were not familiar with shuttering. However, by making use of such professional expertise as was available, this deficiency was quickly overcome. The troop showed its adaptability, good shuttering was produced and several budding steel fixers and concretors emerged.

The second and major problem was the shortage of adequate concrete breaking equipment, which consisted of a 115 cfm Pescara compressor, two medium breakers, two point steels and one chisel steel. Only one breaker (requirement 80 cfm) could be operated at a time and the points soon became blunt, overheated and finally broke. Work continued day and night with the chisel bit and a major part of the breaking out was completed in this manner.

Finally problems were encountered with the supply of concrete. This was provided by a local ready-mix firm. Delays in delivery held up work on two occasions and could well have been embarrassing when the deck pour was in progress. However, despite several anxious moments this pour was completed satisfactorily. The concrete quality was variable, with aggregate poorly graded and water content too high, with the result that one wing wall had to be hacked out and repoured.

Despite these difficulties the task was completed within the time schedule and a good standard of workmanship was achieved.

ADMINISTRATION

Although lacking some of the excitement of construction work, the role of the

Photo 3. Happy Valley Bridge—Pouring concrete apron.

Photo 4. Happy Valley Bridge—Breaking out of edge beam.

administrative sections of the Regiment was an equally important aspect of the exercise. The Regiment is normally self supporting in all respects including medical and pay, and all these functions were fully exercised in Cyprus. The Regiment provided its own messing facilities at Dhekelia, although 120 Sqn at Episkopi was

Exercise Latin Field 3 & 4

maintained by regular units, an unusual luxury for a TA camp. Particular emphasis was laid on hygiene and health precautions in general. These measures proved extremely effective and no personnel were left behind in hospital at the end of the fortnight, thus avoiding what can be a serious inconvenience both for the individual and the military authorities. Returning sappers safe and healthy on the prescribed date is an important consideration for their families and their employers. In fact the most serious casualty was a broken leg, not incurred on training, which limped back with the rear party.

The final task of RHQ was to organize the recovery phase to UK. Five RAF flights were allocated to the regiment but all administrative procedures had to be carried out by the unit. Hence much of the activity of RHQ in the second week was devoted to preparing passenger and cargo manifests, and arranging transport. The first half of the regiment departed in two chalks on Day 14, with the remainder in three chalks on the following day. The entire movement proceeded without a hitch. At midnight on Day 15 the last of the troops disembarked at Brize Norton and the exercise was over.

THE LESSONS OF LATIN FIELD

More lessons are learnt from failures than from success. In this respect Exercise Latin Field proceeded perhaps too smoothly to contribute much to the extension of military science. However, it amply reinforced the following conclusions:

1 A reserve army regiment can be rapidly mobilized and transported to any part of the globe to carry out a military role.
2 Provided there is adequate support from regular units, an engineer unit can move immediately onto its task and accomplish a considerable volume of work.
3 The effort devoted to advance planning proved fully justified, and contributed in no small measure to the success of the operation.
4 Site visits by the CO's recce party are extremely valuable in assessing the scope of the work, establishing a liaison with the supporting regular units and obtaining the maximum efficiency from a short training period.

Correspondence

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12 June 1973

UNDERWATER ENGINEERING

Sir,—I read Brigadier Crosthwait's letter in the June issue of the *RE Journal*, with considerable interest and agree in general with the points raised. However, I feel that it is essential that there be a good background of information and knowledge, regarding the present state of offshore construction work and underwater technology in general in the Corps, before the precise tasks which can be undertaken by specialist Sapper Officers can be properly assessed.

The Society for Underwater Technology in addition to holding regular meetings in London has recently held meetings in Maidstone to which Members of the Institution of Royal Engineers have been invited. I am delighted to say that several attended and at least one has joined the Society.

Such meetings certainly are an excellent way for interested Officers in the Corps to keep up to date in fields of engineering which are outside their normal activities and I hope that even more will attend any future meetings, they will certainly be most welcome.

However, I do feel that, in the final analysis, it is virtually impossible for a serving Sapper Officer to keep up with the present advances in underwater technology, unless he be fully employed in such works on a day to day basis, and that the Army's expertise will have to be found among the Specialist Officers of the Reserve Army who, by the nature of their civilian appointments, have up to date experience in underwater technology in all its various aspects. —Yours faithfully, R W Flint.

Brigadier G MacLeod, MC, C of St J
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12 May 1973

Sir,—As a contemporary of Charles A West and a friend of 57 years standing, I beg leave to proffer some intimate word with which to ameliorate his somewhat pedestrian obituary in the March 1973 *RE Journal*.

Our introduction coincided with mine to the battle of the Somme; the date 21 October 1916 and the place Aveluy Wood, not far from such notorious names as Thiepval, the Schwaben Redoubt, Stuff Trench and St Pierre Divion and the Ancre.

I was joining the 227th Field Company RE of the 39th Division and found that West, who had borne the brunt and burden of the day since 1914, was in temporary command, pending the arrival of C E Egerton. The Company, as were the 225th and 234th, was recruited from the young apprentices and artificers of Hartlepools and Stockton-on-Tees in particular. West came from his adjutancy of the 39th Divisional RE (CRE, L E Hopkins) to fill in, and as such, he was the sole regular sapper in a welter of temporary gentlemen. There were such roughnecks as Mackesy, a Joburg mining engineer; H M S Meares, a construction firm's agent; Evan Macrea, an engineer from the Buenos Aires Pacifico Rail Road and P F Seale, a Winnipeg Canadian civil engineer.

I see West, on this of many succeeding "hopeless dawns", with his pink and white complexion and an inch and a half of watered Military Cross ribbon marking the general location of his destroyed breast bone which he lost in 1915 with the 59th Field Company RE. Now it was covered with a film of skin, so that he had but to fall on a picket to kill himself.

I recall it was with something akin to worship with which we regarded him as he cooly reorganized the shaken remnants of the Company preparing for the Battle of the Ancre. And while everybody was trying to relegate West to some back area job because of his vulnerability, he was for ever dodging their machinations to ensure that he remained in an active battle area.

I had little contact with him from 1917 until in 1938, when he was in the MS Branch at the War Office, in which appointment he proved that he had not forgotten a friend. West was a splendid example of the "Old Contemptibles"; a happy warrior left over from a lost

generation. For me he was always my beau ideal of a Sapper and as such, he continues in my memory.

As that elegant writer, Edmund Blunden, says in his *Undertones of War*, which deals so intimately with the fortunes of the 39th Division: "I must go over the ground again. A voice, perhaps not my own, answers within me: You will be going over the ground again, until that hour when . . . it shall be the simplest thing to take in your hands the hands of companions like CAW . . . in whose recaptured gentleness no sign of death's astonishment, or time's separation shall be imaginable".—Yours faithfully, G Macleod Ross.

Memoirs

LIEUT-COLONEL E W C SANDES DSO OBE MC

CROIX DE GUERRE (WITH PALMS)

Born 13 February 1880, died 3 March 1973, aged 93.

EDWARD WARREN CAULFEILD SANDES, son of Colonel H T T Sandes, late RA, was educated at Monkton Combe School and the Royal Military Academy, Woolwich. He was commissioned into the Corps of Royal Engineers on 20 November 1899. After completing his YO training, and winning the Fowke Medal, he was posted to India where he served continuously until October 1910 in Military Works Services. From 1910–1915 he was Professor of Civil Engineering at the Thomason Engineering College, Roorkee to which he returned after World War I and in 1921 was appointed Principal.

In World War I, recalled for military duty, he arrived in Mesopotamia in command of the Bengal Sapper & Miner bridging train which was attached to the 6th Indian Division during the advances from Kut al Amara to Ctesiphon. By the end of December 1915 he had bridged the Tigris no less than seventeen times. The British and Indian force was, however, defeated at Ctesiphon and had to withdraw to Kut which was besieged and eventually surrendered on 26 April 1916. Sandes was to remain a prisoner in Turkey for the rest of the war. During the brief campaign in which he was involved he was awarded the DSO, MC, Croix de Guerre with palms and was mentioned in despatches three times. He told the story of his many experiences in "In Kut and Captivity" and "Tales of Turkey". He returned to active service in World War II.

Colonel Sandes was the author of "The Military Engineer in India" Volumes I and II, "The Royal Engineers in Egypt and the Sudan", "The Indian Sappers & Miners" and "The Indian Engineers 1939–1947" all published by the Institution of Royal Engineers.

For his services to the Corps of Royal Engineers he was awarded the OBE in 1959 and The Institution of Royal Engineers Gold Medal in 1964.

Lieut-Colonel G Lacey, CIE, writes:

"It was in 1915 that Colonel Sandes, at that time Professor of Civil Engineering at the Thomason College, Roorkee, left for Mesopotamia. It was after his departure that I was called upon at short notice to fill the vacancy.

It was then, for the first time, that I was indebted to Colonel Sandes, for, without the invaluable notes which he had left, all in his own neat handwriting, I would never have had the courage to stand up and deliver my first lecture. I was impressed with the way he marshalled his facts and might then have had the prescience to read "between the lines" the making of an historian.

In 1919 Colonel Sandes married and from 1921 to 1930 held the post of Principal of the Thomason College. From 1928 to 1932 I was once more Professor of Civil Engineer at the College and it was during this period that a warm friendship was established which has stood the test of years. Only close friends would know Warren's quiet sense of humour and the perfect companion which Sylvia proved to be.

My wife and I saw Colonel and Mrs Sandes as recently as June 1972 when we went from Brockenhurst to Weymouth to lunch with them and found both looking well and in good heart."

GENERAL SIR NEVIL C D BROWNJOHN GBE KCB CMG MC COL COMDT RE (RTD), REP COL COMDT 1958

Died on 21 April 1973, at the age of 75

NEVIL BROWNJOHN, known affectionately to most as "B-J", almost certainly had held a far wider variety of appointments, in the Service and after retirement, than any other Sapper, or indeed any officer, of our times. This is not surprising, as he had so many more qualities and qualifications than most as well as the ability to apply them to the full. In not one of his posts was he other than an unqualified success. The result was a career of great distinction when he was serving both in and outside the Corps, and also later in civilian life after retirement.

Destined for the Army while at Malvern, he was determined to be a Royal Engineer. He served in the Signals branch of the Corps in the First World War and was awarded the Military Cross. When the Royal Corps of Signals was formed he remained with the parent Corps.

In the decade after the War he showed his versatility in several different posts. He could already speak French well and he became an Interpreter in Russian, a rare qualification then but one which was to help him greatly in later senior appointments.

He emerged from the Staff College, Camberley, in 1932 with an "A" grading (very rare indeed) and later became Brigade-Major, SME, a post that gave him great pride and pleasure for he was once again with his beloved Corps. Come the 1939 War, however, he was destined necessarily to move through a series of appointments of ever-increasing seniority and responsibility not directly connected with the Corps. He did valuable work for COSSAC preparing for Operation "Overlord" and then for SHAEF during the final advance into and occupation of Germany. General Eisenhower paid him due tribute and he was awarded United States decorations.

Then came the period of his Deputy Military Governorship in the British Control Commission in Germany, when he was able to put his languages, and his knowledge of the Russians, to good use. He moved in 1949 to become successively Vice-QMG and then Vice-CIGS at the War Office, Chief Staff Officer to the Minister of Defence, and Quarter-Master-General, retiring in 1958. With this record it is no wonder that a former CIGS describes him as "having a deep understanding not only of the Army and its problems but of all aspects of the intricacies of our national security and defence". Also, his personality and intellectual capacity enabled him to work happily with Government Ministers whatever he may have thought privately of their politics or methods.

After all this—and he retired from the active list at 61—most general officers would have thought it reasonable to take life more easily. But not B-J. On the official side he became Chairman of the Crawley Development Corporation and a Member of the Commission for the New Towns, in which posts he remained until he was 69. He gave valuable service to many charitable organizations and was on the Trustee Council of the Douglas Haig Memorial Homes. There were humbler bodies too which valued his cheerful help and shrewd guidance, as for instance is revealed by a letter from the Crawley branch of the Boys' Brigade of which he was the Honorary Captain. Apologizing for the intrusion on Lady Brownjohn's grief, the writer said, "my staff and elder boys recall with pride our contact with this Christian gentleman. Rare indeed are men in his position that keep the common touch with such sincerity and the world is a poorer place at his passing".

Fine as these tributes are, it is as a soldier that B-J would prefer to be assessed. That aspect is surely best described by two extracts from an appreciation of him written by a Minister who sat with him on the Army Council. "He was one of those wise, thinking soldiers with a sweet nature so often produced by Britain . . ."; and, "He had a great sense of justice and was one of those dedicated officers who

have made the British Army, so far as I know, the fairest and most civilized in the world." How B-J would have liked that last sentence.

The sympathy of the Corps is with Lady Brownjohn and their son John. It is sad to think that, though they with John's wife and the beloved small grandchildren had planned to join forces in a house in Dorset, something to which B-J had long looked forward, he died a fortnight before they could move in.

FEWS

Gen Sir Nevil C D Brownjohn GBE KCB CMG MC

BRIGADIER R F O'D GAGE CBE MC

Born 29 November 1897, died 11 February 1973, aged 75

RICHARD FRANCIS O'DONNEL GAGE (Rex to all who knew him), died in February after a year's illness. Born in Dublin, second son of Captain Richard Gage of Rathlin Island, County Antrim, he was educated at Wellington and the RMA. He served in France in World War I, was wounded (his wounds aggravated his last illness, 55 years after), and was awarded the MC. After the War he completed his engineer training at the SME and at Cambridge, and later with the Southern Railway and at the Railway Training Centre, Longmoor, where he became OC, 8 (Rly) Coy RE.

Then, after five years in India with the Bombay Sappers and Miners, he returned to Rly TC as Chief Instructor. It was a fortunate appointment. It renewed his contact with the RE (Tn) units of the Supplementary Reserve, which were vital to the huge war expansion of the Transportation Service. Many of their officers were destined, within a few years, to serve under Rex in World War II; and they were devoted to him. This second stint at Longmoor was followed by three years in Malaya, mainly at Penang on the construction of the Military Base. He returned to UK in March 1940 and almost immediately went to Norway as A D Tn of the short-lived North-West Expeditionary Force. The orderly evacuation owed much to his having created a proper small craft organization.

In August 1942 he was appointed D Tn, 1st Army, for the invasion of North Africa, as part of the American-British force under General Eisenhower. The assault on Sicily and the mainland of Italy followed. The task of the RE Transportation Service in this campaign was considerable, and some 20,000 RE(Tn) troops were employed under Rex's direction. Then, in March 1944, at short notice and as a mark of his success in the latter campaign, he took over as D Tn, 21 Army Group, for the assault on N W Europe. The Tn problem, of port and railway reconstruction and operating, was to prove "immense"—to use Field-Marshal Montgomery's word, speaking in October 1945—but Rex was the very man for it. (To mention just one thing: the troops on railway reconstruction alone rose to nearly 11,000. In Holland, practically all the bridges had been destroyed. Rex received the Order of Orange Nassau). In the latter part of 1945, he became D Tn, War Office, and held the appointment until he retired in 1948.

Rex was a most lovable character. He had a wonderful sense of humour. He never tried to do the work of his subordinates. He made crystal-clear what he wanted of them, and left them to get on with it, always giving them any advice they asked for, and then supported them through thick and thin. He would not allow any bickering among his staff and they soon became happy families. Lord Mais, who went to see him in Bart's Hospital shortly before he died, has said, "I shall be ever grateful that I had the privilege to serve under Rex in Normandy. He was quite the best, kindest and most efficient person under whom I have ever had the good fortune to serve."

A senior officer of British Railways has written, "I admired him greatly all the time I knew him—since 1927/28 when he was at Longmoor as a captain. It struck me even then that here was a man one could trust and admire". Another tribute reads, "I knew Rex for more than 60 years. He was a man who could be trusted implicitly . . . He was very able, very ingenious, very wise. He dearly loved his Island home, Rathlin Island, where his ancestors had ruled for more than 200 years"—he spent every summer there—"He and his wife were known and loved by every man, woman and child of the 120 inhabitants. He was a good shot, a skilful fisherman, a perfect host and a delightful companion." His winter home was Pebmarsh, a village in Essex, where he dealt with the affairs of the church, school and the British Legion.

To his wife Marjorie, née Alexander, whom he married in 1931, and his sons, Major E C Gage RA and Lt Cmdr P R Gage RN, and their families, we extend our very sincere sympathy.

JFML/CEMH

Book Reviews

ENGLISH/GERMAN TECHNICAL DICTIONARY OF PRODUCTION ENGINEERING

Edited by ING RUDOLF WALTHER

(Published by Pergamon Press, £5·60)

This is the sister volume to the German/English Dictionary reviewed in the last issue of the *RE Journal*. In some ways it is likely to be the more useful of the two for our English-speaking Members.

EEP

RIOT AND REVOLUTION IN SINGAPORE AND MALAYA 1945–1963

RICHARD CLUTTERBUCK

(Published by Faber and Faber, London. 321 pages. Price £3·95)

Riot and Revolution in Singapore and Malaya 1945–1963 by Richard Clutterbuck is not an easy book to review because it is written by a Major-General, disguised as a Doctor of Philosophy. The reviewer cannot be sure of the spirit in which it was written. It is intended intended as a history by a man who held authority? Or is it a liberal education for anarchists? Or is it a text book for those whose duty it is to uphold the Law? It may even have been written purely as a thesis for some university authority in order to gain academic distinction —a Doctorate of Philosophy for instance.

If this last is the case, your reviewer commends it unreservedly. It traces the insurgency movement as it was carried out in the city area of Singapore and in the jungles of Malaya between 1945 and 1963; and every fact is corroborated by references to the printed word. Even other works by the Author are freely referred to, and a modest work by the present reviewer is quoted with the authority of the second Gospel. Similarly, no personal opinions, that might have been arrived at by fallible processes, are ever advanced. Everything is documented and raised to the level of the Received Word. This is just what academics want, and that is why your reviewer gives the book full marks as a thesis.

The book is equally valuable for the serious student, be he anarchist, soldier, politician or policeman. It tells how communism began in the Far East in quite a small way, and how it developed in city and jungle, side by side, into a formidable threat to the existing regime; and how in the end it was contained and, for the time being at any rate, decisively beaten both in Singapore and the Federation.

The Author describes the two conflicting theories for conducting the overthrow of one regime before substituting another, that is to say communism. The first theory, as practised by Lenin and Mao, depends on careful planning and painstaking organization; no revolutionary steps being taken till all is ready for action. Then, the fruit being ripe and the harvesters ready, they go forth to pick. The other theory, associated with Che Guevara, depends on spontaneity. Organization is sacrificed to speed and instant revolution. There were advocates of both policies in the Far East; and, as in most matters relating to politics and war, there is a requirement for a certain genius to tell at any one time which policy is the more likely to succeed. The factors are hard to weigh: the hearts and minds of the people, the competence of the police and so on. The successful revolutionary, like the great captain, must see light amongst the shadows.

We are shown how various urban and jungle organizations were built up; and the Author displays them sometimes like a family tree and sometimes like equations in organic chemistry. He tells us of the innumerable cells at work, like leven in a loaf; and it is sobering to reflect that a similar leven is probably fermenting silently in our midst today. We see how a crowd is assembled in Singapore. Each man is harmless by himself; but when many thousands, impelled as it were by an unseen force, have assembled in one place they become an agent of infinite and unreasoning power. The Author shows how the police and military failed at the time of the Hertogh riots in 1950; and how, by better arrangements, they succeeded in another outburst in October 1956.

For soldiers, who feel inclined to study this subject, this is a valuable book. It highlights some of the things that must be got right: getting the people on the side of Law and Order; having astute people at the top; having first class intelligence; and having the courage and resolution to act when the crunch comes. All this is thoroughly estimable; the trouble is that the form of writing, what might be called the thesis style, does not lend itself to compulsive reading.

When Thucydides, also a retired General, addressed himself to the Peloponnesian War he set out to compile a work that he described as a "possession for ever". He took the same pains as the Author, whose work is before us, to get his facts and figures right; but when he began to write, he cast aside all documents (except in the last Book that he never lived to edit) and based his narrative on people. He filled his pages with what can be enjoyed with the imagination as well as the intellect. His characters are sketched with such clearness that any reader meeting Alcibiades, Cleon or Nicias in the street today would recognize him at once, and could enter into intelligent discussion with him on the problems of two thousand years ago. Yet, in the book under review, a great jungle fighter like Hor Lung appears indistinguishable from a waiter at a Chinese restaurant. Partly this is due to the inscrutable nature of the Chinese people; but more so is it due to the insensitive methods of the modern historian; that is to say the thesis method. Your reviewer, having once enjoyed the first novel by a Sapper Major Clutterbuck, a vivid wartime story of the tensions in a Field Company while building a bridge in the face of the enemy in Italy, can only feel that the academic Doctor is not doing himself justice.

MCAH

GILLINGHAM BOROUGH COUNCIL PUBLIC LIBRARIES

Local History Series

No 5 (Part I)—DIRIGIBLE TORPEDO; (Part II)—GYROSCOPIC MONORAIL

(Published by the Borough Librarian, Central Library, High St Gillingham
Price 2p for each Part, 5p each including postage)

The Gillingham Borough Council's Library and Arts Committee held a Louis Brennan CB Exhibition during the period 12 to 26 May 1973 to outline Brennan's life and inventions, also his association with Gillingham; the above booklets were published complementary to that Exhibition.

Brennan's close ties with Gillingham date from the Spring of 1883 when an experimental station for his torpedo was established at Garrison Point Fort, Sheerness, by Major T English RE, and a workshop for Brennan was set up in Brompton Barracks where the inventor resided during the period of his early experiments in conjunction with the Submarine Mining Service of the Royal Engineers. A Torpedo Factory was set up in St Mary's Barracks (now demolished and the site occupied by Naval buildings) and Louis Brennan was the Superintendent of the factory during the period 1887-1896; he was consultant to the factory and head of the design branch from 1896 to 1907, though manufacture of the torpedo ceased in 1906, due to the duties of the Royal Engineers Submarine Mining Service having been taken over by the Royal Navy in 1905.

During the period 1904 to 1907 Brennan was given permission to utilise the facilities of the Torpedo Factory for his work on his Gyroscopic Monorail, and an article on the Brennan System of Monorail traction appeared in the *RE Journal* of June 1907.

The "History of Submarine Mining in the British Army" by Lt Col W Baker Brown RE was published by the then Royal Engineers Institute in 1910, and because it was published outside of the series of volumes of the 'History of the Corps of Royal Engineers' the name of Brennan is perhaps not as well known as it deserves to be; these booklets published by the Gillingham Public Libraries help to place on record and inform the local inhabitants, many of whom are retired Sappers, of the part that Louis Brennan played in the history of our Corps.

JES

ESSENTIALS OF PRODUCT PLANNING

PETER GORLE and JAMES LONG

(Published by McGraw-Hill, 100 pp £2·25)

The dependence of the Military Engineer on commercial management techniques increases daily and the importance of understanding these techniques (and the vocabulary) cannot be over-emphasized. The Royal Engineers must be at least as efficient and cost effective as any commercial organization, therefore every advantage must be taken of the experience and expertise of others.

This book is one of a series of books on management published by McGraw-Hill, all of which are worthy of some attention. Some of the principles expounded may appear obvious —"all forecasts are, at best, intelligent extrapolations of what has happened already. As such

they are never more than a guide to the probability and significance of a certain sequence of events occurring"—but they are often forgotten!

The term "product" has a much wider meaning in this book than one would normally expect as it means the "business activity". The product of a car manufacturer is cars, the product of a builder may be the provision of shelter, the product of a property company may be property management or investment capital. The product of a Military Engineer is not quite so easily stated, reading this book will help to provide an answer.

EEP

Technical Notes

CIVIL ENGINEERING AND PUBLIC WORKS REVIEW—MAY 1973

Small Firms in the Construction Industry. Small firms constitute approximately 91% of the total number of firms in the construction industry but employ only 27% of the labour engaged in the industry. Much has already been written about small firms in industry but small firms rarely have an opportunity to express their opinions. A survey carried out by the Department of Civil Engineering, University of Leeds published in this issue gives a great deal of information on how these firms operate. The survey shows that small firm owners are more master-craftsmen upholding traditional values than fiercely competitive businessmen pursuing profit and growth. The performance of small firms is often used to decry the construction industry as a whole, particularly by reference to the large number of small firm bankruptcies. The survey attempts to show that this is because of the difficulties in operation and lack of assistance given to small firms rather than financial incompetence.

Estimate of the Critical Flood Discharges. An article by Professor Dr E F Mosonyi which is the text of a paper given at the Conference of the German Association for Water Resources Development in Karlsruhe Federal German Republic in October 1969. The article is a very comprehensive study of the parameters of flood prediction with particular emphasis on the discharge rates, levels and durations of floods. The article concludes that critical discharges should be stated in accordance with the probability theory ie in percentage probability of a discharge value being exceeded. The author also stresses the importance of continually reviewing the environmental data for specific locations and calls for a standard international method of calculating the design flood discharge. This article has an exhaustive list of references and would be an important reference to anyone working in this field.

Field Instrumentation for long-term Measurement of Pile Load and Raft Contact Pressure. This article is a description of the load-measuring instrumentation installed in the piled-raft foundation of a tower block in central London. (Hyde Park Cavalry Barracks). The design and construction of a 6000 kN pile load cell is described along with a portable polarised light used in taking field measurements. Also described is an earth pressure cell for measuring the contact pressure on the underside of the raft. The article concludes that both the pile load cells and the earth pressure cells worked satisfactorily over a period of several years and gave useful data on the behaviour of piled rafts in clay.

JTS

CIVIL ENGINEERING AND PUBLIC WORKS REVIEW—JUNE 1973

Steel Fibres Arrest Cracks in Concrete. A short article on the merits of steel fibre reinforcement in concrete members. Steel fibre reinforcement is a relatively new material which goes some way to overcoming the inherent disadvantages of normal reinforced concrete ie poor impact resistance, low fatigue resistance and its tendency to spall and crack. The reinforcement consists of short steel fibres randomly disposed throughout a concrete mix. The selection of fibre type, proportion with the cement, sand and aggregate and the mixing process dictate the fatigue and impact qualities. Typical applications are in factory flooring, roadways and on aircraft runways. Other applications have been in manhole covers and cast stair treads. A particularly interesting application, making use of the materials resistance to thermal shock, has been in the manufacture of molten iron paddles.

Some Aspects of the Interaction between Reinforcement and Concrete. Reinforced concrete design is often looked upon as a combination of a designer calculating areas of steel at critical sections and a detailer specifying how to place this steel in the most practical and economical way. Detailing, however, is fundamental to the behaviour of a structure and traditional

methods of looking at bond and anchorage are no longer entirely applicable. This article gives a very clear picture of the problems of the designer when faced with ever higher reinforcement strengths and the design methods given in the new code of practice. The article concludes that there is probably a practical upper limit to steel service stresses in reinforced concrete. This limit lies above what is commonly used at present but possibly not so far above as some people may imagine.

Strengthening of Bideford Long Bridge. The Long Bridge of Bideford can be traced back as far as the thirteenth century and is an outstanding example of medieval bridge architecture. The bridge is 200 m long, 7 m wide and with 24 arches carries the A39 trunk road across the River Torridge in Bideford on the north coast of Devon. In January 1968, the most westerly pier No 23 collapsed because of scour, and after a series of investigations it was decided that the bridge needed to be strengthened both in its foundations and its superstructures. The article gives an interesting account of the work carried out to repair this bridge by a combination of the Fondedile and Reticolo Cementato piling and tie-bar techniques.

JTS

MILITARY ENGINEER JAN–FEB 1973

Dust Control. This article gives information on the use of polyvinyl acetate (PVA) water emulsion reinforced with fibre-glass scrim, weighing 1½ ounces per square yard, to control the dust on shoulders and overruns of a runway. Application of the PVA and fibre-glass scrim over a 16 foot width was carried out, using a special vehicle, in one pass. C130 aircraft touching down on the overruns only caused damaged areas of about 3 square feet. Maintenance proved to be quick and easy.

Controlled Blasting for Concrete Removal. Details are given of the explosive used, the borehole pattern and the sequence of firing on a task where it was necessary to remove 70 cubic yards of heavily reinforced concrete. Care had to be taken not to damage the surrounding concrete. Twenty pounds of explosive were used in 8 shots to complete the demolition.

Nuclear Weapons Effects Research. The blast and ground motion effects on hardened structures are being studied. The theoretical and empirical predictions are being tested by using high explosive detonations. Air blast induced ground motions have been produced using a matrix of woven detonating cord in an air filled cavity to simulate a nuclear air blast.

Other articles of interest are 'Centroport' which gives some details of the future development of the Port of New Orleans. 'Innovations at Dworshak Dam' gives practical details of the construction of this dam. This contract is the largest dam contract ever let by the US Corps of Engineers.

RGO

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SOLDIER AND DIPLOMAT

Regimental Commander to Young Officer acting as Mess Secretary in the field:

"Get that wretched CRE to pay his messbill"

Young Officer to CRE:

"Sir,

The President and Members of this Mess invite me to bring to your notice that your messbill, should it continue to remain unpaid, will in course of time, begin to become overdue"

RRLH