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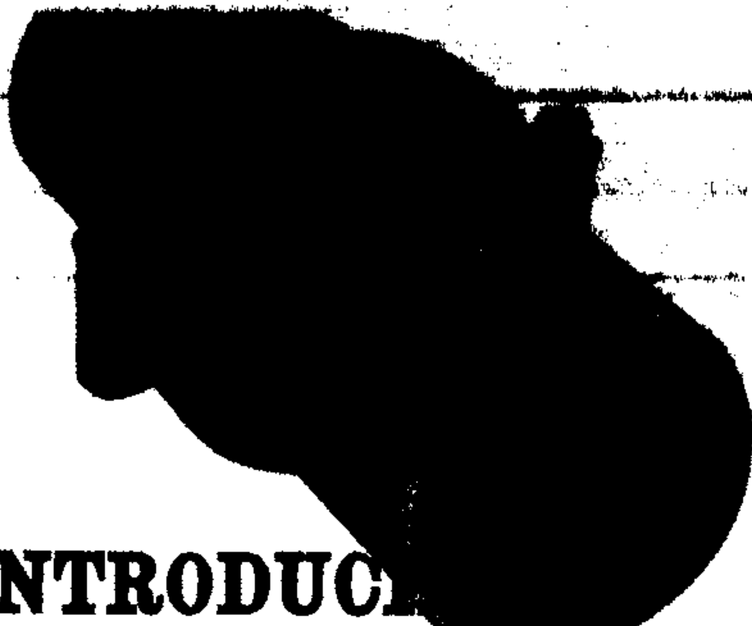

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1968 Cooper's Hill War Memorial Prize-Winning Essay "Talking at Random"

SUBJECT

The pattern of deployment planned in the Defence Review will mean that a higher proportion of our forces will normally be stationed in the UK and the Government is, therefore, studying the scope for developing further the peaceful use of military forces in this country.

In this context: "It is important that the relationship between the services and the community should be easy and beneficial to both."

(Extract from the Defence Review 1967)

This is a change in policy which could give the Royal Engineers an opportunity to undertake engineering tasks in peacetime well beyond the scope of DCI 178 of 1967. How do you think the Corps should be used and what changes should be made in our organization, control and training to meet this challenge?

INTRODUCTION

THE run-down of British bases overseas and the increase in the Forces stationed in the United Kingdom will lead naturally to a closer contact between the civil and military communities and to greater opportunities for gainfully employing military forces for the general good at home.

There will, additionally, be an increased demand for training areas at home and a loss of training areas overseas. It will be logical therefore, as the overseas commitments are reduced, for the Army, and particularly for the more technical Corps such as the Royal Engineers, to consider how they might carry out more work at home both as an aid to training and as a means of justifying themselves to the taxpayer. The Army has always been ready to help in civil emergencies and on these occasions invariably aquits itself well. The good name the Army has earned for the part it has played in times of crisis, together with the knowledge that the Royal Engineers in particular have recently carried out a number of projects beneficial both to themselves and to the civil community, may suggest that an easy way is open to increase the scope of this work and that closer participation by the Army in non-military projects will be widely welcomed by the country as a whole.

This suggestion is not necessarily true: many pitfalls lie ahead and the wrong policy now could endanger both the future of civil and military relations and also the unique position of the Corps as a combat arm and as a Service within the Army. There are certain fundamental issues on which it would be wise to sound a note of warning before examining the employment of the Corps on civilian tasks. Two of the more important ones are considered below.

The first of these concerns the relationship of the Corps with the rest of the Army, and the second concerns the fact that the onus is on the armed services for establishing a closer relationship between the civil and military communities as a basis for the greater use of military forces for peaceful purposes and not vice versa.

THE RELATIONSHIP OF THE CORPS WITH THE ARMY

The Royal Engineer unit commander traditionally serves two masters—and he becomes adept at doing so—whether he is playing off a Brigade Commander against a CRE, or an Engineer Commander against the "Q" Staff. The rest of the Army is conscious of this tendency but, in spite of our motto of "Ubique" and the opportunity in field formations at least, for the Sapper to see and work with a wider cross-section of the Army than equivalent ranks of other arms, we are often accused of a parochial and somewhat insular outlook and of a preference for going our own way.

These accusations are not entirely without foundation and may stem to some degree from the temptation of using Engineer Staffs, essential though they may be in some respects, for matters better dealt with by the General Staff. This tendency to claim exemption from the common rule is not always to our advantage, and could lead to the Corps missing out in other and more important fields. The danger is particularly applicable to the sphere of the peaceful use of military forces which, whilst offering tremendous scope for the Corps, will also offer a great temptation to us to set the pace our way—and even to go it alone, regardless of the approach of the Army as a whole. The Corps has much to offer and much to gain in this field and with our skilled manpower, our versatile equipments and varied experience, we have the opportunity not only of showing the way but also of opening up opportunities for other arms and services to contribute much to the nation and at the same time to gain valuable training. However, if we were to do all this but hazard our position as a combat arm, or jeopardize our relationship with other arms, then we would do ourselves more harm than good. Ways can and have been found for engineer units to accept worthwhile projects without losing their identity as soldiers or their readiness to train and co-operate with other arms. The old adage is still true and it remains important to have the right priorities. The time is not yet ripe for the Corps, or for the Army, to give priority in organization or in training to non-military tasks. If we forget our priorities the likelihood is not so much of going it alone, but of being left behind.

There is scope and potential for the greater use of military forces in the civil field, and not only for the greater use of engineers. Our thinking must first therefore be in Army terms—how can the Army help, what can the Army do—and then within this context we should consider where the Corps fits. We should first contribute to an Army policy and then decide a Corps policy—and in doing this our expertise and our experience will be welcomed by the rest of the Army. Only if we do this will our commitments and responsibilities to the Army be met, and shall we avoid the risk of gaining the respect of our civilian counterparts at the cost perhaps of that of our Army colleagues.

THE RELATIONSHIP BETWEEN THE CIVIL AND MILITARY COMMUNITIES

Although the need, to quote from the Defence Review, for the relationship between the Services and the community to be easy and beneficial to both, may at first appear to throw an equal responsibility for attaining this relationship on to both sides, the indications are that the onus is almost entirely a military one, certainly as far as it might lead to furthering the peaceful use of military forces.

The civil community is understandably reluctant to call on the Services even in times of crisis. To do so suggests that some department or organization has fallen down on its commitments or has met a task too big for it. Local Government, the Public Services and regional authorities naturally believe that they can meet the calls made upon them and will tend to guard their responsibilities jealously. One has only to read the disheartening accounts of the Army's efforts to help at Aberfan, or to study the Torrey Canyon affair, to realize that there is not only ignorance of the Army's potential to help on such occasions but also a reluctance to invite their assistance.

The reluctance of the civil authorities to ask the Army's help in times of national disaster is likely to be emphasized in pursuits of a more routine or peaceful nature. Doubts over the Army's ability to execute non-military tasks will be associated with a suspicion of interference and with the possibility of a threat to the employment of organizations or individuals.

The task of the Services in improving relationships with the civil population is not made easier by a surprising lack of knowledge of the Services on the part of the public, and regrettably also by the deep-seated image that the public has of the Services. A sad example of the latter has occurred recently in several towns where military families have been quartered within civilian housing estates.

This ignorance and suspicion of the Services may have historical origins and perhaps results from the Army's primary role having previously been overseas. The nations on the mainland of Europe view their Armies differently as they have, throughout history, witnessed their Armies fighting to defend their own homeland. The image of the British Army at home has not been its best—stemming perhaps from Cromwell's time and from the traditional image of garrison troops returning from long service overseas. Two world wars and twenty years of National Service may have alleviated but certainly have not eradicated the position. The bewhiskered, hard drinking red-coat, veteran of many Indian summers, may have given way to a nineteen-year-old stripling who in spite of his trade qualifications or O levels is still often suspected of joining up because he couldn't settle down in a civilian job. Equally it is probably accepted that the Army officer is no longer one of the privileged classes but he is still often thought of as one who prefers to shelter in a protected and somewhat archaic society rather than to face up to the realities of life. It may even be true to say that the civilian intellectual suspects the ability of the Army officer to think deeply, and the civilian executive doubts his ability or inclination to work hard. These are hard words and are, one hopes, an exaggeration—but it is better to face up to them rather than to ignore them.

All this may be summed up in terms of the Army's image. The public has been quick to applaud the Army's efficiency, patience and courage in the multifarious tasks that have beset it throughout the world since World War II and the Army's image stands high in this respect. But at home it will not be so easy. People will be on the look out for things going wrong, criticism will abound, and errors, misjudgment or mismanagement will be exaggerated and publicized.

The fundamental lesson is that we must tread warily and that it is largely up to us to improve our own image. Success will breed success but a failure will multiply likewise. The lesson of the Festival Bridge across the Thames in 1951 is still fresh in our minds—or should be.

It is against the background of these fundamental issues that the intentions of the Defence Review of 1967 might be reviewed and some major factors affecting the Army's, and in particular the Corps', participation in peaceful occupations can be considered.

THE SETTING

Since World War II, the Regular Army in UK has fallen into three main categories—the Strategic Reserve, the Training Organization and the Static or Base Organization. Of these the Training Organization has normally been geared to a very close timetable with a rigid programme to be adhered to. Except in times of emergency it has not been appropriate for them to become involved in work for the civil community.

The Strategic Reserve have always been at varying degrees of readiness to move overseas. In addition, due to the rotation of units and individuals there has been a continual training requirement which has had to be given high priority. Nevertheless a considerable number of valuable and useful tasks have been carried out by the Royal Engineers of the Strategic Reserve, but these have usually been limited to tasks of low priority which could be started, then left and completed at a later date. In addition a variety of valuable tasks have been and are still being carried out by the T and AVR.

This situation will change in future not only because the number of troops at home will increase but also because the operational demands on the Strategic Reserve may be less and therefore a smaller proportion of them will need to be kept at a high state of readiness. The emphasis on training will be first to reinforce Europe and secondly to maintain readiness for future and as yet unknown commitments. The demand on existing training facilities at home will be intense but both government and public are reluctant to offer the Services more facilities. Training overseas will increase but will never provide the whole answer. The opportunity for the useful application of military effort to peaceful tasks is therefore ripe and it is appropriate to consider in this respect both what the Services have to offer the community, and what the community can offer the Services.

Firstly, what has the Army, and in particular the Royal Engineers, to offer the civil community? One's mind instinctively turns to the possibility of engineer units carrying out tasks in aid of, or in common with, their civilian counterparts and this possibility will be discussed in some detail later. There is however a quite separate field in which the Corps, and indeed the whole Army has much to offer the nation and mention of this is perhaps a justifiable digression. This is the field of specialized education. The Corps can claim to specialize in two educational aspects of particular value to civilian youth—technical training and character training. Our Apprentice Colleges and Junior Leaders/Tradesmen Regiments have high standards and much experience. A reduction in the number or size of these units is under consideration and it would be regrettable if the expertise and techniques developed by them were to be frittered away at a time when the Nation is crying out for more and better tradesmen and is also concerned at the rate of juvenile delinquency and the apparent lack of responsibility in many of the youths today. One would hope that any training which aimed to improve character building and to impart a sense of purpose would be welcomed, particularly if at the same time it would save the government the need for opening further Government Training Centres by providing a sound technical training. It is possible to envisage a Government training scheme whereby a proportion of the places at Army Apprentice Colleges and Junior Tradesmen Regiments would be open to boys who had no intention of making the Services their career. The problems are numerous, not least financially and administratively, but it should be possible for the Ministries of Defence, Labour and Education to get together and iron out their differences. A more fundamental problem would concern the relationship in such an environment between "Army boys" and "Civilian boys". This could be fraught with risks and could only be overcome by setting and demanding such a high standard that there would be keen competition to obtain vacancies and it became a privilege for a civilian boy to gain one. In the present climate of opinion amongst the young of today such a possibility may appear wildly optimistic, but nevertheless young people are very conscious of the value of trade qualifications and are prepared to work for them. They are also enthusiastic and energetic in outdoor pursuits and adventure training. It is the image of the military organization behind it all that might be the deterrent, and if this could be put right the rest will follow, and such combined civil military training organizations could become a power for good in the land.

It is not the intention of this paper to consider this possibility in detail but merely to suggest that there is great scope for a closer relationship between the civilian and military communities through the facilities the Army and particularly the Corps have to offer in the realms of technical education and character-building training.

Reverting to the main theme, the Army can offer flexible, self-contained organizations which are free of labour troubles and ready to move to wherever they are required. The most attractive asset of any engineer unit is its completeness—self-contained in management, tradesmen, labour, administrative staff, tools, equipment and transport. Although the structure of most engineer units is based, as a result of experience, on an organization which will best cope with the tasks it is likely to meet on active service, and also in the way it is best suited to support other arms, units can add or leave off sub-units, specialists or equipment to meet a variety of tasks civil or military. The Corps can, in summary, offer an organization capable of surveying, planning and executing a task under almost any conditions.

The Corps has for decades built up an envious reputation in civil engineering and in "Hearts and Minds" campaigns throughout the world, and the countries that once formed Britain's Empire still bear untold evidence of this. The same spirit, versatility and skill could be available in the homeland.

What now has the civilian community to offer the Army in the way of gainful employment and, as a corollary what might the Army be looking for from the civilian world?

There is much to offer, but a necessary preliminary is a closer relationship between the civil and military fraternities. This will be a slow business and one of evolution, for the wrong approach or too much haste could result in setbacks. It might be best therefore in considering the field open to military assistance to try to define areas where military intervention would be unwise. In due course, with success, goodwill and understanding these sensitive areas might be reduced and the scope of employment increased to include a wider variety of tasks. Areas which, initially, indicate risks to goodwill are those where there is already keen competition in the civilian world—it is here that the Army would be most likely to come into conflict with civilian interests, primarily with the labour aspect and trade unions, and also with expertise and techniques strange to us.

DCI 178/67 restrict the employment of RE units to projects with official (i.e. Regional or Local Government) or non-profit making authorities. It is now suggested that the time may now be ripe to widen the scope of employment beyond that outlined in the DCI. We should assuredly look for tasks outside this restriction and should start to pave the way for us to carry them out but there need be no urgency in this direction. The conditions of DCI 178/67 offer scope for a variety and volume of employment for the Corps which could satisfy us for many years to come. We would do well at this stage to keep our interests to fields lacking a profit motive and unattractive to the civilian businessman and to those where the Army could use its attributes of mobility and self sufficiency to advantage. There is adequate scope for work within these limits which offer a greater possibility of laying a good foundation of mutual respect with industry and with the public but which avoid conflict with trade unions and management. Success will breed success, and further experience and greater know-how of civilian techniques may bring invitations to work in more competitive areas. But this trend must evolve, and we would be unwise to take the initiative.

Local and Regional Government authorities could well be encouraged to welcome the Corps' assistance in improving communications and in such tasks as combating floods or soil erosion, land reclamation or eyesore relief. In addition the numerous non-profit making organizations in the country ranging from The National Trust, The Nature Conservancy and Forestry Commission to Nationalized Industries could be approached. The various Trusts and Commissions concerned with preservation of natural or historical assets are traditionally short of funds, are accepted to exist for the public good, and can usually accept military assistance in a wide variety of tasks without opposition from the trade unions. However it is natural to hope that the Corps could make a more effective and tangible contribution to the Nation's economy and this could perhaps be achieved by turning to Nationalized Industries. The potential here is endless and, although there is a greater likelihood of clashing with the unions, there are still areas where the Corps can gain great training value and also be productive. The closing down of branch lines, stations and even marshalling yards by British Railways offers great scope for earth moving, and the demolition of bridges and buildings. The Gas Board and the Central Electricity Board are spreading their power across the countryside by grids or pipelines and one would hope that both these organizations would welcome the assistance of the Corps in pursuing these projects particularly in isolated areas where labour recruitment may be difficult. There are great possibilities too in the new towns whose Development Corporations would assuredly welcome the Corps assistance in clearing away old buildings and other obstacles to new construction. This field, more than most, offers opportunities which are both challenging and productive.

The field of employment is wide and varied and we can afford to be selective without going outside the terms of DCI 178/67. The DCI hints, if we did not already know it, that the task of the Financial Sections of the Ministry of Defence is to act as watchdogs of the Defence Vote and that they will be quick to see that the Services' votes are not used to the benefit of others at a cost to themselves. The situation is understandable but regrettable, and it is hoped that the day will come when the Army's efforts for the common good, as well as for its own training value, will be recognized by a greater readiness on the part of central ministries and local government to be more flexible in the control of their finances.

It would pay us to be selective in the tasks we undertake. Certain principles which may help are suggested:

(a) The task should demand the skills, attributes and management techniques which the Army has to offer and not merely be a demand for cheap labour.

(b) The task should make best use of a complete unit or sub-unit organization—i.e. can the task fit or be made to fit the unit rather than vice versa?

(c) The task should offer good training value, and be a worthwhile challenge to the Army.

THE ESTABLISHMENT OF A MACHINERY FOR WORKING WITH THE CIVILIAN COMMUNITY

Although the Services may have to accept the onus for improving relations with the civilian community, the actual planning and execution of work will require goodwill by both sides and the establishment of an accepted machinery for consultation and planning. Such machinery should ideally be based on contact between the civil and the military at every level but there will be two particularly important areas of contact—firstly the agencies or authorities through, or with whom, tasks will be arranged, and secondly those to whom the Army may appear as competitors and who might resent the Army's involvement in non-military tasks.

The first group will range from central government officials, regional and local authorities to various forms of public and private bodies or even individuals. In their daily business, these officials and executives will be used to traditional and well-tried systems of business which will seldom, if ever, have included dealings with the Services. Many of them, and particularly those in local government and similar employment, may spend most of their working lifetime in one area, if not in one type of employment, and they will be surrounded by colleagues and friends with whom they are well acquainted. On the other hand the Army's method of working will be strange to them and the problems of contact between service and civilian folk will be emphasised by the rapidity with which army personalities and units change.

On the Army's part there may well be an ignorance of the responsibilities and duties of the various civilian officials or agencies, and these difficulties may be increased if the Army representative is working in a part of the country strange to him. Difficulties over personal contact can encourage misunderstanding, and this in turn may lead to mistrust.

Within their own purview, the Services overcome this problem by applying the principle of one adviser in each speciality at each level—one gunner, one sapper, etc—regardless of the number of gunner or sapper units he may command or co-ordinate. It is suggested that this principle be applied in military-civil relations and at appropriate levels contact be arranged through a nominated military representative and a specific civilian representative. An example would be the Command or District level on the military side and Regional Government level on the civilian side. At the latter, a Board of Trade or Ministry of Labour representative would be appointed as the civilian liaison contact with the Services, through whom all inquiries or contact concerning the peaceful use of military forces should, initially, be channelled. He would act as a filter for all possible military employment and could advise the Army of projects which would cause least disruption of the industrial or official machinery or alternatively, which might for instance, be particularly sensitive to trade union susceptibilities and be better left alone. Such machinery might appear time consuming and unnecessarily bureaucratic but this need not be so. The involvement of such a liaison staff in any project need not be for long, for once the overall principles of military employment and of cost, materials, etc be agreed by both sides the liaison staff could step back and the military-civilian agencies involved work directly with each other.

On the military side, one arm, service, or branch of the staff at the appropriate headquarters would be responsible for liaising with the civilian opposite number on behalf of the Army—and it is suggested that at Command level the Chief Engineer's Office could probably best fill the bill. The responsibility of the Chief Engineer's Office would include frequent and regular contact with the civilian representative at the Regional Government Office to keep abreast of tasks suitable for the military to carry out and to keep the Regional Office informed of the Army's working capacity in his area. Close liaison with the General Staff will be necessary as all but the most minor tasks will require their approval.

The second area of military-civil relationships which is critical is that with the trade unions who may feel that every soldier employed on a non-military task is doing one of their members out of rightful employment. This, perhaps, is the most difficult of all the problems affecting military employment in the civilian field and its solution will require patience, perseverance and understanding. It is however no more difficult than the difficulties which the government and employers are having with the trade unions at present in trying to impress upon them the need for national economic growth as an essential preliminary to improved individual earnings. The two situations are related, for the involvement of the Services on civilian tasks is indirectly for the national gain, both in providing valuable training for defence services, and in carrying out tasks for the general good in the country for which funds or labour are unlikely to be available from other sources. If the unions can realize this, and can accept that the Services will always try to avoid putting themselves in direct competition with unions, then there should be hope for understanding and good relations.

The increasing use of military facilities in the country is timely as far as this particular problem is concerned for, in spite of their undoubted power, the unions at this particular time are sensitive to criticism over their somewhat parochial and narrow approach to the economic ills of the nation. On the whole they are beginning to realise that a more rational policy may be necessary unless they are to invite more legislation. It could be argued, therefore, that the unions are in a mood to be persuaded that a greater involvement of the Army in civilian life is for the national good.

There is no clear cut or easy answer to this problem. It is doubtful if the serviceman can realize the complexity and sensitiveness of the unions or the dangers of hazarding their prestige and ignoring their importance. Closest liaison and goodwill with the unions is essential from the start, for they do not like receiving unpleasant surprises and will react strongly against them. We must avoid exacerbating union feelings and steer clear of areas where labour problems are particularly sensitive. We must never try to dictate to them nor to compete with them. Nevertheless, and somewhat surprisingly, the unions are sympathetic towards the Services and realise the need for them to have training facilities at home. There are grounds for optimism provided there is close consultation, good will and understanding on both sides.

THE LEGAL, FINANCIAL AND ADMINISTRATIVE RESPONSIBILITIES INVOLVED

Once an accepted link between the military and civilian sides has been arranged one of their main responsibilities will be the resolution of the legal, financial and administrative aspects of the employment of troops on non-military tasks. The details of these will vary in almost every case but in principle they will need little change from those outlined in DCI 178/67.

However, certain guidelines are applicable and wherever possible these should be slanted towards easing the use of military forces on civilian tasks as far as the financial, legal and administrative aspects are concerned.

One example is the question of indemnity which needs to be clearly established in each case, and it is one in which the Army could afford to be generous. Damages, losses and accident occur in everyday life in the Services and on all forms of training and it would be naïve for the Army to demand additionally strict terms of indemnity when working for others. A too narrow approach here might militate against improving military-civilian relations and against requests for further tasks.

The costing of civilian work must also be clearly agreed by all concerned. The principles are largely governed by common sense. Few individuals or organizations offer or expect something for nothing and there is no reason why the Army should be an exception in this respect. Nevertheless the Army is in a position to offer its labour free and materials at cost and wear and tear of equipment can be reasonably charged for if it is more excessive than would occur on training over the same period. The question of materials and equipment is dealt with in more detail below.

Other aspects to be resolved include the clarification of responsibility for the inspection of work and standards to be achieved and also for the timing of completion of work. It will, for instance be necessary to clarify the priority of the task in relation to training or other military commitments which might interrupt its completion.

None of these legal, financial or administrative points pose particular difficulties but, in the main, they will be strange to the military mind. This emphasises the need for the military-civilian liaison outlined earlier and for the evolution of commonly accepted regulations to cover these aspects in all circumstances.

RESOURCES AND EQUIPMENT

A policy for the provision and accounting for all stores, equipments and materials used by the Army on civilian projects needs to be clearly established and agreed by all parties.

It may help to clarify the categories of items concerned. In any project, civilian or military, some tools and equipment will be necessary to enable the work to be carried out. In addition, other stores and materials will usually be required for incorporation in the project itself. These, in their turn, may be of a common-user nature such as cement and aggregate or may be particular to the project, such as a pump of specific capacity or a pre-fabricated hutment.

Where the Army carries out a project for any civilian agency, government or otherwise, it can be accepted that the civilian agencies must bear the cost of all items incorporated in the project, and in addition will defray additional expenses for materials and equipment whether they are used as an aid to the execution of a project or are included in it. These expenses will include hire charges for equipment and structures over and above that necessary for, or attributable to, training. This policy is clearly stated in DCI 178/67 and there appears to be little or no need to change it.

It may be advantageous to outline certain suggestions as a basis for implementing this policy although their application will vary with circumstances.

The equipment table for each unit includes the transport and plant necessary for the unit to carry out its military tasks and the normal scale of replacement is based on reasonable wear and tear due to training, administration, or operations. Tools and machinery held on unit G1098 are likewise scaled and treated. When employed on specific military projects for which the scales of tools and equipment have been insufficient units have, in the past, either been supported by park or specialist units or have drawn up additional stores and equipment as project stores. There is little reason why the same principles cannot be applied to units employed on projects for civilian agencies provided that a unit's readiness for war is not jeopardized by its employment on civilian tasks. This proviso establishes a principle in that wear and wastage of military equipment, plant and transport should not, through usage on non-military tasks, prejudice a unit's military efficiency. Normal wear and tear will always occur but this will be accelerated in units heavily employed on civilian tasks. The dangers of reorganizing the conventional field units of the Corps to make them more suitable for civilian tasks are discussed elsewhere, and for the same reasons it would be unwise to make permanent adjustments of unit holdings of plant or equipment because of a unit's likely involvement to non-military tasks.

If these principles are to be met without inhibiting the provision of stores and equipment needed to fulfil civilian tasks then either the scale of supporting units will have to be increased or the system of project stores be enlarged. The latter would probably provide the preferable system. A scale of project stores would not only include materials and items to be incorporated into a project but also tools and smaller items of plant and equipment. The wise policy would then be for units to use their own tools and equipment only on minor tasks where no additional plant or equipment is necessary and where the wear and tear on tools and equipment is unlikely to exceed that which would occur under normal training conditions. For larger tasks, and those requiring additional equipment, recourse to the project stores system is recommended not only for materials but also for tools and equipment. Accounting is then simplified, both quantitatively and financially, for establishing hire charges for tools and equipment used, and for the purchase of stores and materials incorporated in the project.

Once the Services undertake a task in aid of the civilian community, the efficient and timely completion of the task is all important and work should not be held up due to delays over provision of stores or materials. "Normal channels" may sometimes be too slow and recourse may have to be made to local purchase. A generous local purchase authority must be allowed to officers in charge of projects and the local purchase system would have to cover the acquisition of plant or other proprietary items for incorporation in the project itself.

In summary, therefore, the policy for the provision and accounting of stores, equipments and materials used on civilian tasks could be based on the following principles:—

(*a*) The use of a unit's holdings of equipment plant, tools and transport on civilian tasks must in no way prejudice the combat efficiency of the unit.

(*b*) The principles affecting payment of hire charges for equipment and structures and for the cost of items incorporated in the project should be as detailed in DCI 178/67.

(*c*) The provision of tools, stores, equipment should, except for the most minor tasks, be through the project stores system.

(*d*) Officers responsible for the execution of civilian projects should be given authority to use any reasonable means of avoiding delays on their task through lack of stores, shortage of spares etc. This will usually involve generous authority for local purchase.

THE TRAINING, ORGANIZATION AND EMPLOYMENT OF RE UNITS

Factors affecting the employment of the Services as a whole have been discussed and it is now appropriate to look in more detail at the employment of Royal Engineer units on civilian tasks. This can be done under the headings of training, organization and control.

Training

In principle it should not be necessary to carry out any major changes in training policy for the Corps. It is hoped that the traditional training background which has in the past fitted officers and men to carry out many and varied construction tasks world-wide should suffice to equip them for similar tasks at home.

Certain adjustments will, however, be valuable and these could have a two-fold aim:—

(*a*) To give Officers and NCOs a better knowledge of how local authorities and public utilities operate and are organized. This can be achieved on YO and NCO courses by visits to civilian organizations and by doing everything possible to improve the knowledge and understanding of each others' responsibilities and methods of work—perhaps even by including civilians on courses at the RSME or be seconding Clerks of Work RE to local government appointments.

(*b*) To improve our knowledge of civilian engineering practice by giving more time in the appropriate courses to, for example, costing, financial control of work, standard specifications and other aspects not normally covered in detail.

In addition the present policy of attaching officers on long courses to civilian firms and organizations should be continued and if possible widened.

Organization

On any civilian project economy demands that a contractor tailors his labour force and organization to suit the task. The organization of engineer units has been based, through experience, on that best suited for likely military tasks and they may therefore appear somewhat extravagant in manpower when compared with civilian organizations. Nevertheless units are not entirely inflexible and can be adjusted to suit particular tasks by the attachment or detachment of sub-units, specialists or equipment. This principle has often been applied to the employment of engineer units on military tasks and can equally be applied in the civilian field also. Although this process of adjustment of organizations should enable a wide variety of civilian tasks to be undertaken, there is a danger in taking the process too far and organizing engineer units more permanently for civilian tasks rather than for their true military role.

There is perhaps a principle here that established field units organized primarily for military purposes should not, except on a very temporary basis, be chopped and changed about solely to suit civilian tasks. This principle need not however be so strictly applied to small units such as plant or park troops or to specialist teams which could well be tailor-made for specific projects. Failure to keep to the main principle however could tend to denigrate the Corps in the eyes of the Army and would be most unwise.

Employment

A suggested method of employing engineer units on civilian tasks can be most easily considered by looking at one possible sequence of events.

It has already been suggested that within each Command or Independent District military/civilian liaison can best be achieved through the principle of one civilian and one military contact for all tasks, and that the military representative might well be the Chief Engineer, who would of course work closely with the General Staff. On this assumption the Chief Engineer would require a small staff to carry out a detailed assessment of the work, stores and equipment involved in any proposed task, who would report to him on the feasibility, or otherwise, of the task being undertaken by Royal Engineer units. For every task undertaken by the Corps there might be several investigated but discarded but the engineer units in a Command or District are unlikely to have time or facilities to recce and assess all these without detriment to their other duties.

There would, therefore, appear to be a place for a specialist team in each Command and Independent District, not only to carry out the role of surveyor, investigator and estimator for the Chief Engineer, but also to act as consulting engineer to the units carrying out the larger projects.

The composition and size of the specialist team would vary both from one command to another and also from time to time depending on the likelihood, or otherwise, of tasks suitable for the Army. It could be that in a quiet area a team need only be one officer and a Clerk of Works, perhaps part-time; but ideally each team would include a quantity surveyor and a resources expert. The team would also be responsible for close liaison with the Command Secretary's office.

Once the specialist team has reported to the Chief Engineer that a task is suitable for an engineer unit to execute, and has outlined the stores, equipment and timings involved, the next stage would be for the Chief Engineer to approve the task in consultation with the General Staff and to earmark the unit or units to carry it out.

Where more than one task is recommended as feasible by the specialist team, and the engineer effort available cannot meet them all, a priority for the tasks will evolve based on general parameters. These will include the aim and purpose of the tasks, the nature of it as good publicity as well as good training for the Army, its likely benefit to the Army and to the nation as a whole, its location in relation to units etc.

Assuming that a task is accepted by the Chief Engineer and the General Staff, and the units have been nominated to carry it out, the detailed planning will start. Depending on the size and nature of the task the specialist team will either carry out the detailed planning themselves in close consultation with the civilian agencies involved and with the units carrying out the work, or, in the case of small tasks, will hand the planning over to the unit concerned.

At this stage thorough clarification of all details of the work must be agreed between the military and civilian parties concerned and these should be issued jointly through the Chief Engineer and the Regional Representative. Such an instruction might be issued under the following headings:—

(*a*) The authorities, civil and military, involved and the allocation of responsibilities for planning, supervision, execution and inspection of work.

(*b*) Full details of tasks and specifications.

(*c*) Financial policy and control.

(*d*) Responsibilities for third party risks and associated legal aspects.

(*e*) Safety and standards of work.

(*f*) Timetable, and priorities in relation to training and other military commitments.

(*g*) Policy over stores, materials, equipment and local purchase.

One would like to see this instruction following a standard format or sequence of headings throughout UK which would lead to a better understanding and saving of time by all concerned.

In addition to the above there would need to be special arrangements made with the Staff for the administration of the units involved, and the Commander of the unit or units concerned would also prepare their own instructions and requirements for plant, equipment, etc. These would largely follow the present engineer practice of appointing a Project Officer, OIC Task, Stores Officer, etc, etc, and one can well see the development within each Command or formation of "Standing Orders for the Employment of Engineer Units on Peaceful Tasks". These need not be discussed in detail here as they would be based on experience and practice and need only reflect the lessons learnt over the years by Royal Engineer units in the many and varied tasks carried out by them world-wide.

CONCLUSION

The Corps has the ability to carry out tasks in this country well beyond the scope of DCI 178/67 and there is little reason why, in due course, this potential should not be realized. However it could well be that the problems of human relations could prove more intractable than those of preparing the Corps to carry out these tasks. For this reason our efforts in the near future would be better concerned with establishing good working relations with our civilian counterparts and in improving the Army's image at home. If we can achieve this and at the same time maintain our efficiency as a combat arm then our standing in both military and civilian eyes will be enhanced and we will never lack for challenging and worthwhile tasks in both fields.

Exploitation of the Main Water Table of North-Eastern Libya

MAJOR F. MOSELEY AND MAJOR P. K. CRUSE

INTRODUCTION

General

North-eastern Libya may be divided into three regions (Fig. 1). The most northerly is the high ground of the Jabal Akhdar north of a line from Benghazi to Bomba which, with its higher rainfall, is to be classified with the Mediterranean countries rather than with the African deserts. The second region of Marmarica and Ad Diffah is the stony desert south and south-east of the Jabal extending to Giarabub oasis 150 miles from the coast, and is the region with which this article is concerned, whilst the third region, south of Giarabub is dominated by the Great Sand Sea.

Proceeding southwards from the coast rainfall falls off sharply until, 50 miles inland it is virtually nil and one is faced with true desert and inevitable problems of water shortage. The whole of this area is in fact a low altitude desert plateau, usually with a thin layer of gravel covering horizontally stratified limestone and there are flat monotonous surfaces continuous for mile upon mile. It is a desert particularly familiar to those who took part in the last encounter, and their vehicle tracks are almost as fresh as when they were made, always heading east or west on the bi-annual pilgrimage. There is a remarkable stability to this desert surface. Around Giarabub the ground falls to below sea level in a succession of low escarpments and flat topped hills (mesas), and a few miles to the south of here is the third region with the Great Sand Sea and Calanscio Sand Sea rolling for hundreds of miles towards Kufra.

Our present object is to detail knowledge of the water resources of the second region of Marmarica and Ad Diffah and to show how supplies may be obtained for military units on exercise. It is not surprising that during the desert campaigns a good deal of information was assembled about availability of fresh water in the Western Desert, and although most of the localities are either farther east or along the coast, the general principles established (Addison and Shotton 1946, Shotton 1946) are applicable for the whole of this region.

Subsequently, during the last ten years, oil company exploration has added to knowledge, and situations in which fresh water occurs are reasonably well known in outline, if not in detail. These situations are respectively the main (sea level) water table and perched water tables in the Miocene limestones, and in old Roman cisterns and bedu wells. They will be referred to in turn.

The main (sea level) water table, can be expected to underly the whole of the area of Fig. 1 at depths approximating to sea level. There is in fact a gentle slope to this water table which falls from about sea level near the Mediterranean coast to below sea level in the region of Giarabub. South of Giarabub there is an essentially different water province and the water table rises gently again into south Libya (Jones, 1964). In detail of course there are many complexities and in fact there are insufficient boreholes in north-east Libya for really accurate assessments to be made.

On the Jabal Akhdar and along the coastal strip there is an appreciable annual rainfall and aquifers are recharged with fresh water annually. Consequently on the southern slopes of the Jabal where south-flowing wadis regularly bring in quantities of flood water, prospects for successful boreholes are fairly good (Fig. 5). Near the coast the fresh water is near the surface and forms a thin pad on salt water percolating from the sea. In these regions, with Timimi as a prime example, care has to be taken not to over-pump or salt water will be brought up into the well. In fact with the water close to the surface collecting galleries are to be preferred to conventional wells and have been previously described by Addison and Shotton, 1946, and Moseley, 1963. It has already been noted that farther south precipitation falls off rapidly, and in these areas the water is largely fossil water which accumulated many

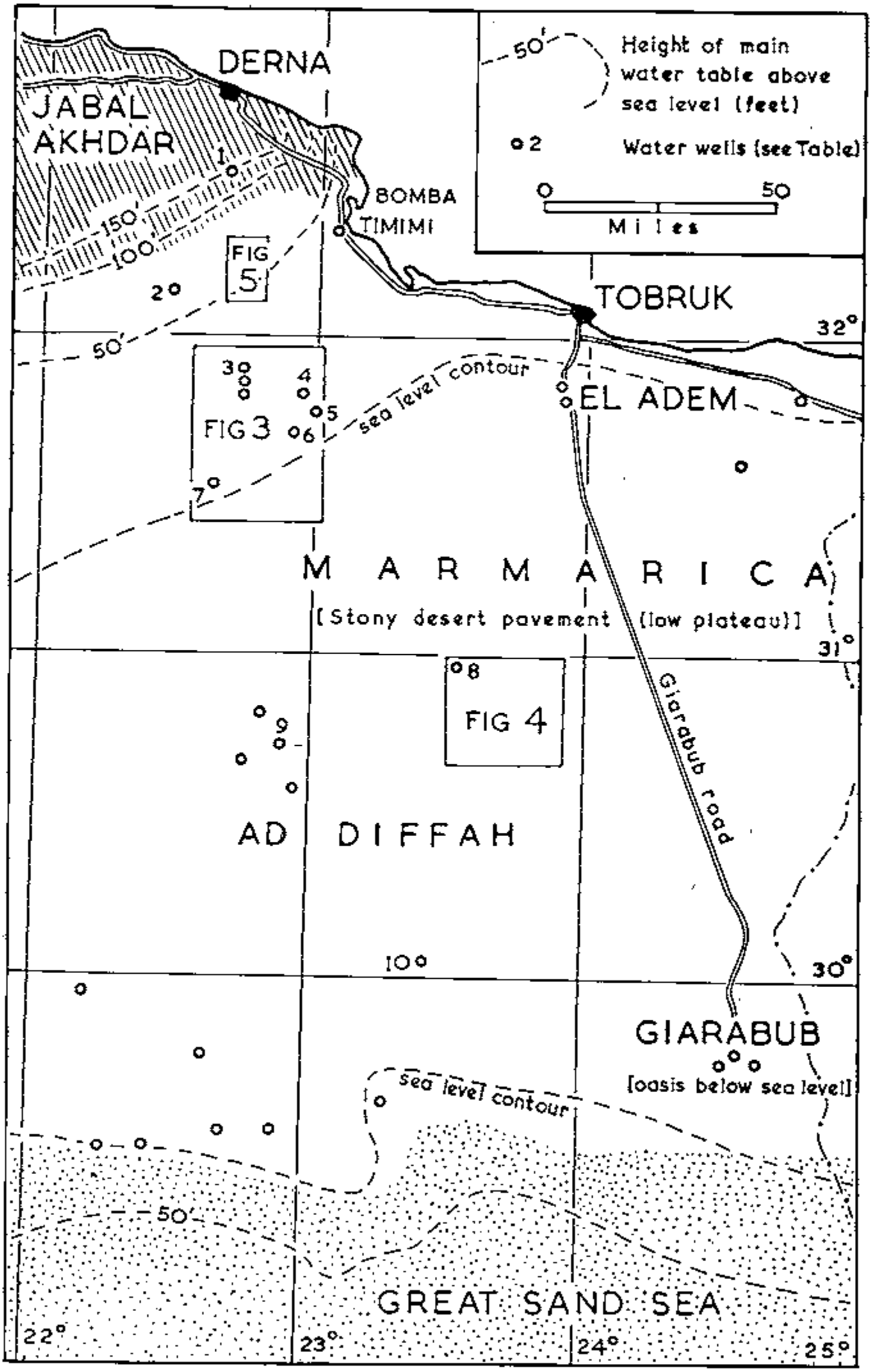

Fig 1. North-eastern Libya showing the area of stony desert between Jabal Akhdar (diagonal lines) and the Great Sand Sea (stippled).

thousands of years ago during a wetter climate than now prevails, in fact during those well known "Pluvial Periods" of the Sahara, the equivalent in time of the Ice Ages of Europe. This water has thus been standing in the Miocene limestones for a long time, gradually acquiring increasing quantities of salts dissolved from the rock and only in the most favourable situations will it be fit for human consumption. Ironically, farther south in the central Sahara, beyond the region considered in this article, water purity improves, the reason being that it is contained in a different aquifer (the Nubian Sandstone) which is relatively free from soluble salts (Jones, 1964).

Perched water tables in the Miocene limestones are important in northern Cyrenaica, as at Derna, Martuba and Umm Errezem, and yield considerable quantities of fresh water (Moseley, 1963). Unfortunately the likelihood of perched water tables within the more southerly areas is remote.

Existing native wells include converted Roman cisterns and shallow bedu wells. The former are particularly numerous in the coastal areas of northern Cyrenaica and Marmarica the majority collapsed but many still in reasonable state of repair, in which case they may have had recent well heads built upon them. The cisterns can be recognized from a distance by the low spoil heaps near to them, and on close inspection by the rectangular openings cut into the limestone pavement.

A particularly good example is to be found at 590785 (Fig. 5) in which region there is abundant evidence of former Roman occupation with extensive ruins still apparently awaiting excavation. Proceeding south from the coast, however, cisterns become increasingly scarce, and what little water there is comes from the traditional sparsely scattered Bedu well. These wells, many of which are of ancient origin are hand-dug and most of them are unlined, except perhaps for a ring or two of stones around the top; the feature is necessary as much due to the gradual increase of ground level around the well caused by the deposition of animal droppings and wind-blown sands as to the need for stability when hauling water at the well-head.

Mechanical pumping of water from native wells, apart from depriving the locals, is normally impractical owing first to the limited depth of water, usually less than 5 ft, and second to the lack of a screen for retention of the aquifer. Since the well-sinkers had no method of dewatering whilst working at water level they could only deepen the well during a particularly dry year; this will often provide the observer with data on the long-term variation of the water table. Note should be made of the fact that some Bedu wells produce small quantities of quite potable water in regions where boreholes will yield water of higher salinity. This is because the native well only skims the surface of the water table in a situation where a thin stratum of relatively fresh water overlies a substantially saline layer. This is particularly the case near the coast where fresh water rests on salt (see above).

2 GEOLOGICAL SETTING

The whole of north-east Libya, excepting parts of the Jabal, is underlain by horizontally stratified Miocene limestones already mentioned. There is limited variety to the rock but it does include interesting shell limestone with large numbers of well preserved fossils, much softer chalk and occasional bands of shale and clay which are responsible for holding up the perched water tables of the north. Although these rocks have not been subjected to major earth stresses the region is within a minor earthquake zone and the limestones are fractured (faulted) along well defined WNW courses which are clearly visible on aerial photographs (Fig. 5). These faults, often almost open fissures underground, are important to water supply since they permit water flowage to take place. In addition to the faults there are considerable numbers of minor fractures (joints), in many cases parallel to the faults and closer spaced near to them, which will also transmit water under favourable circumstances. If it is at all possible water wells should be sited to take advantage of these features of geological structure.

The present terrain, eroded from the horizontal layers of Miocene limestone, is extremely flat, but nevertheless does have some variety. Most common are the stony desert plateaux and plains, essentially formed from limestone gravel a few feet thick, resting on Miocene limestone beneath. The actual surface of the desert is strongly winnowed by long continued wind blast, and the sand content removed leaving behind the stony desert pavement, the "serir" of Libya. The resistance of this pavement to erosion has already received comment. It may be noticed that in some areas the pavement is made up not only of white limestone fragments, but that there are equal numbers of black fragments. On close inspection these turn out to be chert, a silica rock originally forming "nodules" in the limestone, similar to the well-known flints in the chalk of England. These cherts have been blackened by "desert varnish". It may be finally noted that the "serir" plateaux flat for mile upon mile, are ideal for rapid cross-country movement in any direction, and indeed in the region south-east of Baltat al Uqdah it was possible to keep to 40 mph in a dead straight line for 30 miles and more.

The gravel plateaux usually terminate in low escarpments, typically 50 to 100 ft high which break up into isolated hills with limestone cappings (mesas) and in the separating shallow depressions mudpans are often to be found, some of them several miles in diameter. These mudpans, formerly lakes during the wetter periods referred to in the introduction, are usually made up of smooth, perfectly flat, baked mud, with the typical pattern of hexagonal cracks formed on drying out. It is notable that none of them contain salt, which in other desert areas of the world, is so commonly found in this type of situation. This apparent anomaly is attributed to the rapid sink-in of periodic flood water with no time for evaporation and is occasioned by the floor of permeable limestones beneath the pans. Wadis are an uncommon feature of the whole area and testify to the sparcity of rainfall. Those that exist are extremely shallow features, usually with sparse vegetation along the wadi line, and an infilling of sand. In a number of cases the wadis end in large mud pans.

3 EXISTING WELLS

Oil company water wells are the only water sources of any consequence, the few commercial wells for the other concerns being outside the area under discussion. The positions of known water wells are shown on Figs 1, 3 and 4. The operation of an oil drilling rig requires something like 2,000–3,000 GPH continuous water supply for mud make-up and for storage against lost circulation and this to be available for about six weeks, after which the wells are abandoned unless there is the possibility of a "workover" job being called for within two or three years, when some effort may be made to preserve the water wells. The above requirement has an overriding effect on the design of the wells which are sometimes very primitive and lack the sophistication of, say, a long-term domestic supply well.

TABLE 1

Data on some water wells, North-East Libya. Well positions shown on Figs 1, 3, 4 and 5.

Well No.	*Lat. and Long.*	*Salinity (where known)*	*RWL* ft	*Depth* ft	*TDS ppm*		*Remarks*
1	32° 30′ 37″ N 22° 39′ 10″ E	220	960	1,170	1,010	2 wells	Fresh water
2	32° 08′ 18″ N 22° 27′ 48″ E		625	750		1 well	(No casing)
3	31° 52′ 47″ N 22° 43′ 30″ E					2 wells	
4	31° 49′ 14″ N 22° 56′ 21″ E		472	526		2 wells	Being tested early May 1968
5	31° 45′ 45″ N 22° 59′ 55″ E		490	600		2 wells	
6	31° 41′ 42″ N 22° 54′ 30″ E		500	650	1,800	2 wells	8⅝ in
7	31° 32′ 26″ N 22° 37′ 14″ E		350	450	2,300	2 wells	
8	30° 58′ 34″ N 23° 30′ 05″ E					3 wells	
9	30° 44′ 05″ N 22° 52′ 51″ E	2,964	374	558	5,500	4 wells	Barely potable
10	30° 03′ 55″ N 23° 24′ 58″ E		180	300		3 wells	

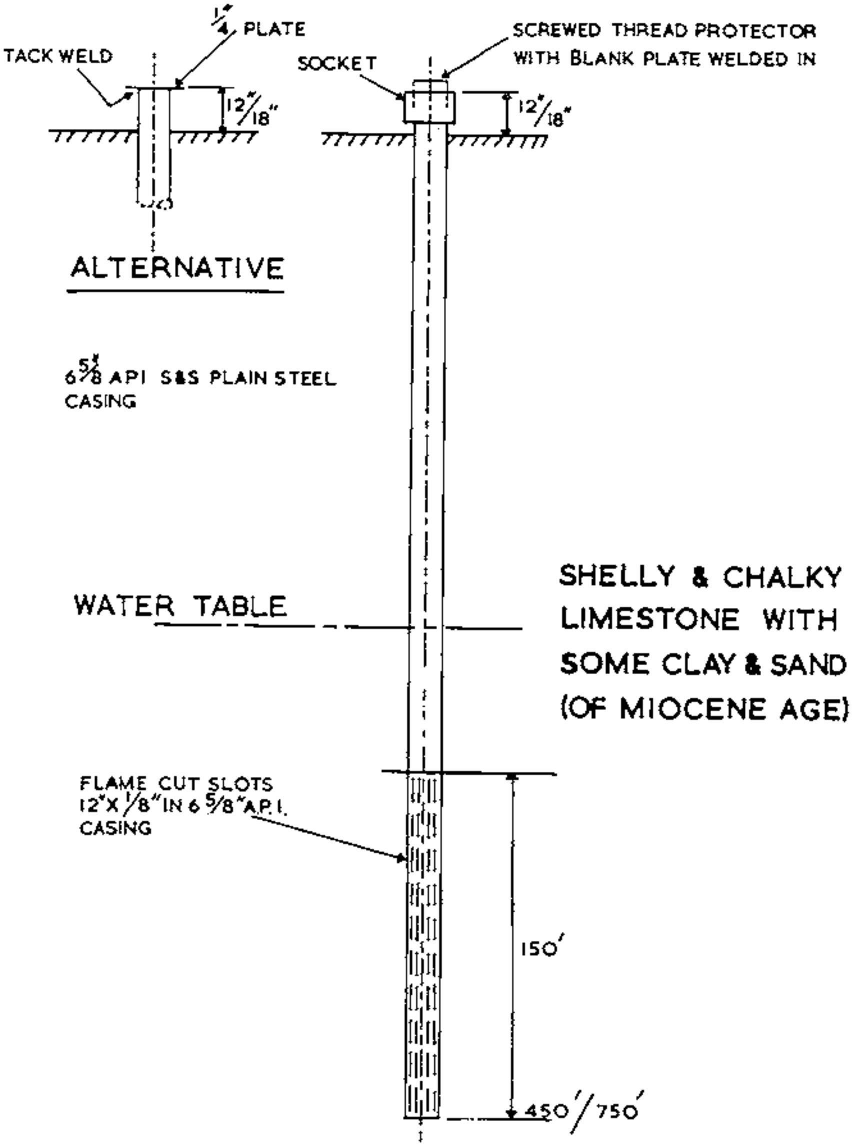

Fig 2. Typical water well for oil rig supply in Libya.

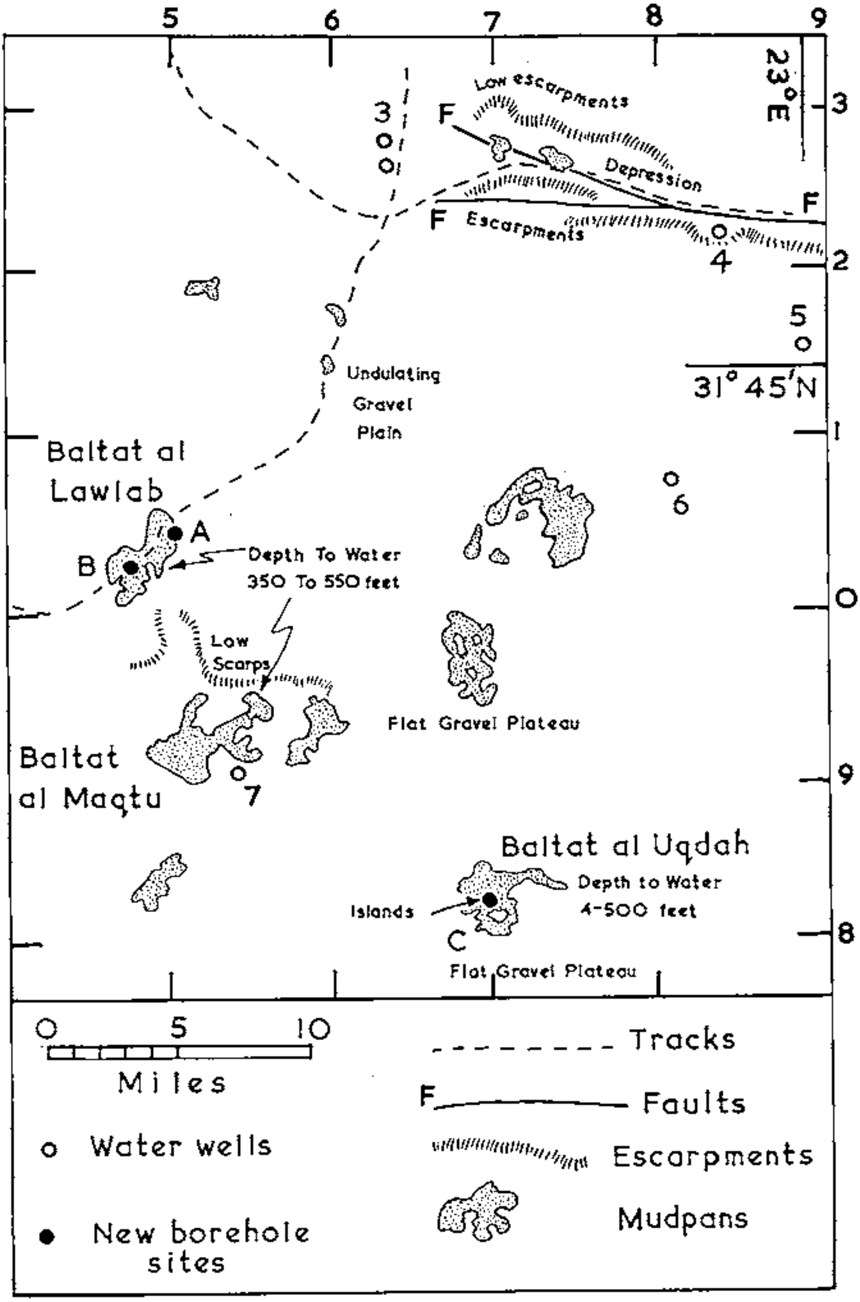

Fig 3. Existing water wells and new borehole locations in relation to features of geology and terrain.

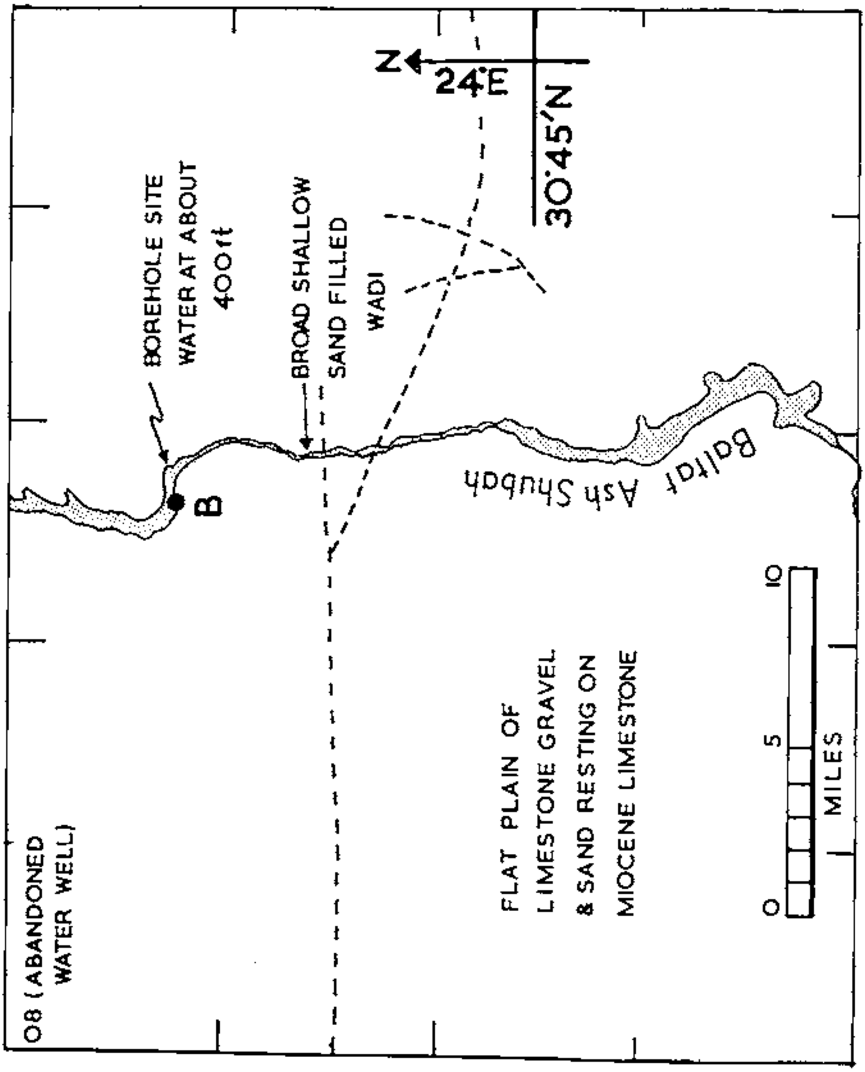

Fig 4. Location of a new borehole along a wadi.

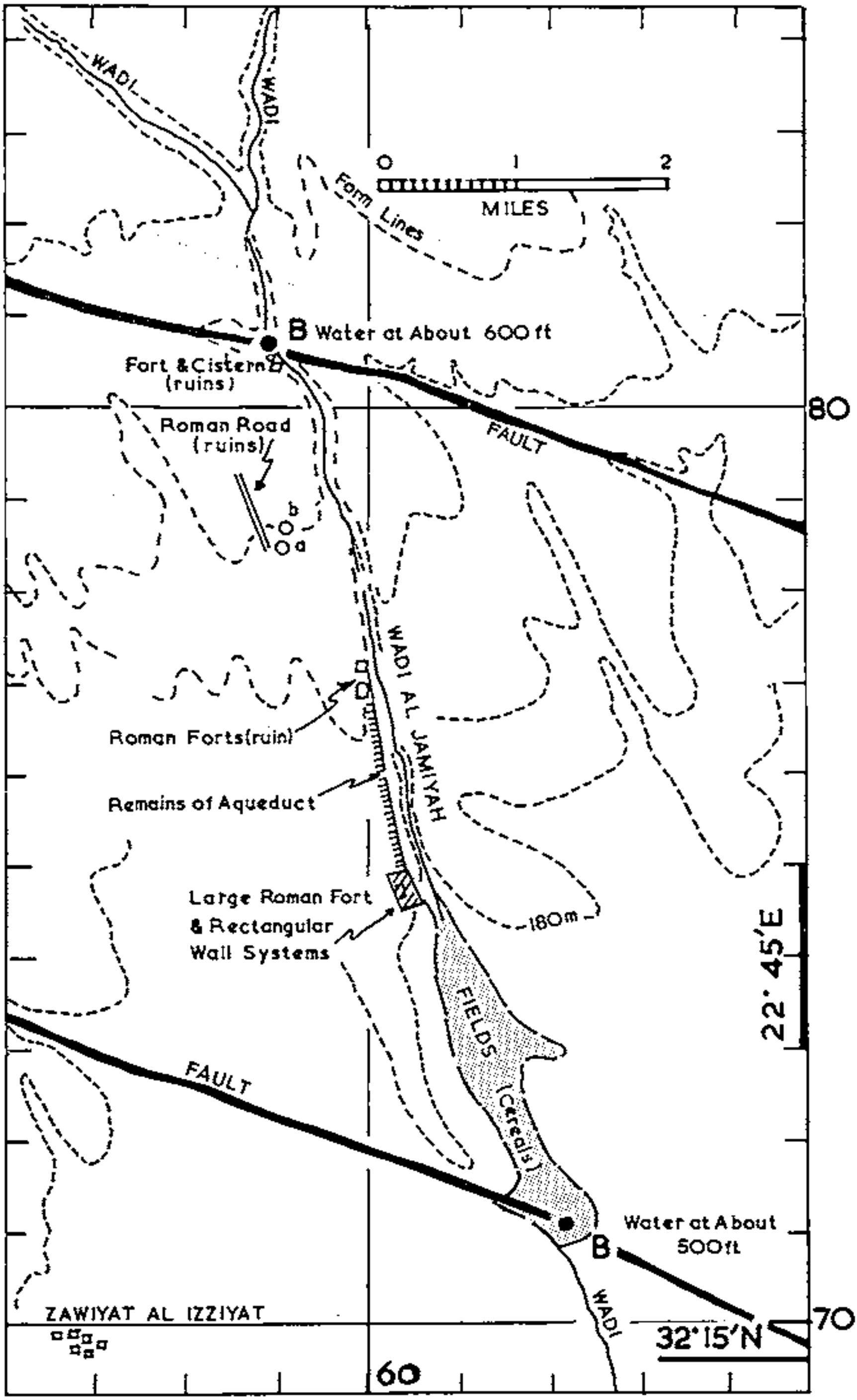

Fig 5. Locations of new boreholes at intersections of faults and wadi drainage.

The layout, construction and exploitation of these existing tube wells will now be considered. An oil rig location usually has two or three wells situated some 200 yds from the oil well. This arbitrary distance is necessitated on the one hand by the need to keep clear of the high-pressure cementing operations carried out in the top section of the oil well lining, whilst on the other hand a long delivery main from the water well to the rig is to be avoided. Individual wells should be about 100 ft apart, but frequently in order to run the air-lift pumps from one compressor (or even in ignorance) these wells are only about 15–20 ft apart.

Regarding depths, the wells were often taken deeper than would be necessary for a long-term well. The reasons for this are (*a*) the mud-flush rotary method of drilling is very rapid in the strata usually found in Libya and another 100 ft of depth may only take six hours, (*b*) this rotary method is notoriously hit-or-miss when it comes to detecting weak aquifers and therefore the driller goes deeper to make sure, (*c*) the wells are usually pumped using the air-left method and this will only function if there is considerable submergence of the pump into the water.

Before the drilling fluid is removed from the finished well, it is partially or completely lined with $6\frac{5}{8}$ in or $8\frac{5}{8}$ in API casing. The lower section of the lining, adjacent to the aquifer, will be slotted by acetylene cutting torch, prior to insertion. This produces a slot of about $\frac{1}{8}$ in width by 12 in long, staggered around and along the length of pipe. In the limestones and cemented sands this screen arrangement is satisfactory, but where an aquifer consists of loose sand there is a considerable inflow of sand through the slots. Under different circumstances steps would be taken to introduce an improved form of screen, but here again the procedure is in character with these types of well; an airlift pump will handle solids without harm and as the water is discharged into a well head tank before being pumped across to the rig, the sand can settle to be cleaned out periodically. The effect of pumping sand with the water more often than not results in a self-cleaning state being brought about. A cavity of increasing volume develops around the slotted pipe and this presents an increasing area of aquifer exposed to the well which in turn reduces the velocity of water moving into the well through any given unit area. Quite often the stage is reached where no sand at all is brought in, but this is more frequent when uninterrupted pumping is undertaken and no "surging" takes place.

When an oil well location is vacated the water wells should, in theory, be capped. However, it has been found that many are left open with the result that they have collected debris dropped by the curious, and sand whipped up during storms. In addition, some wells have partially collapsed.

The method of capping the wells varies according to the way the string of well casing terminated, that is whether a screwed joint came conveniently to a point some 18 in above ground level or whether the pipe had to be cut. If the former, a blanked-off thread protector may have been used whilst in the latter case a $\frac{1}{4}$ in plate, 9 in square would be tack-welded on to the cut pipe.

In many cases the exact construction of the well will be known from records (occasionally inaccurate) as also will be the yield and water quality. However, as most of the abandoned wells were last used some five to nine years ago, they should be approached as largely unknown quantities. The following procedure is recommended:

1. Remove cap—if fitted—and check depth to water with either an electric dipper or a plumb line and float.
2. Check depth of well with plumb line and weight.

Note

It is advisable to measure the line on the way *down*, as in the event of the float tilting and wedging or the weight catching in debris on the bottom, the depths will be known before breaking the line.

3. Check o/d and i/d of well casing, height above ground level and details of capping.

Notes

(*a*) If the well be dry, effort should still be made to cap it, as a drilling rig may be brought in at a future date to redrill or deepen the well. Another factor is the possibility of contamination. For example it was observed that at one location the capped water well—which contained water—was only a few yards from its uncapped dry duplicate.

(*b*) On no account should stones larger than a cherry be dropped in the well to ascertain the presence of water as this could cause delays to future well-cleaning operations.

(*c*) A mirror may be used to direct the sun's rays down the well for a visual inspection. This should not be done near mid-day when difficulty may be experienced in redirecting the near vertical sunlight. In the event of cloud the well may be examined at night with a mirror and a close-parked vehicle headlight.

4. If the location should appear of interest from the viewpoint of future water abstractions a sketch should be made showing the position between wells and the bearing and distance to the parent oil well. A grid-reference is only recorded for the *oil well* and current information on the exact location of the water wells is difficult to obtain.

Another point to note is that the number of wells to a location is never less than two and sometimes total three or more. They are usually arranged in triangular or square plan with the compressor plant in the centre. In subsequently clearing up the site with heavy bulldozers it is known that occasionally a well head may be buried. This can also occur due to wind-blown sand filling a bulldozed depression containing wells. In view of the foregoing, a careful search should be made to ascertain that all water wells have in fact been located. If an altimeter reading be taken and corrected to give height above mean sea level this will assist in estimating the depth to water table.

5. Having selected a well, the next step is to determine the yield. At this point it cannot be over emphasized that no two wells possess identical characteristics and this fact, although of considerable academic interest, complicates pumping procedure and makes the laying down of firm guidance notes very difficult. One could say with some justification that any 6–8-in tube well with less than 20 ft of water in it is not worth pumping. However, if the bottom section of the well should be in fissured limestone (for example), it may be possible to abstract 10,000 gph with very little drawdown using an electric submersible pump.

Generally speaking, the wells will have from 30 ft to 150 of water in them and the aquifer will for the most part stand up. Assuming the availability of a high-head relatively low output electric pump, this should be installed between 5 ft and 15 ft from the bottom of the well—depending on the depth of water available. Obviously such points as pump duty, capability of rising mains to carry the pump and their own weight when full of water, etc, should be considered. A water level indicator preferably of the electric dipper type, should be run down the well and the water level reading checked against the original figure to ensure the electrode is not recording on a cable clip or similar metal object. Water levels should now be taken in adjacent wells within a radius of ¼ mile.

When commencing a pumping test it is absolutely vital that (*a*) the output for the first hour or so be restricted to a very low figure in order to ensure adequate water over the pump; to avoid surging the well which would encourage the ingress of sand; and to establish a steady pumping water level and (*b*) the pump is not stopped during the first few minutes of operation which would allow all the suspended solids to settle back on the pump.

Regarding measurement of yield this may be done either by measurement into, say, an oil drum through a 90 deg vee notch weir, or a water meter. Water samples are usually taken at or near the end of the test.

6. The above notes under paragraph 5 discuss the main points in determining the

well yield since it is assumed that the crew responsible for carrying out the test would have some experience of this operation.

The airlift method of pumping could be tried where the depth of water/depth of well ratio would permit something like 60 per cent pump submergence. Similarly, some wells may be so deep, e.g. 950 ft to RWL in the north-west part of Fig. 1, that only a reciprocating pump unit would be capable of lifting the water to the surface.

7. To sum up, outputs of 500/3,000 gallons per hour can be expected from depths of 350 ft–550 ft over much of the central area. The water quantity and quality and depth should quickly increase approaching the area of Jabal Akhdar in the north-west of Fig. 1. The water quantity and quality will diminish south of latitude 32°N. The general water table will not suffer a depression from prolonged pumping.

4 LOCATIONS FOR NEW BOREHOLES

A borehole at almost any site within the area of Fig. 1 would yield water of a kind, with a water table near to sea level, but this water would in the majority of cases be too saline for drinking. It has already been indicated that, not taking into account the plentiful supplies of the Jabal Akhdar itself, the greater likelihood fresh water supplies will be in the north-west region on the southern slopes of the Jabal, whilst farther south the salinity will inevitably be higher. The all important problem therefore is how to locate pockets of relatively fresh water in this "ocean" of saline water. Quite simply, without geophysical assistance, localities must be selected using normal logic and taking account of the principles already laid down in this article. The criteria are as follows:

1. Boreholes have a better chance of success if they are placed where periodic flood water will be concentrated that is at mudpans and along the few wadis. In such situations providing the rock sequence is essentially limestone, water will penetrate downwards and locally replenish the main water table, thus freshening it. The absence of salt in these situations has already been commented on. In the rare event of rain the mudpans, sites of former "pluvial period" lakes will be impassable and it is perhaps desirable to choose sites on the gravel edges. It would nevertheless be an interesting experiment to bore in the centre of one of the large pans, and considering the rarity of rainstorms there would be no great risk attached to this. A few suggested sites associated with mudpans are shown on Fig. 3. Two (A and B) are placed on the quite spectacular pan of Baltat al Lawlab (500050) and one (C) on an "island" in the centre of Baltat al Uqdah (690820). It will also be noticed that there is an oil company water well in a similar position on the edge of Baltat al Maqta (540910). A possible wadi site is shown on Fig. 4 at a bend in the south "flowing" Baltat ash Shubah.

2. Boreholes are also preferred where the rock is fractured by faulting, and the natural flow of underground water thus facilitated. Comments on such fractures and the value of aerial photographs have already been made. An existing oil company water well (No. 4 on Fig 3) does in fact lie close to such a fracture zone, and on Fig 5 two sites are suggested which combine the advantages of faults with those of south-flowing wadis from the higher rainfall area of the Jabal Akhdar. The latter two sites indeed should have every chance of success if they are tried.

5 CONCLUSIONS

It is apparent that the only truly favourable area for water supplies will be in the north-west of Fig 1 on the southern slopes of the Jabal Akhdar. Farther south although water will always be present close to sea level, it is likely to be saline with relatively few pockets fit for human consumption. Exploitation of this water table can be accomplished both by reopening oil company water wells and by putting down new boreholes in selected sites. There are then several courses of action which may be taken as follows:

1. If one is fortunate and the borehole produces water of low salinity, there should be an ample supply for all purposes.

2. In the event of water of high salinity the possibilities are:

(*a*) To use borehole water for washing purposes, whilst bowsering in drinking water.

(*b*) To mix borehole water with bowsered water to make it more palatable.

(*c*) The preferred method, to install distillation plant, as in fact is the case when the oil companies operate their temporary camps, and as has previously been strongly recommended by Fox. Again, the distilled water could be mixed with some raw water to increase volume and improve palatability.

TABLE 2

Typical Well Water Analysis Figures

(*a*) As could be expected around latitude 30°–31° (Fig 1)

Hardness as $CaCo_3$	2,109	SiO_2	18 parts per million
Dissolved solids	5,371	Al	0·15 parts per million
Specific conductance	6,786	Fe	trace
Chloride as NaCl	2,964	Ca	485 parts per million
		Mg	217 parts per million
		Na	994 parts per million
		K	28 parts per million
		Co_2	none
		HCO	204 parts per million
		SO_4	1505 parts per million
		Cl	1798 parts per million

Water unpotable in normal circumstances but could be drunk in emergency without harmful results—although most unpleasant.

(*b*) As could be expected around latitude 32° to 32° 30′ (Fig 1)

Hardness as $CaCo_3$	489	SiO_2	·009 parts per million
Dissolved solids	1,010	Al	none
Specific conductance	1,540	Fe	none
Chloride as NaCl	220	Ca	·103 parts per million
		Mg	·057 parts per million
		Na	·165 parts per million
		K	·005 parts per million
		Co_2	none
		HCO_3	·271 parts per million
		SO_4	·131
		Cl	·355

Water quite potable and palatable.

Note: The presence of salt in amounts of 500 ppm may just be detected. Salt up to 1,500 ppm is accepted for public supply. In emergency water may be drunk for weeks at a time up to a range of 3,000 ppm without harm.

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The Computer and Military Engineering

LIEUT-COLONEL W. COOK, RE, BSc, MICE, MINucE, M Inst HE

INTRODUCTION

In the December issue of the *Journal* Major Booth has dealt most knowledgably with computers and their characteristics and I would like to follow his article by describing how computers are used daily on a civil engineering project, and by suggesting how we, in the Corps, can make use of them both technically and tactically.

In this age of technology computers have become commonplace calculating instruments available to the civil engineer to assist him with complicated or repetitive calculations. Because of this, civil engineers have learnt how to make good use of them.

Although young officers at Cambridge or Shrivenham may use computers, and others can attend courses at military or civilian establishments to learn something about them, as a Corps we can hardly claim to be computer-minded.

Very simply, a computer may be considered to be made up of three parts, the electronic machinery which performs the calculations, the programme which instructs the machinery on the specific calculations to be performed, and the input data which presents the problem to be solved in a form intelligible to the computer.

The people concerned with these three parts are operators, programmers, and users. As engineers we must be users, but to use a computer efficiently and competently it may be advisable to know something about programming, and about the machines' characteristics, capabilities and limitations.

It should be possible after a short concentrated course to prepare simple programmes and to understand the more complex ones produced by the professional programmer. The programme is the language of the computer and learning to programme is, in effect, learning a new language. As with a foreign language, some learn easily while others struggle, but all find it easier when able to test their new language on the computer itself.

A simple programme with explanatory notes is shown at Appendix *A*.

To illustrate the benefits obtained by using computers some of the methods used in designing a motorway are described below. For simplicity the design task is divided in a similar way to road design in *Military Engineering* Volume V Part I.

SURVEY

Traditionally survey has consisted of a ground survey to provide a detailed map showing spot heights and contours. However, surveys can now be oriented to computers. A number of ground control points are established by traditional survey methods and to these an aerial survey is related. The aerial survey is quicker than ground survey and the accuracy of aerial survey spot levels is normally better than the accuracy of map contours.

The detailed information on ground level is recorded separately as a Digital Ground Model (DGM) (or American, Digital Terrain Model). Three dimensional co-ordinates of a series of points, usually forming a square grid of 50-ft side, over the area being studied, are stored in the computer's memory, providing a mathematical model of the ground surface.

When the ground surface level of any location is required, it is provided by the computer by interpolation from stored levels of adjacent points.

Survey firms are accustomed to providing the relevant data for a DGM on punched cards, or punched tapes, which are used as input data for the computer.

HORIZONTAL ALIGNMENT

The route chosen will have been selected from a number of routes drawn on a plan of the area under consideration, and will be reasonably accurately depicted.

Until now the selected line has been checked and refined mathematically to verify by calculations the geometry of the alignment. This takes time and effort and the alteration to one curve may materially effect every single curve along the alignment. However, by using a supporting computer all the tedium is removed from this stage of design.

To provide the calculated horizontal alignment the computer requires the co-ordinates of intersection points, curve radii, and transition spiral lengths. Where compound curves are used the computer can analyse these as easily as simple curves.

Having analysed the alignment the computer both prints out the required data as well as storing it in its memory for future use. Fig. 1 shows an alignment. *Appendix B* gives the input data for this particular alignment, and from this eight foolscap sheets of printed information are provided by the computer. One typical sheet is at *Appendix C*, and data of this type is provided at the rate of one curve analysed every six seconds.

VERTICAL ALIGNMENT

Details of levels on the selected line are required with precise information on gradients and vertical curves.

The procedures for obtaining this data is similar to that employed for the horizontal alignment and the computer prints out, and stores to memory in a similar way.

Once the Digital Ground Model, and the horizontal and vertical alignment have been obtained, the information is stored for subsequent parts of the motorway design. Precise grid references and levels of any chainage can be obtained. Compass bearings of straights, starting points and mid points of arcs, and details of transition spirals can be printed out at will.

Super-elevation can be applied if necessary. The computer will apply the required amount of super-elevation and give chainage, level, and grade for the inner and outer edges of the two carriageways in a matter of seconds.

SOIL SURVEY

Soil survey must be carried out ahead of any earthwork design.

Once the physical properties of the soil have been evaluated the calculations can be passed to the computer. In the past slip circles were examined by graphical methods, using trial and error to determine the worst case. Now a sheet of data to the machine completes the task, and from the solutions supplied cutting and embankment slopes can be designed.

When the angle of slope has been selected, the computer, using the information and calculations already stored, can provide cross-sections of both the road, on embankment or in cutting, plus the existing ground section, for any chainage.

EARTHWORKS

Having progressed to the stage where the embankment and cuttings have been designed, it is a simple step to move to earthwork calculations. The facilities available for earthwork calculations are almost limitless. The amount of top soil to be removed can be calculated, and also the amount to be replaced on slopes for seeding. Unsuitable material to be removed can be calculated plus the cut and fill for each chainage with running totals from the start of the job. Bulking factors can be applied, and all figures are calculated to the nearest cubic yard.

BRIDGE DESIGN

In bridge design almost more than any other sphere the computer comes into its own in sheer calculating ability.

Once the type of bridge is decided the design process until recently has been long and slow using up many man hours and involving careful calculations of stresses, pressures, bending moments, and shear forces.

Now calculations may be simply and quickly performed by the computer, and a variety of differing sizes of members, amounts of reinforcement, eccentricity of prestress tendons etc, can be tested to arrive at the optimum design.

Pile design, pile caps, foundations, decks, beams, arches, almost everything that goes to make up a bridge can be computerized, and with a proper programme even a perspective drawing of the final structure can be accurately drawn from points plotted out.

CONTRACT DOCUMENTS

When the design is finished, the tender documents are required and working from a prepared programme and the necessary input data for the particular project, a complete specification and bill can be printed out in a matter of minutes.

SETTING OUT

By linking up markers established for the aerial survey and from the data calculated, and stored, on the alignments, accurate bearings and distances for any point on the motorway can be obtained. This makes the task of setting out simple. Using theodolite and steel tape, intersection points, tangent points, or simply the position of a solitary cats-eye can be sited readily.

MANAGERIAL CONTROL

One instrument of modern control is the critical path programme, a kind of graphical appreciation.

Properly used, the critical path programme, apart from showing the critical path, indicates earliest and latest starting and finishing dates for each programme event, plant and equipment necessary, and the dates stores and materials are required. The production of this data is a simple computer operation, but more to the point, the constant editing and revision of the programme to meet changing circumstances which is necessary if it is to be of any value and which is so long and tedious by normal hand methods, can be done in seconds by a computer, hence a programme can be updated immediately any change to the original assumptions takes place. As a side product of the main programme a diary, or list of events, can be printed out each time the programme is processed.

Quality control of every type can be simplified by computer methods, standard deviations, of concrete cubes for example, can be calculated in seconds against the slower and more tedious arithmetical methods.

And the more mundane matters of administration, pay, salaries, and stores ordering, can be arranged electronically.

MILITARY APPLICATIONS

Application of computer techniques to military problems can be considered under two headings, military applications of civil engineering, and combat engineering.

Everything that has been written above applies to engineering construction undertaken by the Corps. For motorways, airfields could be substituted where the problems are similar in type, and capable of the same kind of treatment.

Surveys could be prepared in digital ground model form and alignments, earthworks, drainage, quantities and the like could be prepared by computer methods.

Similarly with bridging, dock and harbour work, and the multitude of tasks undertaken by sappers where the task has to be planned and designed rather than assembled from a prepared construction drill.

In combat engineering also there is scope for the application of computer techniques to speed up the fact finding and calculation necessary to provide the commander with the options on which his decisions will be based.

Survey of enemy held territory could be undertaken from aerial photographs, if need be to an assumed datum, and stored in mathematical form ready for use in airstrip or route selection.

In a defensive role a commander could predict the number of mines required to provide an obstacle of a given percentage effectiveness against enemy tanks of a selected track width, allowing a fair degree of flexibility in the mining pattern.

Data of all sorts could be stored removing the necessity for constant states and returns. As long as alterations were reported and the data store kept up to date, strengths, vehicles, explosives, plant and anything else one chose, could be held in computer memory. Instantly available would be the minutest detail of any sub-unit.

Reinforcement requirements, replenishment of any commodity, movement tables, aircraft stowage tables, all would be available in minutes from the time the requirement was formulated.

Obstacle crossing would be equally easily dealt with. A prepared programme, a digital ground model of the terrain being examined, and bridging available by vehicle loads would provide enough information for a computer to provide a bridging and rafting plan making optimum use of resources. Into the programme could be inserted any number of operational restrictions such as percentage to remain as reserve, cranes available, or hours between which operations could proceed. With the programme, the ground model, and the bridging and rafting holdings, stored in the computer, an answer to this problem would be available in seconds.

Nuclear warfare situations could be programmed to provide answers to the problems of nuclear weapons. Data such as height of burst, wind direction and strength, being fed to the computer would produce fall-out patterns, safe working periods, and decay rates.

CONCLUSIONS

It may seem that the advent of the computer has removed from the engineer, or from the commander, some of his control or command of a situation but this is not so. The computer is a sophisticated calculating machine. It can solve problems with almost miraculous speed, but all the problems must be capable of mathematical, or factual solution. In doing this it provides time for the engineer to devote to designing.

In a tactical situation it could provide the commander with solutions to factual problems, but it will not remove from him the decision making. His is still the task of applying the intangible factors which he alone can assess, state of morale, state of training, fatigue of his force, possible enemy interference and its effect.

Although I have written as if the computer was kept on the engineer's desk, it is not necessary to own one effectively to use one. All that is required is reasonable access. Commercially computers are generally shared, and provided a programme exists for the problem being considered and suitable for the type of computer to be used, an engineer many miles removed from the computer can still use it.

Where answers are not required instantly a postal service could be acceptable. Making use of this method the Corps could effectively use time on Army computers already installed.

A computer with an operational role could be used instantly and effectively if some sort of teleprinter facility were available for remotely controlling it.

There is no doubt that the computer is a calculating instrument of the present, not the future and we, both as engineers and soldiers, cannot afford to ignore it.

ACKNOWLEDGEMENT

I would like to thank Colonel S. M. Lovell, CBE, ERD, TD, County Surveyor, West Riding County Council, for affording me the opportunity of using the computer for the operations which I have described above.

NOTES ON COMPUTER PROGRAMME

Programming for a computer is making use of a new and different language. *Appendix A* is a very simple programme written in Fortran II.

The programme is for the design of a simply supported reinforced concrete beam and was written merely for use as an example. To employ a computer efficiently this simple programme would be incorporated in a larger and more sophisticated one.

In the example use is being made of the Formula $M = Qbd^2$ to find the effective depth, d.

No mathematics or formulae, other than this empirical one, are used, the rest of the programme is taken up with computer instructions. Each line on the statement sheet, *Appendix A*, is an instruction to the computer.

"Read" means obtain from card, or tape, the input data.

"Format" tells the computer either how the data is being presented to it, or how to print the output.

"If" and "Go to" statements instruct the computer in various operations that it is to perform.

Making use of this programme and providing values of bending moments and trial breadths of beam, corresponding depths of beam are calculated at the rate of several hundred per minute.

Although one simple formula has been used and the programme is written, apparently, in English, it will be unintelligible to anyone without some knowledge of Fortran which illustrates that a new language must be learnt to understand computer programmes.

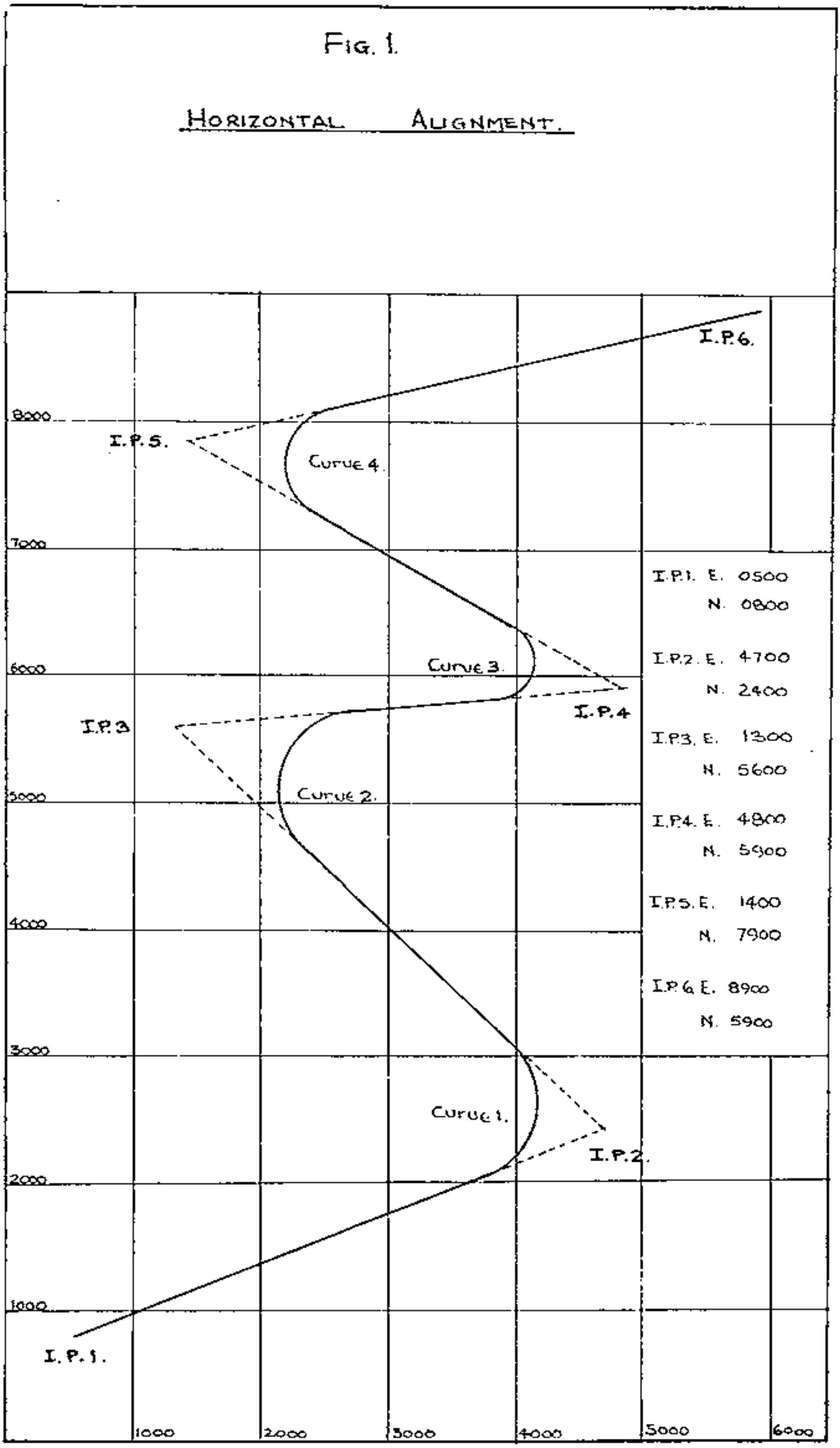


Fig. 1.
Horizontal Alignment.
8000
7000
6000
5000
4000
3000
2000
1000
1000
2000
3000
4000
5000
6000
I.P.1.
I.P.2.
I.P.3
I.P.4
I.P.5.
I.P.6.
Curve 1.
Curve 2.
Curve 3.
Curve 4.
I.P.1. E. 0500
N. 0800
I.P.2. E. 4700
N. 2400
I.P.3. E. 1300
N. 5600
I.P.4. E. 4800
N. 5900
I.P.5. E. 1400
N. 7900
I.P.6 E. 8900
N. 5900

Silver trophies

AUTOMATH STATEMENT

TITLE JOURNL   WRITTEN BY W. Cook   CHECKED BY ______   DATE 23 OCT 68   PAGE 1 OF 1

ABC	STATEMENT NUMBER	CONT	AUTOMATH STATEMENT	IDENTITY

```
      COMPILEX
TITLEJOURNL
      DIMENSION  DATE (1),  JOB (1ø)
      READ 1,  DATE,  JOB
 1    FORMAT  (A8,  6A8 )
      I = ø
 2    READ 3,  BM ,B
      I = I + 1
 3    FORMAT ( F12.ø,  F 6.ø )
      IF END OF FILE  9, 4
 4    D = SQRTF (BM / (184.ø * B ) )
      IF ( I-1- I/2ø * 2ø ) 7,5,7
 5    PRINT 6, JOB , DATE
 6    FORMAT ( 1H1/55B,1øHRE JOURNAL// 55B,11HBRIDGE BEAM//11B,1øA8,1øB,A8////
     C  27B, 6HMOMENT,28B, 7HBREADTH, 28B , 5HDEPTH / )
 7    PRINT 8 , BM, B, D
 8    FORMAT  (F 34.ø, F 33.2 , F 34.2 /  )
      GO TO 2
 9    STOP88
      END
```

APPENDIX A

AUTOMATH DATA SHEET

PROGRAM TITLE

WRITTEN BY W. COOK SECTION ______ DATE ______ TELEPHONE Nº ______

JOB REFERENCE ______

REMARKS INPUT DATA FOR HORIZONTAL ALIGNMENT

```
JOURNL
 0.0         0000.0      5600.0      4800.0      2500.0
 1100.0      5600.0      150.0       3000.0
 5700.0      5900.0      200.0       1500.0
 1800.0      7700.0      200.0       1500.0
 7700.0      8500.0      200.0       1500.0
 FINIS
 FINIS
```

APPENDIX B

AUTOMATH STATEMENT

JOB REF H/M.18 HATFIELD THORNE NORTH INGS INTERCHANGE S.E.SLIP ROAD HORANT RUN 1

		CH	E	N
A PT	END STRAIGHT START TRANSITION	11680.00	40296.34	40472.53
B PT	END TRANSITION START ARC	11680.00	40296.34	40472.53
C PT	END ARC START TRANSITION	12289.34	40271.83	41080.50
D PT	END TRANSITION START STRAIGHT	12639.34	40212.97	41425.47

TR = 3274.049987

R = 3274.050000

TR IS A CHECK ON THE DISTANCE FROM B PT TO CENTRE OF CIRCLE

COORDS OF THE THREE I.P.S USED IN CALCULATING THE CURVE

E	N
40291.610	40382.910
40317.470	40872.600
40157.030	41721.460

TRANSITION DETAILS

		TRANSITION A-B	TRANSITION C-D
LONG CHORD FROM TANGENT POINT TO END OF TRANSITION	=	0.000	349.956
TANGENT LENGTH FOR TRANSITION (X)	=	0.000	349.900
OFFSET FROM TANGENT TO END OF TRANSITION (Y)	=	0.000	6.235
DEFLECTION ANGLE TO END OF TRANSITION (DA)	=	0.00000000	1.02080694

WHOLE CIRCLE BEARING A TO B PT = 3.02292028

WHOLE CIRCLE BEARING D TO C PT = 170.31779350

APPENDIX C

"Bombs Penang"

MAJOR A. J. LOCH, RE, MI PLANT E

INTRODUCTION

The clearing of the island of Penang, off the NW coast of West Malaysia, of the Japanese bomb and other ammunition dumps by the Bomb Disposal Team RE (FARELF) started in March 1967 and has now been completed. This is an account of the first year's work.

HISTORY

During the last war the Japanese used Penang as a naval base. The harbour was used as a base for submarines and torpedo boats and the naval air force used the airfield. They went to considerable trouble to dig tunnels, pits, and cut-and-cover trenches in the foot of the hills near the main road on the east of the island for storing bombs, ammunition, fuel and other stores. When the allied bombing of Malaya started later in the war the Japanese moved also some of their workshop facilities into tunnel complexes.

At the end of the war a start was made on clearing the munition storage dumps using Japanese surrendered personnel as labour, but this stopped long before it was completed. Unfortunately, no records seem to have been kept of which tunnels had been cleared, which tunnels remained to be cleared, which tunnels contained workshops or stores other than munitions, or even where all the tunnels, pits and trenches were. Very rapidly the tunnels collapsed, trenches fell in and everything became overgrown.

From the few records that are available little subsequent action seems to have been taken until May 1956 when 163 empty bomb cases appeared in the Penang scrap market. These bombs were traced back to a complex at Bukit Gedong which consisted of six cut-and-cover trenches and it was estimated then that each trench might contain as many as 1,000 bombs. The Australian troop of 11 Field Squadron was told to clear the dump, but having nobody trained in bomb disposal the RAF were asked if they could provide an expert from the air base at Butterworth to advise on the condition of the bombs as they were unearthed and on their subsequent disposal.

Work started in August 1956 and to begin with there was total evacuation of the local population for 700-yds radius during working hours, but it was realized very soon that it was almost impossible to enforce this. The first plan was to stockpile the bombs until there were sufficient to justify a dumping run by an LCT but it was found that the bombs deteriorated rapidly once they were unearthed and the RAF advised against stockpiling. Instead daily dumping was resorted to using a pinnace from the RAF Marine Craft Unit at Penang. At least 198 × 60-kg bombs were dumped and another ten were blown on site, presumably because the RAF advised against their removal. Work stopped after only one trench was cleared because it had become apparent that the task was much greater than thought originally and engineer labour could not continue to be made available.

Clearance started again in June 1957, this time on Sungei Dua site 1. The labour was provided again from 11 Field Squadron, and the RAF provided technical advice and the dumping pinnace. But on 6 August there was a fatal accident and work ceased temporarily.

Clearance of site 1 was resumed in October 1957 under the responsibility of the DCRE Penang, the work being done by a PWD contractor's labour under RE supervision with RAF technical advisers. Instead of clearing the tunnels as they stood they were opened up from the top using a safe angle of repose of 45 deg. and no vertical face of over 5 ft being allowed. As the tunnels were under 20 ft or more of hillside, photographs of the work are rather reminiscent of archeological diggings in the Nile valley. Disposal was by demolition at a site that had been found towards the centre of the island and the demolition danger zone was fixed by the RAF at 600 yds radius.

The five tunnels of site I were cleared by the end of March 1958. Over 500 bombs had been disposed of ranging from 60-kg HE and incendiary bombs up to 300-kg anti-submarine bombs.

Clearance of other sites did not start because by this time Malaysia had become an independent state and "certain matters of principle had to be decided in London" before work could continue. However, an expert, Mr McKenzie, from the Ministry of Supply did visit Penang in December 1958. His conclusions were that provided reasonable care was taken it should be possible to dispose of the contents of these sites, however, "it should always be remembered that explosives are meant to explode".

By the summer of 1965 discussions had reached a point where it was very probable that the Corps would be asked to undertake the clearance of the whole of Penang Island on behalf of the Commonwealth office. As there was insufficient information on which to make any sort of plan, Major Qualtrough and Sergeant Cooke were sent to Penang in October 1965 to do as detailed a reconnaissance as they could in a month before going on to clear Betio in the Gilbert and Ellice Isles.

An account of this reconnaissance is contained in an article in the December 1966 *RE Journal*.

SUMMARY OF PROBLEMS

The major problem of a task of this nature was that of disposing of a considerable tonnage of explosives. Demolition is a slow process; sea dumping, although a much easier process, involved the availability of a seaworthy boat capable of making a 20-mile offshore journey to the official dumping ground. Loading a boat also presented problems as the bombs grew older because it became an unjustifiable risk to carry deteriorated bombs through a built up area to Georgetown docks.

The second problem which grew over the years was that of locating the bombs and digging them out. Initially this problem did not exist, but as the years grew long and memories grew short the task assumed almost more the proportions of a plant task than a bomb disposal one.

Explosive hazards are discussed below. There are obvious hazards in explosives of not very exact manufacture which have been stored in indifferent conditions over many years. It is believed that these hazards may have been over emphasized in the past and used to some extent as an excuse for avoiding the other problems. In fairness, however, it should be remembered that much of this period of history was overshadowed in Malaya by the emergency, that this was the main preoccupation of the military forces in the Far East and that the requirements of the emergency took priority. Also the inhabitants of Penang seemed to live in peace with the bombs on their doorsteps and generally seemed apathetic about their removal.

PREPARATION

As a result of Major Qualtrough's report and of the progress of the discussions between London and Kuala Lumpur, MOD arranged for a party of bomb disposal personnel to go to Penang and start work in about March 1967. The party was to be smaller than that recommended by Major Qualtrough and was to consist of a major, a sergeant and twelve ORs. No special manpower allocation could be made; the OC was to be held on the Depot held strength, the sergeant on the strength of the BD Unit RE and all the ORs, who were nominated by the Bomb Disposal Unit, were to be posted on paper to squadrons in FARELF. This was an unsatisfactory arrangement which caused much administrative work until approval was given early in 1968 for a special establishment.

Little was known about Japanese bombs, their fillings and the difficulties that might arise in dealing with them, most of the information available was contained in American Naval pamphlets of the 1945 vintage. A certain amount of theory was known about the possible effect of deterioration of the explosive fillings but there was no practical experience to tap.

"Bombs Penang" was chosen as the title for the operation and the team were designated the Bomb Disposal Team RE (FARELF). Although essentially a specialist team, there was no available engineer unit for them to support to do the task and they became in effect an independent unit administered by Penang Garrison, under command CRE Ops FARELF, and reinforced by a number of individuals from other units, vehicles from RCT and equipment from the Engineer Base Installation (See Annexe "A").

The OC, Major A. J. Loch, flew to Singapore on 7 February 1967 and after a preliminary reconnaissance of the sites, obtained approval from the Chief Engineer to start preparatory work for the disposal task, even though the agreement between the Malaysian Government and the Commonwealth Relations Office had not been signed.

The remainder of the BD engineers under Sergeant Duncan left England on 22 February and the team moved up to Penang on 9/10 March 1967.

Consideration was given at this stage to the provision of a boat for sea dumping. The only military craft sufficiently seaworthy to go 20 miles out to sea was an LCT which by regulation had to be escorted by another vessel large enough to pick up all the crew should there be an explosion, and the only escort the RCT could provide was another LCT.

As this would take half the fleet, "Bombs Penang" would have a serious effect on the movement of stores in FARELF and it was agreed that every other source of supply for suitable craft should be investigated before the decision was taken to use LCTs.

BOMB HAZARDS

Last-war Japanese bombs are crudely made by modern standards. This is partly because of the predominance of ship building in the pre-war Japanese engineering industry and also because often the bomb cases were manufactured locally in occupied territory. There is at least one engineering firm in Penang that was rolling bomb cases during the occupation.

The bombs found by the Team in 1967 were in the naval 60-kg, 250 kg and 500 kg ranges. None of the bombs were fused and the pockets were plugged. The bombs all had roughly a 50/50 case to filling weight ratio.

The explosive used in most of these bombs was picric acid. Being an acid it readily forms metal salts and all the salts are more sensitive than pure picric acid. Lead picric is the most dangerous having a sensitivity of a detonator filling; iron picrate is not very much more sensitive usually than pure picric, but under some circumstances can have the sensitivity of lead picrate, while copper picrate is just a little more sensitive than bulk explosive. The other explosive used was a TNA/HND (Trinitroanisole/Hexanitrodiphenylamine) mixture which when wet will form picric acid. Most of the 60-kg and 500-kg bombs were filled with picric while the 250-kg bombs were TNA/HND filled.

To prevent the fillings coming in contact with the metal of the bomb cases the inside of Japanese bombs were coated with a shellac type of varnish. The bodies and tail cones were filled with cast or block explosive and before screwing together a number of packing discs were inserted to stop the filling coming into contact with bare metal on the inside of the joint. Unfortunately, the joint was only a push fit, if that, and was not watertight with the result that over the years moisture was able to get into a lot of the bombs buried in Penang. Picric acid is readily soluble so when moisture got in the acid was able to attack the packing discs and get at the bare metal of the joint. Frequently the dilute picric had exuded and was present on the outside of the joint where it caused erosion and pitting of the case. In some cases when the earth surrounding the joint was cleaned off to examine it, the picric would start coming out under pressure, blowing bubbles and hissing. Luckily iron picrate is not usually dangerous when wet so washing off the exudate, either with water or with liquid paraffin, reduced considerably the risk of an explosion.

In one tunnel the locals had removed the nose fuze plugs because they were brass but had left the brass grub screw. A lot of these bombs had then exuded as there was nothing retaining the picric filling except the varnish shell. The fuze pockets in the 500-kg bombs were plugged with wooden bungs in a brass collar and in a high proportion the wood had rotted allowing exudation over the brass. In both these cases there was a risk of copper picrate. There are no field tests for sensitivity, indeed one of the laboratory tests is to dry the sample and then hit it with a hammer.

But in addition to the explosive risk picric and TNA/HND were most unpleasant to deal with because on some people it blistered the skin very readily. It could be absorbed through the skin or inhaled, and attack the liver and kidneys. In sufficient quantity it will cause death.

Picric was also used in the Torpedo warheads found by the team but the mines contained "type 88" explosive, a dark grey powder which is a mixture of ammonium perchlorate, silicon carbide, wood pulp and crude oil. Little seems to be known about this explosive except that it is sensitive to friction, becomes more sensitive with deterioration, has a relatively low ignition point and burns very fiercely, however it is not, apparently, toxic or a health hazard.

Use of picric as an explosive filling ceased in Western countries in 1918? because of the hazards, and little information seems to be available now about the size of safe and toxic doses and other problems connected with its use. Manuals mention in general terms that it is dangerous but give no specific detail. The only field test seems to be to see if it stains fingers yellow, a procedure not recommended by medical authorities, but there is no other.

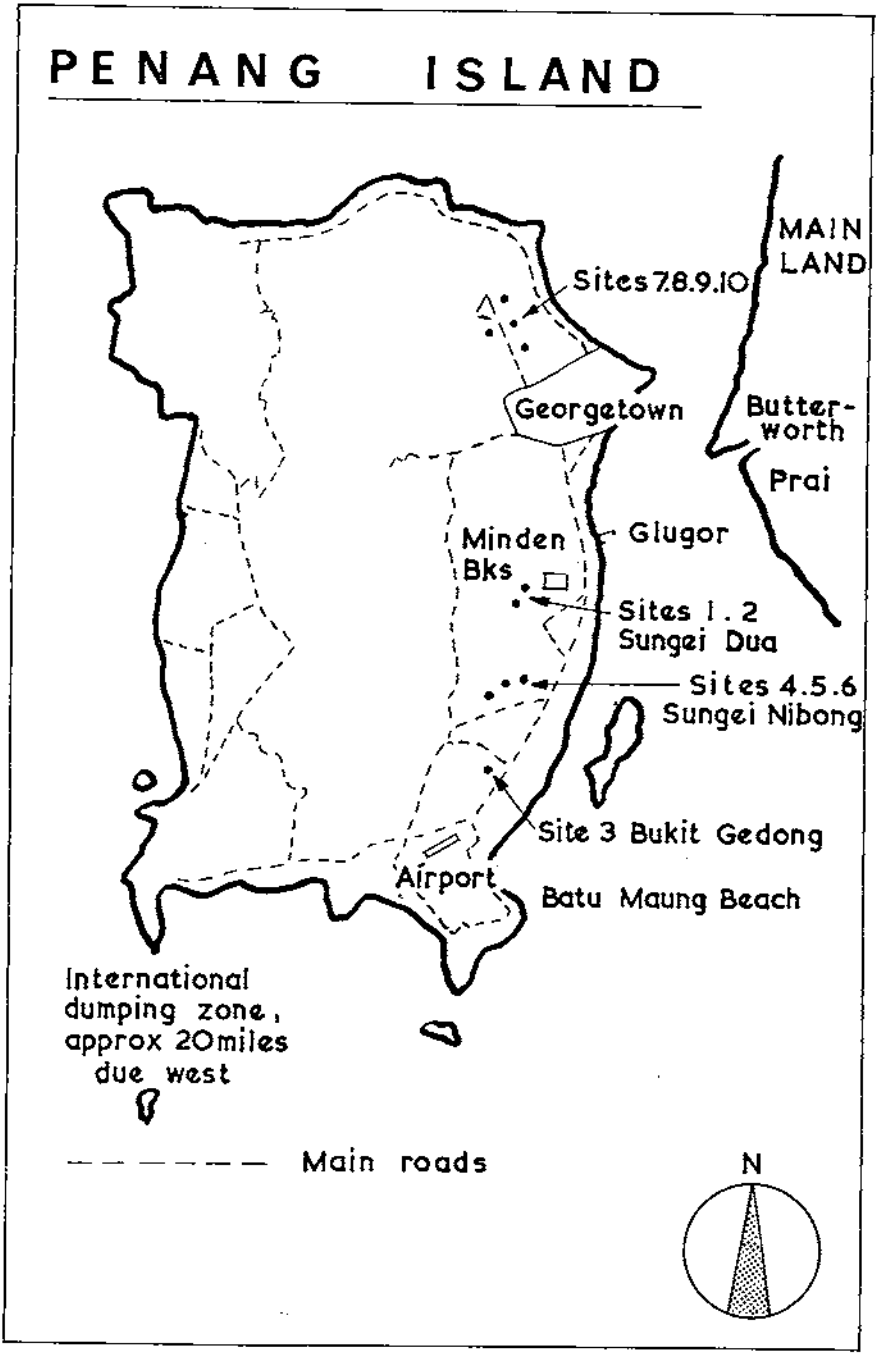
PRELIMINARY WORK

Because explosives were known to be present in the southern sites it was decided to concentrate on them first and the operation started with sub-surface location of site 4.

Bomb location equipment was described in an article in the September 1966 *Journal*. The team had two surface locators and one borehole one, all German commercial equipment. For sinking boreholes the team had two Australian Proline augers, commercial light mechanical equipments. They will drill a 4-in diameter hole up to about 50 ft deep; in clay they are excellent and they will drill through soft rock, but in Penang where the soil is a sort of mixture of sandstone, clay and laterite with rocky outcrops they had their limitations. Drilling speeds were on average two 35-ft deep holes per auger in a day, although in one day in a patch of clay three holes to a total depth of 101 ft were drilled. When the Prolines could not be used, usually because of the steepness of the hillside, hand augering was used with specially made 6-in and 4-in heads on an ordinary earth auger; a very slow and tedious method.

Later mine dogs were tried but they proved unsuitable in these circumstances. Dowsing (divining) was also tried.

It proved almost impossible to do any sub-surface location in the first four tunnels because of the amount of rock, but in digging out the earth that had fallen into the mouth of one tunnel, a 60-kg bomb was found under about 10 ft of earth, although this had not been found by the Qualtrough reconnaissance. Not being allowed to dispose of this bomb, it was reburied. In the fifth tunnel a consistently high reading was obtained at about the same depth from a number of boreholes so that the OC decided to investigate his hunch of railway lines by digging into the entrance. Sure enough lines were found within a few feet. But other objects were found also which could not be identified immediately. There were a lot of very rusty tins empty except for a bakelite tube down the centre, and, while several guesses have been made, these have still to be indentified. There were also some boards which had held bomb fuses and a number of full and sealed metal canisters which were subsequently identified as sound missiles (practice depth charges). As there is no safety pin and no way of telling the state of the contents, it was considered that these objects should not be moved further than absolutely necessary and any more should be disposed of by


PENANG ISLAND
MAIN LAND
Sites 7.8.9.10
Georgetown
Butter-worth
Prai
Glugor
Minden Bks
Sites 1.2 Sungei Dua
Sites 4.5.6 Sungei Nibong
Site 3 Bukit Gedong
Airport
Batu Maung Beach
International dumping zone, approx 20miles due west
Main roads
N

blowing with a turn of cordtex on site. But this was not decided until after one had been taken back to camp for cleaning, X-raying (with the MRS X-ray set) and photographing, and had been taken apart.

Location continued on sites 4 and 5 with various degrees of success until July. Difficulties were experienced with the augers and the locators, all of which required a considerable amount of REME attention; the reason was probably the high temperature in which these equipments, built in temperate climate, were operating. Once the team became acclimatized the working day was 0745–1630 hrs with one hour for lunch, five days a week.

Very early in the operation it was realized that another bomb disposal sergeant was essential and in June Sgt Wood arrived from the BD Unit RE. In anticipation of full permission to start work being given the plant arrived from Singapore in early May together with a plant fitter capable of operating. The plant was landed from an LCT on a routine voyage on to a beach in Georgetown, and as this had not been anticipated by the dispatching unit in Singapore the results of the wade ashore gave trouble later on. Subsequently, more plant and a plant operator swelled the plant section.

On 11 June, as a result of a report of an explosion one evening from the direction of site 3, the OC visited it and found that considerable local enterprise digging had been going on. The estimate was that at least 100 × 60-kg bombs had been removed. The police were informed and found sixteen opened bombs the next day higher up the hillside, and subsequently another eight were found a little further away. All but six of the bombs were practically empty and were taken back to camp to be completely cleaned out and the explosive burnt. The six half-full ones had to be left on the hillside under police guard until permission was obtained for them to be dealt with, when they were dumped by the RAF Marine Craft Unit.

The discovery of this local enterprise activity may have influenced the signing of the agreement and permission to start full-scale bomb disposal operations was given on 15 June.

Discussions in Singapore about dumping craft had resulted in no alternative being found to an LCT but the RAF had agreed to provide a launch from the MCU at Penang as the escort vessel when it was not required for range duties. The first LCT for dumping would be provided in late July and the LCT would be changed fortnightly. Meanwhile, a Uniflote arrived from 10 Port Operating Squadron RCT, with a crew of four, three of whom were ex-sappers, for ferrying the bombs out to the LCT from a ramp at Glugor.

In early July the CO of the BD Unit RE visited the team for a week and was able to agree to the disposal methods to be used. He also agreed that although HQ Penang Garrison were doing the local administration for the team, another sergeant was required urgently to help the OC and troop sergeant with all the rest of the administration, and stores accounting. He materialized in early October.

METHOD OF WORK

Digging the bombs out and subjecting them to changes in temperature and hence internal pressure resulted in the rapid deterioration of some bombs. Because of this it was decided that the picric-filled bombs should be dumped the day they were dug out. The procedure adopted was to leave about two ft of earth on the bombs until the dumping day, when the bombs were uncovered and initially inspected by one of the sergeants. Provided there was no bad exudation they were dug out and re-inspected by the OC who removed any earth from around the shoulder joint and nose if necessary. All "leakers" were cleaned by the OC with liquid paraffin or water. About 40 × 60-kg bombs were put on to each of the two trucks and escorted to the LCT by the OC where they were loaded by a party under the other sergeant. The OC made a final check for "leakers" before the LCT sailed and sometimes found new ones. Either the OC or one of the sergeants sailed on the LCT to supervise dumping. Thus the bombs were kept under observation all the time, but should there be an accident never more that two seniors would have been involved. The TNA/HND filled 250-kg bombs were not so prone to exuding with the change in temperature so to reduce handling on dumping days they were dug out the preceeding afternoon and stock-piled in the trench. All bombs were covered with wet hessian in an effort to reduce the difference in temperatures and to keep any exudate damp. No attempt was made to evacuate any of the civilian population because of the difficulties of enforcing it. The State Authorities accepted the risk.

CLEARANCE OF SITE 3

Clearance of site 3 started on 24 July following a visit to the area by the Chief Minister of the Penang State Authorities who asked the locals to co-operate and told them what was going to happen.

Site 3 consisted of five trenches that had fallen in so the bombs were under only about a foot or so of earth at the front and about 8 ft at the back. The trenches were all about 60 ft long. To give working space the tractors cut a trench alongside the original one and the spoil on the top of the bombs was thrown into this trench and removed by the tractors. Four trenches held 60-kg bombs stacked across the trench in two rows but there was no uniformity in the height of each row; sometimes it was one or two high and occasionally five or more high. There were also gaps with no bombs at all. The fifth trench held 250-kg bombs uniformly stacked in one row two high with the dunnage still in good condition.

Because the RAF escort launch was available only on Tuesdays and Thursdays, work quickly settled into a routine of Monday—remove most of the overburden from the bombs to be dumped on Tuesday; Tuesday—clear remaining overburden, load bombs into trucks, transfer to LCT, then while half the team sailed on the LCT to dump the bombs the other half continued digging; Wednesday and Thursday as for Monday and Tuesday, leaving Friday spare for extra work on the site in the morning and administration and tool cleaning and checking in the afternoon. All the 60-kg bombs were "humped" by hand and it was soon found that about eighty was a fair day's work (about 5 tons) although 100 was tried one day.

The bombs were swung aboard the LCT on a pallet and the whole loading operation took about 1½ hours. When extra sections of Uniflote were sent up from Singapore it was possible to take two trucks out at once and the loading time was reduced by about ½ hour. On the LCT the bombs were stacked on the starboard catwalk although handling them there was very awkward. The trip from the loading point out to the International Dumping Area was about 32 miles and took up to 4 hours, or more if there were contrary tides and seas. The first dumping period was during the south-westerly monsoon when the sea was never calm, the LCT always rolled and on one occasion the dumping party waiting on the catwalk were getting wet as the LCT ploughed into the rollers. However only one of the team was seasick, which is more than can be said for some of the LCT crews! On arrival at the dumping area the LCT hove to, a chute was hung outboard from the derrick at the forward end of the catwalk and the 60-kg bombs slid down it into 20 fathoms. Unlike loading, dumping was very slick and the record for eighty bombs was about 10 min with a working party of only one sergeant and four. Had the bombs been stacked in the tank deck dumping would have been much slower. If the seas permitted, the dumping party transferred to the escort launch for the return journey and came back at over 30 knots.

Difficulty was experienced in dumping the 250-kg bombs. Because they could not be manhandled down a chute, the proposal was to dump them through the bow doors by driving a fork lift tractor to the end of the ramp which would be held level. After the first two had been dumped this way the LCT captain stopped it for fear that the tractor would be banged into one of the bow doors by a wave. No need for an alternative had been envisaged so that the best that could be thought of at the moment was lifting the bombs overside on the derrick and cutting the rope sling with an axe. This worked all right but used up a lot of the LCT's mooring ropes!

Photo 1. Loading 60-kg bombs onto the Uniflote at Batu Maung beach, during the period when the ramp, used normally for loading trucks on to the Uniflote, could not be used.

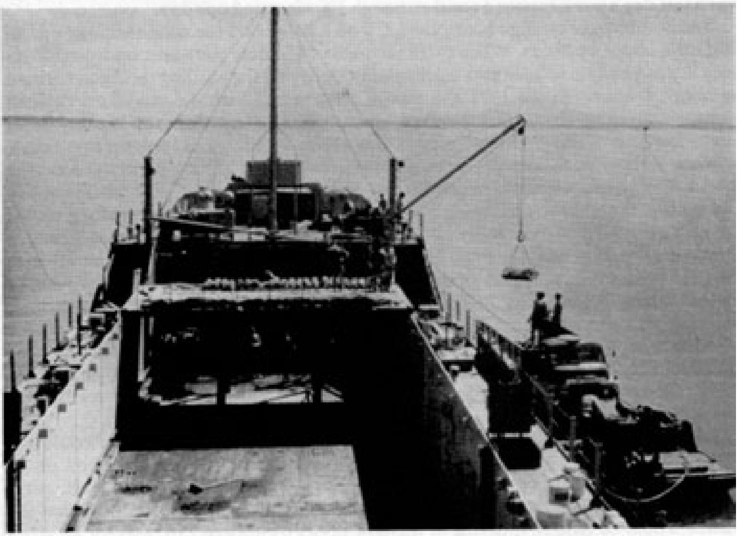


Photo 2. Transferring 60-kg bombs from a truck on the Uniflote onto the LCT in February 1968 when the false decking was in use. Before this the bombs were stacked on the starboard catwalk amongst all the hatches, vent pipes etc.

Bombs Penang 1 & 2

Dumping continued up until 3 October when site 3 was cleared, the score standing at 1,229 × 60-kg and 95 × 250-kg bombs, or 95 tons approx, and over 1,000 cu yds of earth moved; however there were several earlier occasions when it nearly stopped. For a fortnight the RAF could not provide the launch but the RCT solved this by sending up a second LCT. One day the captain of one LCT was rushed to hospital but the threat of the OC of the team and the OC of the RAF Marine Craft Unit taking the LCT out was enough for the RCT to fly a relief captain up from Singapore just in time. Another day all the LCT engine room staff went sick but this was solved by transferring the engineers off the Uniflote. One day the sea even on the mainland side of the island was too rough for the Uniflote to operate so the bombs had to be taken back to the site and reburied. Another hitch occurred when the ramp used by the Uniflote had to be closed for repair for a month, and hand-loading on to the Uniflote over Batu Maung beach had to be resorted to.

The condition of the bombs varied considerably. In places as many as one bomb in three were exuding to some extent or showed signs that they had exuded. One 60-kg bomb, as soon as the mud was cleaned from the joint between body and tail, started to exude under considerable pressure and the decision was taken to destroy it by blowing it up on site. Luckily it was the last bomb in that trench. The police were asked to clear a danger zone which they did by sending down a company of riot police who fanned out and cleared everybody from in front of the trench for 600 yds, the hillside behind giving cover in that direction. A successful low order detonation was achieved. The remains of the bomb case were dumped the next day but some of the toxic picric explosive had been scattered over the excavation. What could be collected and burnt was, the remainder buried as far as possible and the walls of the excavation washed down with water. The OC and Sergeant Duncan made the mistake of going into the excavation too soon after the detonation and both had to retire to bed during the next twenty-four hours. Because of the problem connected with disposal of the residue of a low order demolition it was decided that any more disposal by demolition would be high order if this was possible. Luckily all the remaining bombs handled in the first year were considered safe enough to dump.

FURTHER LOCATION AND "OTHER FINDS"

The clearance of site 3 coincided with the withdrawal of the RAF launch to Singapore until the New Year, so a return had to be made to location in sites 4, 5 and 6.

One proline auger had been in Base Workshops since July and the other went in in October, but wherever surface location or boreholing with hand augers could be done location continued. As a result the presence in a tunnel in site 4 of several large metal cases, probably holding torpedo warheads, was confirmed. Forty gallon drums containing oil were found in a tunnel in site 5. To prove another tunnel one of the wheeled tractors dug it out along its full length down to the tunnel floor level. Although over 1,000 cu yds of earth had to be removed this was done in not much over one week and proved quicker than if boreholing and sub-surface location had been used. In another tunnel that was still standing for most of its length a great many surface readings were obtained which turned out to be over sixty-five timber dogs when they were dug to, and some were 5 ft down. In yet another tunnel when the tractor was digging out the entrance five weird objects were found looking as if they had come from outer space. They turned out to be mine-clearing devices containing 30 lb of HE and they had to be stored for subsequent dumping. They had not been picked up by the locators at a range of 4 ft.

Meanwhile a timbered shaft was sunk in the middle of one of the longest and deepest tunnels where large readings had been obtained. As it was estimated that whatever was there was about 35 ft down, plant was used to dig out a broad cutting about 15 ft deep, and in the bottom of this a 8 × 13½-ft shaft was sunk. Plant was also used as much as possible in digging the shaft as it was considered unlikely that vibration would be dangerous to whatever was buried. A backacter dug to nearly 10 ft at one end and 4 ft at the other end, and after that it was used for removing the spoil by attaching a skip to the bucket. At about 18 ft the first of a row of sea mines was located.

Sea mines were beyond the scope of the team so an appeal for help was sent to the RN Fleet Explosive Ordnance Disposal Team in Singapore and the Mine and Bomb Disposal Officer and his CPO flew up. The mine was pulled into the shaft and lifted out, using the Bray tractor winch with a snatch block hung from the forks as a crane. The mine was in an incredibly good condition, the rubber gaskets being serviceable and the electrical wiring looking as good as new. It was filled with type 88 explosive and had a picric acid primer. Japanese packing labels (printed on the back of British army forms) showed that the primer had been made in 1939, the bulk explosive in 1942 and the mine had been filled in 1944, which indicated that it had been filled in Penang because the allied blockade would have prevented it being shipped in 1944. The packing notes identified the mine as a type 93 model 2 and gave details which did not entirely agree with the US Naval reference books. The type 88 explosive was burnt and the picric primer detonated. The RN EOD Team also confirmed that the contents of the metal boxes that had been found in site 4 were torpedo warheads but could not positively identify them with the US reference books in their possession.

Just before Christmas a tunnel in site 5 was opened up and at about 20 ft in, a mass of small shells were found on, under, and around a pair of railway lines. The nose fuses of most of the shells were just a mass of grey corroded metal and closer examination showed that these shells had been the projectiles of fixed ammunition, but the cartridge cases had been literally hacked off with an axe. Later two shells were found with nearly intact fuses and it was possible to identify them from the fuze markings as German 105 mm anti-aircraft shells. Mixed up with them were other smaller shells, picric primers from sea mines and all sorts. Further digging disclosed three net mines and the start of a row of 250-kg bombs. The Command Ammunition Technical Officer was summoned and he advised that although the fuses were in a very bad state the shells could be sea dumped provided care was taken.

Over the Christmas holidays "private enterprisers" dug up the two torpedo warheads that had been unearthed for the RN inspection and emptied them of the explosive filling. They left a considerable amount of picric powder all over the area which was not very pleasant. It is almost certain that the explosive, over 500 lb, was sold to the fisherman who fished on the 30-fathom line some 90 miles out.

DISPOSAL RESUMED

An LCT became available for dumping again towards the end of January 1968. This time the escort was a Royal Malaysian Navy patrol craft because the RAF had said they could no longer provide their launch.

In the middle of January a party from the Naval EOD team in Singapore came up to help clear the anti-shipping devices in site 4—torpedo warheads and net mines—and the net mines in the tunnel where all the shells had been. The Navy were keen also to get another sea mine out of the shaft. The sea mine and the net mines from the shell tunnel gave no difficulties; but the net mines in site 4 proved to be under further rock and getting them out by digging down into the tunnel floor was not possible. Instead the tunnel had to be dug out from the entrance and the final score from this tunnel was sixteen net mines and ninety-six bombs in the 60-kg range. Some of the bombs were incendiaries using the 60-kg bomb case but heavier—appreciably heavier to those handling them—and one was a 63-kg bomb with a streamlined case.

The bombs were dumped at sea without trouble, as were all the shells and other things that had been found since the dumping had stopped, but disposal of the net mines was a problem. These mines, which were for attaching to boom nets, were so ballasted that they floated at any required depth, so obviously they could not be dumped as they were. It proved impossible to open the buoyancy chamber so the only solution seemed to be to remove the base plate, take out the explosive, burn it and dump the remainder. The filling was type 88 explosive. Because of its sensitivity

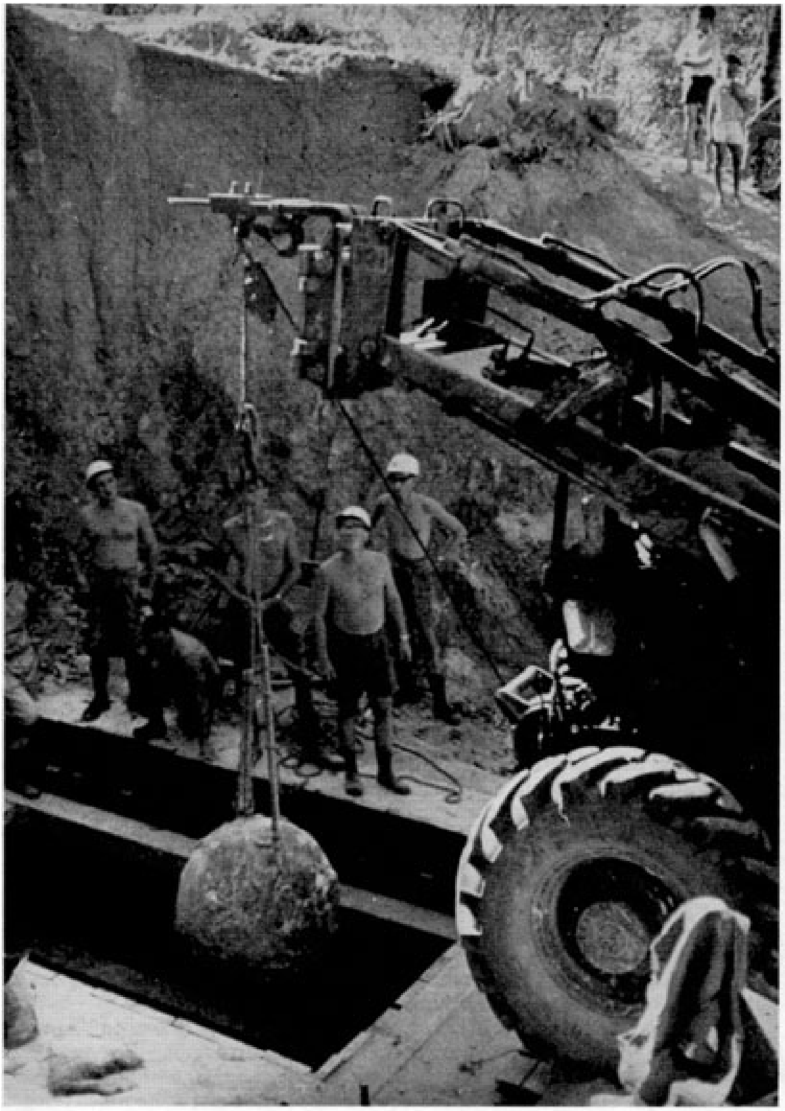


Photo 3. Lifting a sea mine out of the shaft in site 5. Note the use of the Bray tractor's winch and forks as a crane. CPO Bray, RN, EOD team (kneeling), is examining the mine while Sergeant Duncan (nearest tractor) watches for chock-a-block.

to friction it was decided that the mines should be opened adjacent to the tunnel and the filling burnt there. It was during the burning of the filling from the first six mines that an accident occurred which resulted in Sergeant Duncan and Sapper Wardle both being very seriously burnt. Luckily their fitness, determination and good nursing enabled them to recover quickly and both were back to work in three months. The remaining ten mines were left in the stockpile pit until another means of disposal had been worked out with the Royal Navy.

Digging out the torpedo warheads was fairly straightforward and a total of thirty-five warheads were eventually found, in places stacked three high. But because the cases were relatively thin metal and the warhead bodies were only light gauge, sub-surface water had caused a tremendous amount of exudation which contaminated the whole working site. When some of the cases were lifted they dripped picric acid solution and on the last few days there was a pool of dilute picric in the bottom of the site about 8 ft long and over 1 ft deep. However, working on the theory that the risk is from dry picrates all the torpedo warheads were dumped as they were. Dumping was not difficult, in spite of the cases weighing over 400 lb each, as the monsoon had changed and the seas were calm enough to allow dumping through the bow doors.

Whilst the area was being tidied up a lump of lead was found that had obviously come out of a recess in one of the warheads that the "local enterprisers" had emptied. Although there was no mention of this lead weight in the reference books it must have been in all the warheads. In view of the amount of exudation that had been present in most of the cases the team were perhaps fortunate not to have had an accident from lead picrate. All in all this tunnel was easily the worst that was tackled in the year.

At about this time news came through that a temporary establishment had been approved for the Team, roughly the same as the unofficial team, and it was agreed that all the original team who left England in February 1967 would be replaced over the period March to May 1968 because it was considered that about one year on the job was enough.

When the two tunnels in site 4 were cleared operations were moved to site 2. This consisted of two tunnels only that were linked at the back. The beginning of the southern tunnel was still standing and a number of bombs were visible, but the collapsed portion started about 40 ft in and there was no saying what was behind the fall. The northern tunnel had collapsed completely but Major Qualtrough had found 500-kg bombs at the beginning of it. Tunnelling was out of the question and the only way was to dig down from the top mainly with plant, accepting, while the dry weather lasted, near vertical sides to the excavations. There was something like 3,000 cu yds of earth to be moved, and if the rains came before all the bombs were removed it might go up to 5,000 cu yds. As the CRE said, this site was 80 per cent an earth-moving problem and only 20 per cent bomb disposal.

To begin with the job went easily, 221 × 60-kg bombs being got out of the southern tunnel before the fall was reached and 14 × 500-kg bombs from the northern tunnel before the tunnel depth got so great that major earthworks were required. Handling of the 500-kg bombs on the site was made much easier by having a Hiab crane on one of the replacement 3-ton trucks.

Handling on the LCT was improved because Engineer Workshops in Singapore had built a staging to go on the tank deck that provided a loading deck across the well level with the coamings. The 500-kg bombs were dumped by pushing them along a roller conveyor on this false deck and down a very substantial chute which bridged the catwalk. After a good start, extraction had to stop while major earthwork was done, and this in turn was held up by breakdowns on all the tractors. Although most of the 60-kg bombs from this site were in a better than average condition, one was found that had been lying in a void and had a classic example of dry picric crystaline formation on the outside. It was most attractive but very nasty.

The final load in the first year's work in Penang was got out on 7 March, the day before the OC finished his hand-over to Major M. J. V. Hoskins, and while the CO of the BD Unit RE was paying his second visit. This load of 34 × 60-kg bombs and 8 × 500-kg bombs brought the total for the first year up to 1,880 objects disposed of (about 150 tons) (for details see Annexure "B").

THE FIRST YEAR'S ACHIEVEMENTS

The Qualtrough report had said that a team of two officers with three sections would take nine months to clear sites 2 and 3 and one tunnel in site 4, and to check all the other sites. In the first year a team of one officer and two sections cleared site 3, two tunnels in site 4 and had made a good start on site 2. (This side of the operation took only sixteen weeks). In addition they had got rid of a considerable number of other objects found over the year in other tunnels/sites and had, despite major breakdowns in equipment, managed to prove most of tunnels in sites 5 and 6. No work had been done on the northern sites 7–10.

PLANT, MT AND EQUIPMENT

The plant chosen for the operation was limited by what could move about the island on its own, without having to have a plant transporter train. But because of the distance of Penang from Singapore and the delays involved in getting any plant up from there, the family had to be arranged so that there was always a "back up" machine and work would not be held up if one machine broke down. Hence there was a winch on the Drott and on the Bray, and when the Bray was replaced by a Michigan one of the 3-ton trucks had to be changed for one with winch. The Morewear was backed up by a Ferguson tipping trailer; the Michigan and one Ferguson both had forks; the Drott was backed up by wheeled shovel tractors; there were two Ferguson backacters.

A most useful attachment was the Hiab crane on one of the 3-ton trucks. Not only did it allow the truck to load itself with the bigger bombs but it meant that the driver and only one man could load parcels of timber and other stores.

A problem was to give the senior NCOs mobility. This was solved by the OC buying a light motor cycle off a departing officer and letting the sergeants use it.

The biggest problem with equipment was supply and replacement. All stores were issued by EBI in Singapore who either drew from Ordnance or supplied Engineer items from stock. They were sent up either on the fortnightly LCT or by goods train which took up to a fortnight. Either way the stores were subject to Malaysian custom formalities. The result was that the supply of even such common items as shovels or pick helves took anything from one to three months. Specialist equipment took much longer. The timber for shafting was ordered in June and arrived in November, pumps ordered in August had not arrived in March, while replacement batteries for the older locators ordered from UK never arrived at all because they were on a ship that got stuck in the Suez Canal. The difficulty therefore was to try and forecast requirements months ahead, when it was impossible to say what problems would have arisen, and to strike a happy mean between having the work held up for lack of tools and building up a stores "sub-depot" to cater for all eventualities. Luckily the OC was given local purchase powers of up to £10 a month.

SUPPORT

Once the other units in Penang understood the difficulties the team were having to cope with, their support was wonderful. In particular the local detachment of the REME Workshops could not have been more helpful. The team were given a high priority and whenever a vehicle was put into workshops, usually straight off the site and dirty, tradesmen were taken off other jobs to cope. This wonderful REME support was a very great morale booster. Very good support was given as well by the RCT transport troop in Penang who always managed to provide a temporary replacement for any of the team's vehicles that were VOR. The Station Medical Services were very helpful and it is probably due to them that both men injured in January are alive. They made very comprehensive plans for coping with any accidents and

Photo 4. Loading a 500-kg bomb on to a truck with the Hiab crane, site 2, Sungei Dua Dua. Two bombs have been loaded already and are chocked with sandbags.

Bombs Penang 4

arranged clinics and outstation visits so that there was always one MO on immediate call whenever the team were handling bombs.

MORALE

Bomb disposal has earned a reputation, undeserved in peace, for being a dangerous occupation. "Bombs Penang" has earned over the years an added reputation for being a very difficult task, and one expert had said it could not be done without an accident. Undoubtedly most of the team knew something of the reputation of the operation and there was therefore a morale problem peculiar to this type of task which was perhaps not appreciated by all the staffs involved.

In particular the wives must have often wondered when they saw their husbands off to work, if they would see them back in the evening, and this of course, got far worse after the accident when it became necessary to arrange for a wife to be reassured if her husband was kept working late. Unfortunately it was not possible for all the married men to live near each other and families were scattered up to as far as 12 miles away.

Paradoxically maintaining the morale of the men was much easier. The fact that the team were spared routine military duties meant that they could concentrate their energies on the task. It was a job also with a purpose and in which definite progress could be measured. Although visitors were so frequent that at times the OC was hard put to cope, their presence reminded the team that everybody was taking an interest in the task. Over the year senior visitors averaged more than one a week. A visit by a PR team resulted in most of the team appearing in their local papers and one being reported on by his BBC local station. But probably the greatest factor was the men themselves. With one exception all were hand-picked, above average, intelligent enough to appreciate the dangers and all could be trusted not to do anything stupid. Each had confidence in the rest.

LESSONS

The fundamental lesson on this task, as on any other, is that there is no short cut from detailed forethought and planning. When undertaking a task a long way from a centre of support, and involving a number of staff branches, this lesson is emphasized by the time it takes to effect even a minor change of plan.

The critical activity in a critical path analysis of this job was the OC's employment. A second officer would undoubtedly have helped to speed the task.

A tendency which had continually to be watched was that of overconfidence. In particular in bomb handling, the maxim that familiarity breeds contempt showed its truth.

In a small unit in a remote place, versatility of the individual was a great asset. One of the most useful members of the team was the Combat Engineer Lance-Corporal who was originally attached for administrative duties. He was also an Electrician RE (useful for self-help lighting of the canteen), quite an adequate carpenter, had taken mechanical drawing for ACE and could drive a vehicle and ride a motor cycle. And if three of the Bomb Disposal Engineers had not been able to drive, frequently vehicles or plant would have been idle. If the pattern of Corps activities is to accept a variety of jobs in underdeveloped areas, or away from normal military support, the value of training men to turn their hands to many trades is stressed.

EPILOGUE

No apologies are offered for the length of this article. It is the history of the first year of an intensely interesting operation, full of problems and challenges, often unpleasant, never dull, always rewarding.

It is sometimes said that the best command is a troop, but most troop commanders do not appreciate this and long for a Squadron. I consider myself very fortunate to have gone from commanding a Squadron to commanding a very independent Troop of above-average soldiers engaged on a very worthwhile job. It was hard work but I shall never regret it.

ANNEX "A"

COMPOSITION OF THE BOMB DISPOSAL TEAM RE (FARELF) MID 1967 TO MARCH 1968

OC—Major	1	from UK
BD Sergeants	2	from UK
BD L/Cpls	2	from UK
BD Sprs	10	from UK
Plant Fitter L/Cpl	1	Attached from units in FARELF
Plant Op Spr	1	Attached from units in FARELF
Combat Engr L/Cpl	1	Attached from units in FARELF
Driver RE L/Cpl	1	Attached from units in FARELF
Driver RCT L/Cpl	1	Attached from units in FARELF
Driver RCT Dvr	2	Attached from units in FARELF
Sgt RE	1 (for Admin duties)	Attached from units in FARELF
Total	23	

Vehicles

1 × $\frac{1}{4}$-ton Landrover
1 × $\frac{3}{4}$-ton Landrover
2 × 3-ton trucks (1 × GS, 1 with Hiab crane)

Plant

2 × light wheeled tractors
2 × ultra-light wheeled tractors
1 × light crawler tractor with Drott 4-in-1 bucket
1 × Morewear tractor and dump trailer
1 × Ferguson tipping trailer
1 × 7-ton low loading trailer

ANNEX "B"

"SCORE" OF BOMBS AND OTHER EXPLOSIVE WEAPONS DISPOSED OF

Bombs 60 kg	2,260
Bombs 63 kg	1
Bombs 250 kg	109
Bombs 500 kg	70
Sound Missile Mk 2 (Practice Depth Charge)	211
Sea Mine, type 93	2
Net mines, type 96	55
Explosive hooks, Mk 2 (Mine Sweeping Devices)	22
Torpedo warheads	74
Torpedo exploders	47
Depth charge pistols	225
Depth charge boosters	68
Sea mines	13
Picric intermediaries	228
Depth charges	122
Shells	122

Total tonnage clearance from the Island before work completed about 255 tons.

Tools and Techniques

COLONEL D. SHERRET, MC, MARCH, ARIBA

A Study of the Attributes, Methods and Techniques of Certain Interrelated Disciplines and their Application to the City Planner. Presented to the City and Regional Planning Department of the Catholic University of America, Washington DC.

> "To make a plan is to realize an idea, for in making it all the factors physical and aesthetic that bear on a problem have to be considered. Out of these factors a solution must be sought that will harmonize all."
>
> VERNER O. REES, ARIBA
>
> *Plan Requirements of Modern Buildings*, 1931

INTRODUCTION

CITY planning is a vastly complicated procedure which must take account of a broad range of factors and numerous variables. This applies to such a degree that a state of unmanageable complexity may appear to be approaching.

Certainly the time is past when the architect could sit in isolation and like Sir Christopher Wren, with inspired detachment, remodel a city. Past too is the hey-day of the city engineer, who, in the absence of a comprehensive plan to regulate with efficiency and vision the evolution of the city, directed and controlled its growth within a framework of sewers, water supply, and drainage systems.

Something more than inspiration and technical knowledge is required, but what? Let us consider first the aims or goals of city planning. These have been variously described but the two definitions which I believe most aptly illustrate this hypothesis are:

"The broad objective of city planning is to promote the welfare of the people in the community by helping to create an increasingly better, more healthful, convenient, efficient, and attractive environment."[1]

"Planning is an evolutionary process which utilizes the various techniques and methods of interrelated disciplines in defining problems, establishing goals, and evaluating alternative courses of action to provide a framework for making rational decisions to effectuated programmes to the development of a sound community."[2]

Each definition projects a width of interest and responsibility far beyond the confines of one discipline or profession, and points back to the complexity of the problem which would appear to be mainly one of co-ordination and direction. Is this co-ordination and direction the main role of the planner? Is there at last a place for him as a key figure in society? I am in no doubt that the answer to each question is in the affirmative but it is equally apparent that the task of effective co-ordination and direction will, as the complexity of planning problems increase, be quite beyond the capability of any planner unless he has adequate tools for the job. As a comparatively recent creation he does not fall heir to these; he must design or borrow them.

In science advances rest on the basis of prior knowledge, and it is accepted that one of the principal methods by which science evolves is by the transfer or application of a principle or technique discovered in one field to another field where it is frequently instrumental in bringing about further discoveries. This is known as the transfer method in scientific research. An extension of this principle is that disciplines once separate are linked by newly discovered connections, and the projected emphasis or capability of one field permeates other fields which have become more closely related. This twofold concept has application in planning. Obviously, the most fruitful source for borrowing or transfer of techniques, methods or attributes, the tools of the planner, are the interconnected professions and disciplines; but the net can with advantage be spread further. In illustration, it is generally accepted that the planner must look ahead and plan for many contingencies. In no field is the ability

[1] Mary McLean (ed.), *Local Planning Administration*, 1959, p. 10.

[2] Juan A. Casasco, *Lecture to Graduate Students at C.U.A.*, 3 October 1966.

to look several moves ahead, to anticipate various courses of action, and to weigh up consequences more necessary than in the game of chess. Henry Wright was a great lover of chess and he used to say that his skill in chess made a better planner of him; ready with alternative solutions, able to think many moves ahead, trained to co-ordinate many variables. Certainly for him planning itself appeared to have all the excitement of that noble game.[3] This paper is not, however, aligned to the chess board; instead, it will consider various professions and disciplines, mainly those with which I have been directly concerned, and will attempt to relate these to the planner and his needs.

OBJECTIVES

The objectives of this paper are:

1. To examine the methods, attributes and techniques of military science, architecture, ecology and operations analysis.
2. To suggest those tools of each discipline which the planner could, with advantage, add to his own inventory.

METHODOLOGY

Just as the tools of the planner must vary from simple procedures to intricate systems and analytical methods, so will the examples considered and advanced in this paper vary greatly in complexity and level of content.

It is proposed to consider first the planning procedure of the soldier and the military engineer, and to extend this to areas developed by and for the military which have application to the planner. The tools of the architect, the ecologist and the operations analyst will then be considered.

It is not intended to convey the impression that characteristics attributed to these disciplines are confined to those disciplines alone. All the points raised are, however, considered germane to the issue and it is important that they should be recognized. The context in which they are presented is less important.

MILITARY SCIENCE

The Profession of Arms

Traditionally the public image of the soldier has been one of physical endurance, "seeking the bubble reputation", and of a colourful uniform. What possible connexion could he have with planning and planners? Yet, a direct connexion exists.

The words "military" and "planning" have long been almost synonymous. Strategic and tactical plans are a *sine qua non* of both offensive and defensive war. Because the outcome is so totally critical, and military action so intense and potentially quickly decisive, thorough planning well in advance of conflict is mandatory. Successful military action today is inconceivable without extensive planning. Defence of one's country, with the threat of modern warfare, has assumed such proportions that many new techniques have been developed. These, together with old and well tried methods, are of significance to the planner.

The Planning Process

The planning process in use by the soldier is very similar to the well-known engineering planning process in general use today. This process may have been formalized by the fighting soldier, adapted by the military engineer, borrowed by his descendant the civil engineer; and adopted by the planner; an example of the transfer system.

The soldier is concerned primarily with the defeat of the enemy in battle. To achieve victory a sound plan is essential. How is this prepared? First by collection and collation of all possible intelligence data concerning the enemy's strength, equipment, morale and likely intentions, the terrain, the weather, the phases of the moon, et cetera; data obtained by methods varying from physical reconnaissance to the interrogation of prisoners. This is the *Information* step.

[3] Lewis Mumford in the Introduction to *Towards New Towns for America*, by C. S. Stein, p. 12.

Having obtained all available information, the next step is to make a formal appreciation of the situation.

This takes a stylized form and includes the object, the factors, courses open, and outline plan.

The Object

This is a clear, unambiguous and unequivocal statement of the aim or "goals" of the study. In a given situation the object may have been stated as:

To capture Hill A;

when in fact what was intended was:

To destroy the enemy on Hill A.

The important thing in this case was not to occupy a feature which had no tactical significance but to ensure that the same enemy troops would not be able to form effective opposition in any future engagement. As a correct statement of the object is fundamental to the military appreciation, so too is the accurate assessment of the aim, "goals" or objectives of the planner all important to the resulting plan.

The Factors

These will vary with each case although many factors are common to most military appreciations; factors such as terrain, time, enemy strength, and own strength. No factor is considered without a deduction being drawn from it. The question is invariably posed "Therefore?" or "So what?" If there is no answer to this query, then the factor is either not fully developed and must be considered further or it is irrelevant and should be discarded. This is a step which might well be adopted in planning procedures to avoid confusion of main issues by unnecessary and irrelevant material which so often stifles planning reports.

Courses Open

Those courses open both to one's own forces and to the enemy are considered. In each case the advantages and disadvantages are clearly assessed and listed. Each course open to one's own forces is considered in relation to likely courses of action by the enemy and to the maintenance of the object. (This is the "feedback" step.)

Outline Plan

The course selected forms the basis of an outline plan which completes the appreciation. This outline, in turn, forms the basis of a

Detailed Plan

which, in turn, is issued in the form of an

Operation Order

It might be said with accuracy that the appreciation is merely a process of logic and reason, as indeed it is. The main lesson is that the process is taught to each military officer early in his service so that logical reasoning, disciplined in a strict format, becomes automatic, enhancing greatly the probability of the emergence of a sound plan even under operational conditions. The process outlined is not quite complete. There is the

Implementation (in battle)

and the

Evaluation

This takes the form of a reappraisal with a listing of lessons learned. At this stage, according to popular belief, the commander is either promoted or dismissed. As either course stems directly from the effectiveness of the planning process, and in particular the appreciation, it is not to be wondered at that generals insist that their staffs are experienced in the technique.

To extend the planning process from the soldier to the military engineer is but a step. The same general procedure is used:

1. Information: Collection of information from all sources including air observation, aerial photography, and ground reconnaissance.
2. Appreciation: Object, Factors, Alternative Courses, Outline Plan, and Feedback to Object.
3. Detailed Plan: An elaboration of the Outline Plan into one capable of effectuation. In preparing this, the critical path method of scheduling and programme evaluation and review techniques (where applicable) are used.
4. Execution of work.
5. Assessment.

This is very similar to the process used by the planner. Whether or not it originated with the military is unimportant. What is important is that the manner of implementation contains lessons of value to the planner.

Planning for Defence

It is at the other end of the scale from the simple planning process that the greatest impact has been made by the military on other forms of planning. Sophisticated defence systems such as strategic aircraft, missiles or radar chains call for complex planning. Even more complex is the planning demanded by the space programme. Mathematical probability and reliability analysis have been extended to meet the needs of producing, using and controlling supersonic aircraft and superspeed missiles. Indeed the first American electronic computers were built under contract for the United States Department of Defense.

This list can be greatly extended. Great advances have been made in the development of complicated operational test designs and mathematical models with full computer support are used to produce answers to complex military problems. Also developed to an advanced degree are the two-sided exercises, "war games", where computer inputs are made by two competing teams with different, completely opposing viewpoints, resulting in the establishment of parameters quite impossible to determine except possibly on the battlefield. So too are other simulation-type exercises being developed with computer support. Many of these planning aids developed for the military could, it is suggested, be of great value to the planner. Particularly valuable in finding solutions to complex urban problems is the simulation model, especially the opposing viewpoint variety represented by the war game. These techniques I shall consider again in relation to the operations analyst.

Other Developments

The military have led the field in other areas of value to the planner. These include air photography, photogrammetry and air photographic interpretation. Electronic methods of displaying information graphically and simplified versions of command and control centres too have their uses in corporate planning while programme evaluation and review techniques (PERT) and critical-path scheduling, first developed for the military in the United States, will undoubtedly be used by municipal and state agencies in their planning and its effectuation.

Summary

The main areas where the planner can, with profit, learn from military methods are as follows:

1. Basic lessons include the importance of good organization, sound administration and a clearly defined chain of command.
2. In the military planning process, the following are given emphasis:

(*a*) On a clear and unequivocal statement of the aim, goals, or objectives rests the success of the plan. So often planning is shown to have been based on an ill-conceived or inaccurate aim which has led to wrongly oriented decisions.

(*b*) Firm deductions must be drawn from all factors; any factors from which a relevant deduction cannot be drawn after full consideration are likely to be meaningless and should be discarded.

(*c*) Alternative courses of action should be analysed with the advantages and disadvantages of each listed to ease the process of evaluation and to increase the chances of the best plan emerging.

(*d*) Regular "feedback" should occur to ensure the maintenance of the aim.

(*e*) The planning process should be practised until it is automatic. Only then will this tool be capable of quick response to the will of the craftsman.

3. Defence requirements have in recent years resulted in the development of mathematical probability and reliability analyses and of computer techniques. Special areas of planning application include:

(*a*) Test design techniques and the use of mathematical models.

(*b*) Simulation type exercises of great diversity.

(*c*) Two-sided exercises where computer inputs are made from two completely opposing viewpoints.

4. Other military developments capable of increasing use in corporate planning include:

(*a*) Air photography, air photographic interpretation, and photogrammetry.

(*b*) Electronic methods of graphical display.

(*c*) Techniques for operational command and control centres.

These military techniques, old and new, would appear to have, at varying degrees, a place in urban and regional planning and its effectuation.

ARCHITECTURE

General Aspects

If the hypothesis advanced regarding the connection between the soldier and the planner may at first have appeared somewhat remote, few will question that many of the attributes and techniques of the architect have application in great measure to the planner. This is so apparent that I shall deal briefly with only a few of the "tools", those I consider of particular importance.

The architect has long been the leader and co-ordinator of a loosely knit team of surveyors, engineers of many types, builders and craftsmen; all working together not on some remote idea but on one to be translated into bricks and mortar, a complexity of forms in space, bringing advanced concepts into the realm of practicability, and fulfilling a function in terms of human use and aesthetic value. The ability to lead, to organize, and to co-ordinate, is fundamental.

Architecture is an art and a science of essentially human application. It is therefore axiomatic that the values, views and objectives of the people who are to occupy the buildings must be given due weight by the architect. At the same time, he must have the strength of character to impose his own ideas when he feels certain that these are in the interests of his client or of the community. To act thus, he must comprehend fully the human ends to be met, he must analyse and evaluate these, he must rationalize conflicting requirements, and he must feel the spirit of his creation in human aesthetic and functional terms. Only then can a successful plan emerge.

Site Analysis and Graphics

Very many techniques used traditionally by the architect in site analysis are of value to the planner and have been adopted by him; land use analysis, communication and use diagrams, systems of activity patterns, even the importance of aesthetic and functional linkages has, I believe, been accepted.

Graphics have been the architect's foremost technique and long before "simulation" appeared in the vocabulary of the planner, the architect practised simulation through the sketching medium, and extended this as a tool for evaluation and value judgement. This form of graphics might with advantage be increasingly used by the planner. He has already discovered the value of the simple architectural model.

Summary

The problems of the architect and the planner vary mainly in scale and timing; the architect implements while the planner projects. It is considered, however, that many of the attributes and techniques of the architect have a place in the planner's inventory. The main ones are an ability to:

1. Co-ordinate the work, ideas, and contributions of a large diversified team of experts.
2. Bring advanced ideas, however remote, into the realm of practicability and effectuation, and to keep abreast of technological advances.
3. Appreciate the human aspects of planning and design.
4. Consider and evaluate all forms of data as an essential to the implementation of a plan.
5. Feel the spirit of projected development.
6. Simulate, through sketching, other graphic forms and simple architectural models, and to cultivate value judgement by these techniques.
7. Fit together a complexity of parts and intricate patterns to produce a cohesive whole capable of implementation.
8. Impose his will on design issues when he feels strongly that these are in the interests of client or community.

ECOLOGY

The Comprehensive Standpoint

I have only recently become involved in ecology but the teachings of that grand old man of planning, biologist and sociologist Patrick Geddes, has long made me conversant with the theory that a direct connexion exists between the environmental system of the ecologist and the city.

Geddes insisted that the aim of planning was to provide a healthy and attractive environment. To achieve this, all relevant phenomena have to be investigated. Geographical, historical, social, individual, and cultural data should all be included in a civic survey. Only after such a survey was completed could a realistic plan be made. He further taught that the planner must strive to place himself at a comprehensive standpoint—that of the city as a whole, with the city recognized as being part of a region.

This was a revolutionary concept when it was advanced early in this century but biologists and ecologists have taken it much further.

The Urban Region in Systems Terms

Since ecologists are concerned with the structure and function of nature, and as man is part of nature, ecologists now argue that human behaviour should logically be brought within the general approach of ecology. Recent ecological studies have included quantitative studies of energy flow of materials as the major form of reaction between individual organisms and populations of various species and their non-biological environment.

It is but a short step from this to consider the urban region not just as a healthy environment comparable to the ecological environment of the biologist but identified with it. Thus the urban region in systems terms is defined as "a complex human ecosystem of people, natural organisms, and man-made artifacts. Some of these components are fixed and some movable. Components are linked by structural interconnections and interact through operational flows of movable components plus money, messages, signals, and energy. Components are organized in "man-artifact-nature' sub-systems which are operating or decision making units established to satisfy the goals of individual human components or the requirements of other sub-systems".[1] This theory goes on to describe the human ecosystem as a number of interconnected and interacting sub-systems, interconnecting patterns determining sub-system and ecosystem operations. The urban-regional ecosystem as conceived

[1] Stewart Marquis, "The Urban-Regional Ecosystem", p. 6.

includes these patterns and sub-systems together with the space within which they are located with inputs and outputs to environments outside its own boundaries or those of the contiguous spaces—one level in a hierarchy of human ecosystems.

This is an interesting and useful analogy and, as a theory divorced from practicality, it relates easily to the urban image. But when one reaches the moment of truth, "So what?" Is there an answer or is it comparable to the interesting but scarcely relevant factor in the military appreciation? The Geddes theory is fundamental. No comprehensive plan can be made without a comprehensive survey, but can one go as far as the human ecosystem theory as developed? I do not consider that the value of this advanced concept lies in the detailed comparisons made and the complete identification of the city and urban region with the ecosystem. I believe that the importance of the theory stems from the concept of the city as a *system*, thereby indicating the way for the development of an operational systems approach to the comprehensive planning of an urban region. If the complex problems of the city are to be solved, such a systems approach must be further used and developed, drawing on the systems approach of many disciplines including the highly developed and useful ecological one.

The Ecological Site Technique

There is one other aspect of the ecologist's approach which is worth considering and this does not consider analogies or advanced theories. This is the technique for carrying out the study of an area. How does he, for instance, go about analysing a unique area such as a virgin forest? First, he carries out the information phase of any planning procedure, making himself thoroughly familiar with all known facts of the area; its location, history, geological and geographical characteristics, climate, accessibility, and the nature and distribution of trees, plants and wild life. Having done this, he makes many visits to the area, studying in great depth all aspects of the area, observing, analysing and evaluating, until he has a thorough understanding of the environment as a whole, the system, interacting sub-systems, patterns of behaviour and interactions which occur under many conditions. This is a technique which the planner must acquire. It is all too easy for him to become so involved in the mechanics of planning that he does not take the time or effort to cultivate the "feel" of the city or region and to assess the important human flows and patterns. If he, as a planner, is to be capable of decision-making, then he must have this important design criteria at first hand.

Summary

The main lessons which I believe can be learned from the biologist and ecologist are:

1. The need for a comprehensive standpoint, the area, region or city viewed as a whole.

2. The value of the concept of the urban region in systems terms; the region being considered as a complex human ecosystem. This analogy is considered a useful one although complete identification of the city with the environmental ecosystem may not yet be capable of being translated into terms of practicality.

3. The need to gain a thorough knowledge of the region, particularly its human flows and patterns. The first lesson is now almost universally accepted; the second and third are rapidly gaining acceptance.

OPERATIONS ANALYSIS

Main Functions

For the past two years, I have been in daily contact with operations analysts. It is clear that their general approach to the solution of problems has a place in planning. That they are mathematicians, engineers and physicists working together in one field at once establishes a direct connexion with the planner. They work within the framework of an operations system which is akin to the ecological system. Within this overall systems framework, their main functions are to test design, the formation of mathematical models for projecting internal and external characteristics, the solution of problems by advanced mathematics and computers and the analysis and evaluation of data. The operations analyst's main tool (apart from an analytical mind and the ability to do "sums") is the computer.

Models

The formation of models is not only one of the main functions of the operations analyst, the mathematical model is one of his most productive techniques, the "basic building block" approach being potentially of great planning application. In this approach, mathematical models of each individual component of a system are formulated individually, another model is formulated for the interconnecting patterns between these components, and finally, all sets of models are put together into one large model representing a complete system. The application of this form of model to the urban region and city appears to be gaining acceptance among leading planners and the basic and widely accepted strategy for model design is based on the concept that a complete model can be built up of intercommunicating sub-models. For example the problems of retail, industrial and office location, and residential choice can be modelled separately and the effect of decision in one sphere elaborated in another sphere through model design.

Many other forms of model are in use, and many are designed for simulation purposes. The technique in use widely is to devise a model which uses data established by field testing and use it to simulate trends and characteristics, and to produce detailed data which can lead to a great saving in field operations. This specialized simulation type model would appear to have a place in the planner's tool kit.

The production of data has been touched on. This is a major operation in any field, and it is increasingly appreciated by the operations analyst that a central data bank is an essential, and that this should be located at the highest possible level: the optimum being one serving the whole country: the information being readily obtainable by teletype or more advanced methods yet to be developed. Most planners would, I believe, support this.

Lastly, it is suggested that the analytical approach of the operations analyst is one which the planner could well cultivate.

Summary

Lessons for the planner from the field of operations analysis are:

1. The fundamental nature of the systems approach in handling complex problems.

2. The value of the mathematic model using computer techniques. The "basic building block" approach would appear to have particular application.

3. The value of simulation techniques in reducing field work and in collection of data.

4. The value of the most advanced mathematics in solving analytically complex problems, particularly when used with simulation type operations.

5. The need for the data bank and of centralizing one comprehensive bank, preferably on a country-wide basis; and

6. The advantage in an analytical approach to problems.

CONCLUSIONS

In selecting for consideration in this paper a few disciplines which can contribute to the planner's inventory of tools, I am in no way suggesting that they are the most important. Military science, architecture, ecology, and operations analysis happen to be disciplines with which I have been connected but many others have direct application; engineering, economics, geography, sociology, political science, public and business administration, scientific management: the list could be extended almost indefinitely. Comprehensiveness has not been an objective of this paper: indeed it is recognized that the sources for adding to the planning inventory are so diverse that to aim at this would negate the principle that the planner should be receptive to new ideas, however unlikely the source. This concept forms the tenor of this paper.

Planning is a highly complicated business which, when related to the problems of the urban region or the metropolis, is in danger of becoming unmanageably complex. If the planner is to cope successfully with the great task of co-ordination, projection into the future, analysing, evaluating, designing, and decision-making, he must retain a flexibility of approach to the methods, techniques, and attributes which he employs and brings to his calling. Above all, he must continuously be prepared to learn from other professions and activities and to be watchful for new technological concepts and advances which could, with advantage, be transferred to the planning field. Only by so doing can he aspire to a key position in society.

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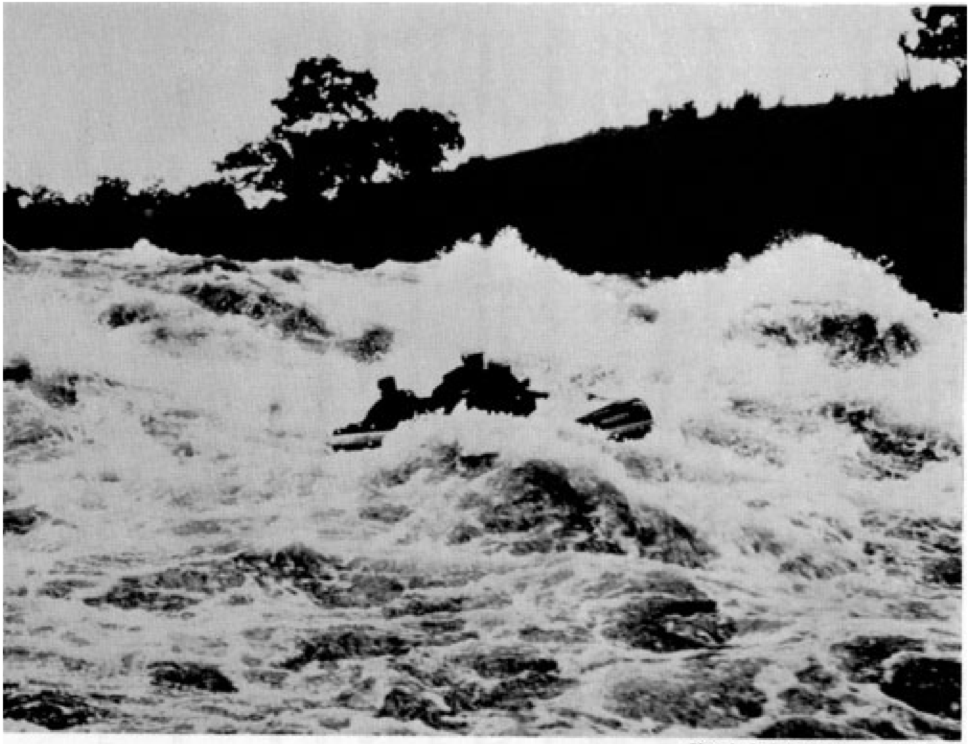

Photo by Lt J. G. Williams, Light Infantry.

Photo 1. Lieut J. Masters, RE taking his *Avon Redshank* boat through cataract k1 on the Blue Nile.

Tools and Techniques

The Great Abbai Expedition

MAJOR J. N. BLASHFORD-SNELL, RE

"FROM Africa always something new." The Service expeditions to Ethiopia in 1964 and 1966 brought back many new things of interest to Britain's scientists. They were planned and organized at the Royal Military Academy, Sandhurst. The aim in each case was to collect specimens for the Natural History Department of the British Museum. The collections were made in the lake district of the Ethiopian Rift Valley. Both were a great success.

The expeditions were, of course, operations of some magnitude and were made possible only by the kind help of numerous companies and other organizations.

His Imperial Majesty, Haile Selassie I, Emperor of Ethiopia, graciously received members of these expeditions in audience and on the last occasion said that he hoped similar visits would continue. As a result, the Ethiopian Wildlife Conservation Department asked the leader of these expeditions, Captain John Blashford-Snell, RE, to mount another in the summer of 1968, to carry out a scientific exploration of the gorge of the Blue Nile, known to Ethiopians as the Great Abbai.

The actual source of the Nile lies in a swamp south of Lake Tana. It is easy to reach and was seen in the seventeenth century by Fr. Pedro Paez, a Portuguese missionary, who wrote "I cannot express my delight in seeing that which Cyrus, Cambyses, Alexander and Julius Caeser so strongly and so unavailingly desired to know'.

The first Briton to see this spring was the adventurer James Bruce.

He visited Ethiopia in 1771 and wrote of "people who annointed themselves not with bear's grease or pomatum, but with the blood of cows, who instead of playing tunes upon them wore the entrails of animals as ornaments and who, instead of eating hot meat, licked their lips over bleeding living flesh".

The stream that flows from this spring becomes the Picolo Abbai, which is said to flow through Lake Tana and become the Great Abbai or Blue Nile near the town of Bahadar.

For the first eighteen miles this river is wide and shallow, flowing through swampy water meadows and around numerous islands. There are long stretches of dangerous white water and several small waterfalls.

At Tisisat the river suddenly drops 150 ft over the second biggest falls in Africa. There the huge volume of water is compressed into a narrow sheer-sided gorge.

For almost one hundred miles the river races through this cleft in the earth before the valley opens out and becomes less severe. However, the river is still at the bottom of a great hole in the Ethiopian highlands and Mount Chokai towers 10,000 ft above. From here on, the river alternates between rocky cataracts, dangerous shallows and stretches of flat water populated by hippo and large crocodiles. The crocodiles are some of the largest in the world and grow to a length of 6 metres.

Mosquitoes, insects and disease as well as rumours of radio active gas keep the local people away from this inhospitable world.

As far as is known the first attempt to navigate these waters was made in 1902 by W. M. McMillan, an American who brought specially designed iron boats from Britain. However, after only three miles these were swamped in a cataract.

In 1905, a Swede called Jessen came upstream from the Sudan. However, he could only get his boats to the Azir river and there he marched away from the Nile. Later he reported that it would be suicidal to attempt to force a passage in steel boats over the rocks and rapids.

In 1926 Major R. E. Cheeseman, the British Consul in NW Ethiopia tried to follow the course of the river on foot. His survey work was invaluable, but due to the difficulty of movement along the banks he was soon forced up on to the plateau.

Herbert Rittlinger, a German, and a small party tried to canoe down the river in 1955. However, repeated attacks by crocodiles made him give up.

One of the best organized expeditions was mounted in 1962 by the Canoe Club of Geneva. Six very tough men set out in two large Canadian-style canoes. They travelled from the Blue Nile Bridge to a point near the Sudan border. There they were attacked by bandits as they slept on an island. Two men died in the fight and the rest escaped in one canoe.

A Swedish conoeist Arne Rubin was the first man to travel from the Blue Nile Bridge to Rosiares. He did this in 1965 in a Kleeper canoe, alone! It was a splendid achievement. The next year he returned and with a friend attempted the top stretch of the river, but after fifty miles he was forced to abandon the voyage having capsized many times in the white water.

A less well prepared attempt was made by a group of Britons in March 1968, but it came to grief after eighteen miles.

None of these explorers had been able to examine the banks or carry out any scientific programme.

The Blue Nile has been described as the "Everest of rivers" and "The last unconquered hell on earth".

The aim of the 1968 expedition was a scientific survey of the Great Abbai or Blue Nile river in Northern Ethiopia.

The team consisted of seventy selected servicemen and civilians from Britain and Ethiopia.

The scientists included zoologists, geologists, archaeologists, an ornithologist, a limnologist, a veterinary surgeon and medical officers. The Army's role was to get these experts into the area, assist them in carrying out their work in the face of great geographical difficulties, and extricate them safely with the specimens and other results of their research.

This survey was conducted by experts, military and civilian, and was backed by a strong support team, several of them members of previous expeditions in Ethiopia. Some of these scientists and Army officers were from the Royal Military College of Science, Shrivenham, where the expedition was planned, and whose Commandant, Major-General N. Crookenden, CB, DSO, OBE, AFRAeS, actively supported the project. The team included personnel of the Royal Navy and T and AVR as well as regular soldiers.

The excellent scientific facilities at Shrivenham were put to good use during the preparation. Boats were modified after extensive trials in a fluids laboratory, where a working model of the river was used. The prototypes were tested on the Severn and the Dee by Lieutenant Jim Masters, RE, the "Chief Engineer".

The Expedition HQ was established in the deserted Chiseldon Camp near Swindon and here the leader and a small sapper staff worked for ten months to organize the venture. As plans progressed the corps became more and more involved, advising, encouraging and providing.

The logistic support was provided by 3 Division Engineers and Lieut-Colonel C. A. Landale, RE (CRE 3 Division) backed the project to the hilt. Major Ray Parr, RE, at HQ Southern Command and many people at RSME and MEXE also assisted and sappers everywhere supported the team.

The task was to last from July until October and take place during the monsoon period so that the high water should smooth out the cataracts.

The survey was to extend from the virtual source of the Blue Nile where it debouches from Lake Tana, past the famous Tisisat Falls and down the curving course of the gorge itself, until it emerges into jungle covered plains some 500 miles away.

An AAC Beaver aircraft from the School of Army Aviation, was to accompany the expedition for recce and resupply support. Major Alan Calder, RE, and Lieut Richard Grevatte-Ball RCT were to fly from Britain to Ethiopia, support the expedition and then fly home.

River-level research would involve descending from the rain-swept plateaux of the Chokai mountains, to the hot floor of the gorge almost a mile below. Many cataracts over which the Blue Nile surges at over 10 knots, would have to be conquered or by-passed. Numerous tributary gorges which enter the main course would have to be painfully descended and ascended. All this posed problems of resupply and required a high degree of physical fitness.

The expedition was to face extremes of heat in the gorge and cold in the mountains, torrential rain, snakes, mosquitoes and bandits.

In order to make the survey of the region it was planned to sail on the river which had defeated all previous attempts at navigation.

The sponsors included the British Museum (Natural History), the Royal Geographical Society, the *Daily Telegraph* and numerous organizations, firms and individuals.

In March 1968 the project was explained to HM the Queen and HRH Prince Philip during their visit to the Royal School of Military Engineering at Chatham, when they examined boats to be used on the river. The expedition was given a small grant by the RE Mountaineering and Exploration Society and also received donations from a number of retired sapper officers. Although it was a joint service and civilian expedition; of the fifty-one British, twelve were sappers.

By the end of July the sixty-eight men and two ladies of the team had completed their preparations. They had already won a major battle, which was the raising of the £14,000 to pay for the venture. However, funds were only just sufficient and sweat was to replace cash on many occasions.

The expedition arrived by air in Addis Ababa on 31 July. Lieut-Colonel Philip Shepherd, RA, the expedition's senior liaison officer, who had come out a few days earlier, had been working extremely hard to pave the way for the project. He had an enormous task and in a short time achieved administrative miracles. The main problem was in obtaining customs clearance, which despite promises by various authorities, had not been done.

The US Mapping Mission and Ethiopian Government departments kindly provided transport to enable the movement of stores and personnel to Debra Marcos, where on the 2 August the expedition's main base was established by the QM, Captain Buck Taylor, RE.

Debra Marcos is the provincial capital of Gojjam and is situated at an altitude of 8,250 ft. The high plateau is densely populated and in August is swept by frequent tropical storms. The ground was therefore extremely muddy and movement off the main road was impossible for all vehicles. The Governor-General of Gojjam was most helpful and throughout the expedition did everything possible to assist.

While stores and equipment were being prepared for the initial part of the expedition a recce programme started. The Beaver aircraft proved invaluable and the expedition area was studied in great detail by group leaders. Obstacles were photographed with a Polaroid camera and these pictures were invaluable at briefings. Mules and donkeys for river resupply teams were arranged by the Governor-General.

The plan was that the scientists and their immediate supporters should move along the river in boats and resupply would be by air drop and mule. In addition another group were to march to the river through the Didessa basin and carry out a game survey.

Because of the river conditions necessary for a safe passage the first part of the expedition was to be from the Blue Nile Bridge to Sirba. Having successfully completed this phase the teams were to be reorganized to explore the river from Lake Tana to the Blue Nile Bridge.

On 5 August "A" Group, the river party, began to assemble with their boats and equipment at the Blue Nile Bridge. Two days later the thirty-two-man team in the four light alloy assault boats started the voyage to Sirba.

The boats were powered by 40 hp Johnson outboard engines from the Royal Navy and each carried a total of eight persons plus approximately 500 lb of stores. The flagship was named *Kitchener* in recognition of the Royal Engineer support.

Daily Telegraph Photo.

Photo 2. RE assault craft on the Nile.

The engines were wonderfully reliable and made a great contribution to the success of the venture.

This group moved very rapidly on the water and indeed stopping was a problem. The current speed varied, but at times was as high as ten knots. This part of the river had only been previously navigated by seven canoeists and contained a great many potential hazards.

As may be seen from the map, the first of these obstacles was the Black Gorge. This was a narrow steep-sided deep cleft in the black basalt starting some fifty miles from the Blue Nile Bridge. It then continued for another fifty miles and throughout its length contained numerous cataracts. These occurred where bedrock caused a ridge in the river bed. The river rushed towards a definite "brink" and then was carried down a fast moving slope of brown water.

At the foot was a huge "hydraulic" wave which rolled and tumbled. Beyond this there were more large waves, coming in from the sides of the gorge and giving a V-shaped impression. When the boat left the "hydraulics" it was confronted by a mass of deep whirlpools and the river appeared to be flowing in several directions at once. As one bucketed through the cataracts one was extremely conscious of the immense power of this mighty river. Contrary to expectations crocodiles were seen in the Black Gorge. They lay on sandy reaches isolated by the turbulent brown water that rushed through the cataract like a stream of liquid cement.

Marching out of the gorge was likened to the ascent of a never ending ladder in a Turkish bath. The 60 degree slopes were covered in broken, loose rocks concealed by elephant grass up to twelve feet high. Occasionally snakes slid across the path, but in this dense vegetation few animals were seen. Both men and mules were eaten alive by the swarms of ants and insects.

At Uamet, the valley began to open out and the going for the next 60 miles proved easier. However, the number of crocodiles and hippo increased and the crews were ever on guard. Only one crocodile actually tried to bite an assault boat and as it was about to be run down, it probably did this in self defence.

The western Cataracts began at the Azir river and these dangerous shallows continued to the Didessa river junction. This obstacle was much broader than the Black Gorge, thus making it vital to have high water before attempting to negotiate the cataracts. Even so *Kitchener* struck a rock in the last cataract and broke a sheer pin. During the journey in this area the archaeologist discovered a neolithic settlement; a find of great importance.

The few people seen *en route* were friendly, although many were terrified by their first sight of a white man and fled as the expedition approached.

The voyage from the Blue Nile Bridge took three weeks and included a number of difficult moments. However, careful calculation of the water-level, coupled with the skill of the helmsman and the excellence of the boats ensured a safe passage. This success promoted an excellent team spirit. The navigation of the lower sector of the Great Abbai was the responsibility of Jim Masters and his Engineer Section and it was accomplished with great competence and determination. Another key man in this voyage was Lieutenant Martin Romilly R. Anglian, the IO, who had to predict what was around the next corner.

During the journey the entire aim was to make a scientific survey of the region, and thus halts varying from three to five days were made at selected points. At these Forward Bases the scientists examined the area and collected specimens. Astro-fixes were taken by the surveyor, Lieut Spencer Lane-Jones, RE, in an effort to correct the inaccurate maps of the region. The Medical Officer, Surgeon Sub-Lieutenant Nigel Marsh, RN, and Limnologist carried out a programme of studies on the distribution of bilharzia. All these experts made valuable discoveries.

Resupply of the boat party was by air drop from the Beaver and by mule parties marching across country from Main Base. The appearance of the Army Air Corps overhead always raised morale and their expert flying never failed to impress their customers. Almost all their parachutes landed right on target and their free dropping

Daily Telegraph Photo.

Photo 3. *Kitchener*, the flagship in the Western Cataracts.
Lieut Jim Masters, RE (Chief Engineer) in the bow. Captain John Blashford-Snell, RE in pith helmet.

was equally accurate, although on one occasion they almost destroyed the zoologists! The fact that the skipper was also a sapper greatly helped in engineer recce tasks. The mule parties had some terrible terrain to cover and great credit is due to them. They crossed ravines, flooded rivers and deep swamps but although they did lose the odd mule and some stores they always got through in the end. On their way back they took out scientific specimens and mail. L/Cpl Henry, RE (Chief Clerk) became the Chief mule procurer and by the end had a reputation for being able to procure anything anywhere.

"B" Group marched in from Ghimbi to meet "A" Group at the Didessa/Nile junction. They carried out a game survey *en route* and covered 150 miles of very rough country. This group was commanded by Captain Nigel Sale, RGJ, and contained members of the Wildlife Conservation Department, including an ex sapper officer, Mr John Blower, the Chief Game Warden. It originally had a number of donkeys, but the terrain proved too much for them so the Vet, Capt Keith Morgan-Jones, RAVC, marched them back to Ghimbi, fattened them up and resold them.

At Sirba, the boats were brought ashore and the combined "A" and "B" Groups were then evacuated by the Beaver and a US Mapping Mission "Huey" helicopter.

While "A" and "B" groups were converging on Sirba, the resupply teams, known as C2 and C3 were employed on other tasks. Group C2 had spent some time carrying out route recces in the Ghimbi area where they met impossible going on the mud-bound tracks. Their route recces had been aimed at finding a good overland withdrawal route out of Sirba and as a result of their efforts a plan was made to get "A" and "B" groups out by a combination of foot, mule, aircraft and vehicle. However, in the end air support was available and this rather difficult plan was abandoned.

C2 Group then spent until the 4 September making a zoological collection in the Ghimbi area. Their efforts were most rewarding. They became the terror of the district and Lieut Gavin Pike 14/20 Kings Hussars, one of the recce officers who acted as a "Zoologist", skinned non-stop for seven days.

C3 Group, under Lieut Gage Williams, LI, having completed a long and arduous resupply via Mabil, moved north and made a foot recce of the Northern Gorge in preparation for the last phase. During this journey they were captured by tribesmen and held for several days, until the local Governor intervened. L/Cpl Henry had tried to solve the problem by giving out free medical treatment. In fact he reckoned that with a packet of Cascara pills he could have wiped out the enemy single handed.

Communications between groups and the river party were controlled from Debra Marcos. The signallers also maintained a link with Britain. Lieut Barry Cooke, R Signals, had a great many links to maintain under very difficult conditions.

The expedition now regrouped at Debra Marcos and prepared for the final phase. This was a study of the river from Lake Tana to the Blue Nile Bridge. The first stretch of the northern half of the Abbai to be examined was from Bahar Dar to the Tisisat Falls. Contrary to earlier information this stretch was much more difficult than anticipated, with the water flowing in raging white torrents over many cataracts and waterfalls. The White Water Group (WW) had been selected, equipped and trained especially for this task. Under their Group Leader, Captain Roger Chapman, Green Howards, they had trained on the River Dee in North Wales. Their boats were modified Avon Redshank Inflatables and had been specially manufactured for the expedition. These craft were incredibly tough and survived continuous battering.

WW Group was supported by several parties and an Engineer Group under S/Sgt Mansley, RE, was sent ahead to construct an aerial ropeway to take the boats over the famous waterfalls at Tisisat. In this group were J/RSM Hampson, RE (17) and J/Sgt Whitwell, RE (17), of the Junior Leader Regiment at Dover. These young men did excellently throughout the expedition, in spite of their youth.

On 8 September WW Group paddled away from Bahar Dar wearing their frogmen's suits, white crash helmets and lightweight lifejackets. The party was armed with revolvers for defence against crocodiles. Their first day was highly exhilarating and they negotiated some fearsome white water.

However, on the second day they struck trouble and had a bad capsize. Three members almost lost their lives and one boat was reported missing.

The casualties were evacuated to Bahar Dar and after reorganization the team continued with great caution to Tisisat.

The movement south of Tisisat was even more formidable and long portages were necessary. N Group led by Nigel Sale was equipped to assist WW negotiate the hazards. They carried rock climbing equipment and moved ahead to man the cataracts. Meanwhile I Group under Lieut David Bromhead, SWB, had joined up with the expedition Command Group, which had flown in to Mota, and with eighteen mules advanced to the river. Here they set up base at an ancient bridge known as the "Portuguese Bridge" (code-name Bridport).

At this point the local people near Mota readopted their hostile attitude. One especially troublesome tribesman was dismissed by the acting medic (L/Cpl Henry, RE), who treated the man for a foot infection by placing two Horlicks tablets between his toes and sending him to bed for three weeks. It seemed that they believed the expedition to be involved in a tax dispute they were having with the Government.

It was during this difficult time that Cpl Ian Macleod, BW, was tragically drowned whilst crossing a tributary of the Abbai. He was one of the most popular and outstanding members of the expedition and his death was felt deeply by everyone.

By 20 September Groups WW, I and N had reached the Portuguese Bridge. A new team, called P Group, was formed by the expedition leader and included further members of the scientific section. Its task was to survey the completely unexplored region south of Mota. It was ten strong and had two army recce boats with 9½ hp Johnson engines and two Avon Redshanks.

The route passed through fantastic vertical sided gorges and included every hazard the expedition's planners had ever envisaged.

On 21 September 1968 P Group of the Great Abbai Expedition moved by boat from the Portuguese Bridge. The group consisted of ten persons in four boats, and was commanded by the expedition leader. Its mission was to carry out a scientific survey of the Blue Nile from the Portuguese Bridge to the Blue Nile Bridge at Shafartak.

The group left Bridport at 1030 hrs and after a difficult voyage over numerous cataracts reached a deep sheer-sided gorge where camp was established, near the Tammi river junction on the north bank of the Nile (see Sketch Map A).

On 22 September some nearby caves were examined and archaeological and zoological specimens were collected by the respective scientists.

At 1205 large numbers of tribesmen appeared on the high ground surrounding the camp and began to threaten the group with rifles. The leader went on to the beach and tried to convince the natives that the expedition was friendly. Using a loudhailer he called to them in Amharic, but they replied by firing at him. He repeated the attempt, but they continued to shoot at him. The bandits' manners however, were of the highest order and one sniper rose to bow to his targets between shots.

At this point large boulders were rolled down from the bluff behind the camp and the enemy on top of the cliff hurled rocks into the Nile to prevent the expedition's escape. The group was now surrounded. Rifle fire then increased and sling shot whistled through the trees. The leader then ordered the Group to abandon such equipment that remained in the camp site and withdraw downstream with all speed. He ordered the recce boats to cover the withdrawal by firing at the enemy on either side of the Nile and the inflatable boats were then launched under a hail of rocks, sling shot and bullets from a range of 100 ft.

As soon as the Redshanks were clear of the beach, the recce boats withdrew and escorted them out of the enemy range. The leader and Mr Colin Chapman (Zoologist) engaged the enemy from the recce boats throughout the withdrawal.

Mr Chris Bonington (*Daily Telegraph*) was struck on the back by a rock and several boats were hit by stones. However, by a miracle no one was hit by the small arms fire.

At least one enemy casualty was observed. The enemy strength was estimated at around forty.

The group then moved some five miles downstream, reorganized and reported the incident to the Expedition Main Base by radio.

At 1700 hrs on 22 September P Group made camp on an island approximately two to three miles upstream of the R. Bascillo/Nile junction. The camp was established at the far end of the island where trees gave some cover from view and possibly from small-arms fire. The boats were then positioned near the water's edge on the southern tip of the island to facilitate a speedy withdrawal. One recce boat *Semper* was moved near the camp to avoid the necessity of carrying the radio approx 70 yds over a shingle beach.

Shortly after the expedition arrived six natives swam to the island and appeared to be friendly. They asked for medicine and were given a few aspirins, chocolate and plastic bags.

In spite of the seemingly friendly attitude P Group was taking no chances and the leader briefed members on a plan of defence and, if necessary, withdrawal.

At 0115 hours on 23 September Roger Chapman was on guard and David Bromhead was writing a log in his "basha". As Roger walked to the beach to inspect the boat moorings he surprised a party of some ten natives who were creeping silently along the beach. He challenged them and was immediately fired on by another group from the west bank of the Nile.

Roger Chapman and David Bromhead returned the fire, gave the alarm and the camp stood to in a few moments. The leader fired a mini-star to illuminate the attackers and a close quarter battle ensued. The enemy fire support group continued to shoot at the camp. The attackers who had landed on the island were soon driven off, taking their casualties with them. While the leader and one party engaged the enemy fire support group, another moved to defend the boats. The fire fight con-

Photo: C. Bonington.

Photo 4. The scene of the battle during the night 22/23 September 1968.
The enemy attacked from both flanks.

tinued for some fifteen minutes with the expedition using mini-star to illuminate the enemy.

During this battle Sub-Lieut Joe Ruston RN dismantled the vital "Squadcall" radio station and skywave dipole aerial, loaded it onto the recce boat *Semper* and single-handed took the craft downstream to the prearranged RV at the southern tip of the island. In so doing he passed within thirty yards of the enemy position.

By 0200 hrs approx the expedition had withdrawn to a defended perimeter around the boats, sheltered by a low shingle ridge. It was intended to hold off the enemy until dawn and then withdraw quickly, hoping for sufficient light to see cataracts that were believed to be a mile downstream.

Recce boat *Semper* was found to be leaking badly in a forward compartment and ammunition was running low.

The enemy were heard to be moving about on the west bank and occasional shots were exchanged.

The mini-star proved extremely effective at dispersing the attackers and attempts were made to ignite the dry grass on the hill behind them, without success.

Enemy activity began to increase at 0300 hrs and at 0315 hrs a horn was heard sounding the same calls as used during the initial attack. The leader then ordered the group to withdraw and using a process of fire and movement P group launched their boats and finally slipped silently downstream.

Some twenty minutes later the enemy attack was heard going in on the evacuated island.

A new hazard now faced the expedition. The Nile was flowing at approx 6 m.p.h., a cataract could be heard ahead and the crocodiles were a possible danger. In addition it was pitch dark. Engines dare not be used for risk of giving away the position of the boats to enemy "cut off" groups. *Semper* and *Ubique*, the two recce boats, were leaking badly, nevertheless the Redshanks were taken in tow and P group paddled silently along in the rushing water. Quite suddenly the cataract was reached. *Semper* and Redshank No. 2 only just negotiated it and by now *Semper* was in danger of sinking.

Joe Ruston cast off his tow to Redshank No. 2 and using his engine took his deflating boat into a beach on the west bank.

Ubique and Redshank No. 1 were less fortunate. On hitting the cataract, both crews, with the exception of Roger Chapman, were hurled into the water and were extremely fortunate to get back into their boats, assisted by the prompt action of Roger Chapman. Mr John Fletcher (boat fitter) started his engine and with great coolness edged both boats out of the cataract into the beach near to *Semper*. Mr Alastair Newman (Sandhurst lecturer) and his crew managed to paddle Redshank No. 2 into the bank 800 yds downstream.

The group had lost much equipment and rations and was soaking wet. However, they remained on the bank until first light. Meanwhile the leaking recce boats were repaired, a damaged propeller on *Ubique* was changed and ammunition redistributed.

At dawn P Group reformed and slipped away. As daylight crept into the gorge the next hazard appeared. Lying on almost every sandbank were huge crocodiles, renowned for their ferocity. The boats cruised silently past and tired eyes watched the reptiles. Occasionally one of the brutes would slither into the swirling brown water, and swim towards the boats.

No one had any doubt what effect a bite would have on the inflatable craft. Lieut Garth Brocksopp R Irish Rangers kept them at bay with well aimed geological specimens and the convoy sailed through safely.

At 0815 hrs P Group reached an assault boat team commanded by Captain John Wilsey, The Devonshire and Dorset Regiment. This team had been motoring upstream for seven days to RV with P group. They had experienced considerable problems in battling against the current and theirs was the first boat ever to travel so far upstream on this stretch of the Nile. Forcing a passage through the cataracts called for great skill and indeed by the time they met P group they had "blown up" two engines and were running on the last one the expedition possessed. The efforts of WOII R. Wright RE (chief mechanic) in getting the boat so far, deserved high praise. With the Beaver's flying hours running short, resupply had to be kept to a minimum and one can imagine J group's feelings when a parachute failed to open and they saw their next seven days' rations plummet into the river. When John Wilsey missed a duck because he believed, quite correctly, to shoot it sitting was unsporting, it did not increase his popularity with his starving crew. The next two days were spent making a crocodile survey and at 1630 hrs on 24 September P and J groups sailed into the beach at the Blue Nile Bridge.

The expedition had achieved its aim and in addition had conquered the unexplored Blue Nile or Great Abbai River.

Press and TV reporters were among the small crowd which greeted the successful flotilla and they were told that the keys to the success of the expedition were thorough preparation, excellent equipment and outstanding team work. One reporter asked the leader why it was that the British were always prepared to accept such challenges; no doubt it is due to the strong spirit of adventure which fortunately is still unquenched in Britain.

Copyright: The Great Abbai Expedition.

The Future of the Institution of Royal Engineers

BRIGADIER J. R. G. FINCH, OBE, BA, CEng

A FEW years back there was discussion about possible changes in the constitution of the Institution to bring it more in line with the Chartered Engineering Institutions. No agreement was reached, possibly due to the then limited knowledge of the civil institutions, but also because there was no clear definition of where the science, art and practice of military engineering stood in relation to civil engineering. (The terms civil and military are used in their widest sense.)

It is not the object of this paper to carry out a post mortem. Rather it is intended to suggest that there is risk of underrating the importance of our Institution and the contribution it can make in the wider fields of military engineering.

THE NATURE OF MILITARY ENGINEERING

Military and civil engineering have many origins in common such as in materials technology. It is normal practice for military equipment to be constructed, as far as possible, from commercially designed components. Whilst it is admitted that there is a limited field of technology that is purely military, such as the long history of gun steels or the effects of projectiles on targets, it can be argued that military engineering practice is, in the main, a special application of civil engineering science and art. For example, in the last was the science of soil mechanics preceded the development of bitumized hessian for airstrip construction.

On the other hand military need often forces the pace of what becomes a civil engineering art, as was the case at the beginning of the century with reinforced concrete design. The relevance of scientific discovery is not always clear. Much was known about electrical effects long before there was any wide scale military application. Combat development as often follows on from the evolution of a new technology as the other way about; there are examples of this in the evolution of tank warfare. It is necessary for both combat development and technological progress to be pursued along their parallel courses so that each can stimulate the other. Civil engineering has become compartmented whereas military engineering is a broad cross-discipline subject and needs to be studied as such. In 1947 the Engineer-in-Chief of the Army pointed out the implications for air strip design of the then trends in aircraft development but without inducing any joint-service technical study of matters where Mechanical and Civil Engineering design concepts had mutual implications.

Military engineering seems to contain elements in it other than the specialized application of civil engineering principles. These might be defined as the application of the physical sciences to military art and practice for the benefit of national security.

MILITARY/CIVIL RELATIONSHIPS

Whilst there may be a distinction between civil and military engineering, the civil institutions have a very great deal to give the military, apart from the fact that members of the Civil Service working in Defence Research and Development Establishments can only be members of the former. Until 1973 the Institute of Marine Engineers and the Royal Institution of Naval Architects are accepting into corporate membership Naval officers with the sole qualification of an appropriate rank and have registered such as Chartered Engineers. Corporate Membership of the Royal Aeronautical Society does not necessarily require an engineering qualification, for instance, certain grades of pilot are acceptable. The Royal Engineers have always had a close relationship with the Institution of Civil Engineers and have arranged joint meetings with the Structurals, Mechanicals and Electricals. Similarly, other Corps and Services have relationships with the Electricals, Mechanicals, IERE etc.

Whilst concern has been expressed as to the professional status of the military engineer when he leaves the Service, especially in view of the declared intention of the Chartered Institutions to adopt the degree standard of academic qualification by 1973, the average standard of academic qualification of officers in the three Army Technical Corps in on a par with, if not better than, the average of membership in the thirteen Chartered Institutions that comprise the Council of Engineering Institutions, and distinctly better than some. This is a situation that will continue for some years if not indefinitely as the Army raises its standards of entry. The CEI Institutions in 1965 included only 30 per cent membership with degrees and diplomas and three Institutions had less than 20 per cent (the range was from 15 per cent to 85 per cent). However, reciprocity of membership is not yet practised between the CEI Institutions and an exception is not likely to be agreed between the civil and military institutions. Much will depend on how the military institutions develop their activities and the consequential status they will derive from them. Much will also depend on how competent the Army shows itself in developing the careers of the professional men it recruits.

THE CHARTERED ENGINEERING INSTITUTIONS

Like so many other things in this country the Chartered Institutions are entering on a period of change stemming from the Education Act of 1944 and the resulting growth of University output. Today, the greatest proportion of those being registered as Chartered Engineers has qualified through part time study and the Higher National Certificate. So far, no more than one-third of the numbers obtaining degrees in engineering are joining Institutions, or one-fifth, if relevant degrees in industrial science subjects are included. The question for the future is whether by 1973 the larger Institutions will capture the extra degree men due to a strong financial position and relatively low overheads for good facilities or whether the smaller Institutions, with a less remote management, more informal atmosphere and more specialized activities, will prove the more attractive. The larger Institutions are better able to deal with cross-discipline subjects, important with the generalized trends of present-day engineering. The small Institutions have a fine record of work in specialized fields but, unless they can continue a high standard of activity, they may either be "swallowed" by one of the big institutions or be forced to turn more to the technician engineer to keep up membership.

A factor that may affect the outcome of this struggle is the centralization of the qualification function and the possibility that it will pass out of the direct control of the Institutions altogether. For the academic requirement, national qualifications are replacing Institution exams and the new CEI exam will continue for the benefit of a minority whose studies have not followed a normal pattern due to some personal factor. Training is becoming increasingly the responsibility of the Industrial Training Boards, with the Institutions acting in an advisory capacity. In any case, the Institutions have never had much success in supervising training schemes of their own. The experience requirement has operated, in the main, under a system of case-law with great differences between Institutions and a trend is appearing to replace it by an examination in technique or by a specialized oral test or interview. The high median age (33–34 in the case of some Institutions) of acceptance for corporate membership may be acting as a deterrent to University Graduates who do not have the same compulsion to join a Chartered Institution for acceptance as professional men. Where graduates do join it is for reasons other than status, which may well favour the smaller bodies.

Three features of the Institutions of Civil and Mechanical Engineers are of interest when considering how the wider interests of military engineering can be provided for. The Mechanicals has semi-autonomous groups within its structure dealing with specific fields of activity. They ensure that the enthusiast can organize his programme of activities, whilst co-ordination is effected by the Institution's superstructure. In military engineering this could be translated into groups for electronics, mobility, weaponry and construction, with cross membership facilitating the treatment of the wider topics. The Civils has subject groups which are open to both engineers and non-member, non-engineer experts. Activities cover a range of subjects in which engineering is only one element. In military engineering such groups would be useful where military art was dependent on some civil technology.

For activities overseas, together with the Electricals, they have formed local groups which bring all engineers together, so making possible a viable programme of activities.

THE MILITARY INSTITUTIONS

In an address to a November meeting of the Royal Signals Institution, Mr Anthony Verrier made a strong plea for more open discussion, particularly amongst the younger officers, of the many imponderables in equipping the Army with present-day limited finance. His remarks were a reminder of unfortunate decisions taken under financial pressure between the Wars and the effects indifferent equipment had on subsequent operations. Presumably Mr Verrier had in mind greater activities by such bodies as the one he was addressing. It is necessary to question the means of bringing it about.

There are three Army Institutions concerned with military engineering in the broad. Each is closely associated with an Arms School and serves one technical Corps alone. The Royal Military College of Science, which has a status close to that of a University, organizes discussion meetings primarily for those officers of all Corps and Regiments who have qualified on Technical Staff and similar courses. The RMC of S and the Institutions have no direct link and do not seem to co-ordinate professional activities although the Corps that maintain the Institutions have a direct interest in the nature of the courses at the College. The Royal Navy and The Royal Air Force have technical colleges similar in purpose to that of the Army, but nothing with resemblance to a professional engineering Institution. For such activities officers must join a Chartered Engineering Institution.

The Royal United Service Institution is concerned with the profession of Arms in the broad rather than with more technical aspects and with the use of equipment rather than with how it is specified and designed. Recently it has developed more of a technological bias, examples being the teaching of technology and a series of articles headed "Advanced Military Technology". If however, military engineering is more than civil engineering applied in other circumstances, there might be a case for a Joint Service Institution of Technology to work in parallel with the RUSI concentrating on specialized engineering topics. Its membership would need to include the Civil Servant working in R & D establishments.

CONCLUSION

In preparing this paper I have not intended to propose anything specific. Rather I have tried to show the possibilities open to the Institution should it be decided that development of its function is desirable or necessary. My own feeling is that military engineering has a wider meaning than is common usage today and it would enhance the importance of the military engineer if the wider meaning was emphasized by our actions.

The Institution of Royal Engineers is of long standing and nearing its centenary. It has a Charter. Its objects are wide in their implications and with minor modifications could be made to meet the needs envisaged. A widening of membership would be involved. I suggest that there is a possibility of gaining more in prestige than ever would be lost in service to the limited needs of our Corps alone.

Covenants

ARE you a covenant subscriber to the Institution of Royal Engineers?

Anyone who pays the standard rate of UK income tax on any part of his total income and enters into a seven-year Deed of Covenant with the Institution increases the value of his annual subscription by 70 per cent.

For instance, if your annual subscription is say £3 then you have to earn £5 2*s* 2*d* to pay the Institution that sum at the present standard rate of income tax of 8*s* 3*d* in the £. In the case of a covenanted subscription the Institution can claim each year the tax element of £2 2*s* 2*d*; whereas if your subscription is not covenanted, you still have to earn £5 2*s* 2*d* to pay it but the Inland Revenue retains the tax element to the Institution's dead loss. Over the seven-year period of a covenant the Institution will receive £35 15*s* 2*d*, as against £21 in the case of an uncovenanted subscription. The figures are proportionately the same for other annual subscription rates.

The Council is most grateful to all those Members, amounting to just over half the total membership, who do covenant their annual subscriptions and thereby bring great financial benefit to the Institution of Royal Engineers.

The Council feels, however, that there must be many other Members who are either unaware of the Institution's Covenant Scheme, or who confuse it with other Covenant Schemes, operated by the amalgamated Royal Engineers Association/Royal Engineers Benovolent Fund and the Royal Engineers Officer's Charitable Fund, and may not be sure whether they are covenant subscribers to the Institution or not. To clarify this latter point a *C* has been placed against the names of Members in the Royal Engineers List who subscribe by Deed of Covenant, and an *I* against the names of those who are Members of the Institution but are not covenant subscribers.

If there is an *I* against your name in the RE List, why not write for full particulars of the Covenant Scheme to The Secretary, Institution of Royal Engineers, Chatham, Kent?

Correspondence

Lieut-Colonel J. N. Holden, RE,
HQ South Eastern District,
Steele's Road, Aldershot.
9 January 1969

36 ENGR REGT AND THE WEST COUNTRY FLOODS

Sir,—It has been suggested that in the article in the December *Journal* on the South West Floods, I was less than fair to the leaders of the two initial Recce Parties. They were faced with difficulties of which I was not aware when I wrote the article. When the recces were completed, they found that the civilian telephone system in the West Country was very overloaded. They experienced great difficulty in getting through to Maidstone and were unable to do more than pass a short message when they were connected.

Officer Commanding 20 Field Squadron suggests that a further lesson can be drawn from this, namely—that while the civilian telephone system is of great value after a disaster, it cannot be relied upon in the immediate aftermath.

I hope I do not need to add that no unfairness or criticism of individuals was intended or implied. I made the point about the Recce Parties because it seemed to me to bring out a useful lesson. And surely the main value, indeed perhaps the only value, of articles describing actual operations is that certain lessons emerge, from which others may profit. The responsibility for any shortcomings in the sort of operation described rests fairly and squarely as always with the Commanding Officer.—Yours faithfully, J. N. Holden.

Major G. K. Booth,
26 Wildown Road,
Bournemouth, BH6 4DR.
12 January 1969

COMPUTERED!

Sir,—I should like to add two points to the article in the last issue of the *Journal*. The first point is an omission brought to my notice by Survey friends and the second is a relevant addition.

Survey Computer: a Ferranti Pegasus was installed in 1959 and is now being replaced by an ICL 1902 with a 16K corestore and a 4-deck magnetic tape system. The computer is used for survey computations including calculation of co-ordinate positions on aerial photographs from a sparse network of conventionally surveyed control points and adjustment of world-wide survey networks. Computer programming is taught on the Army Survey course.

Time Sharing: it is possible now to share time on a computer using a remote terminal consisting of a teletype-writer and a modulator demodulator that enables GPO telephone lines to be used. The cost, subject to a minimum and plus the terminal hire, can be as little as 10*s*. per hour to an educational establishment using off-peak time. The terminal with its immediate response is excellent for learning programming but for running programmes the cost is unlikely to be less than that of using a computer bureau. This might be a possible tool for Chatham.—Yours faithfully, G. K. Booth.

Brigadier H. A. L. Shewell, OBE,
Rock Close,
Ashburton,
Devon.
18 January 1969

BRAILLE

Sir,—I wonder whether any of my retired brother officers, who while perhaps slowing up physically remain mentally active, would be interested in learning to write Braille? The Guild of Church Braillists exists to transcribe books (mainly of a religious nature) which are specifically asked for by blind readers and which they cannot otherwise obtain. The Guild works closely with USPG which needs books for blind readers overseas. New blood is needed, for the demand is insistent but many of our transcribers are now too old to do much.

I began to learn Braille sixteen months ago and obtained the RNIB Diploma last October. I found and still find the work both mentally stimulating and pleasantly rewarding. The necessary equipment can be obtained for an outlay of under £7. The volunteer student would then work each exercise in the Primer and send it to me or to some other instructor for correction and comment.

Would any officer who would like to know more about this please write to me.—Yours truly, H. A. L. Shewell.

Brigadier M. L. Crosthwait, MBE,
HQ Engineer-in-Chief,
Old War Office Building,
Whitehall, SW1.
20 January 1969

THE FUTURE OF THE INSTITUTION OF ROYAL ENGINEERS

Sir,—I have read with much interest Brigadier Finch's article in this issue on the future of the Institution. Many will remember that this subject was discussed in some detail in 1961. As I recall it, in general the aims of the Council's proposals then were:

(*a*) To increase the status of the Institution of Royal Engineers and its members in the eyes of the professional institutions.

(*b*) To provide a greater incentive to RE officers to increase their competence as military engineers.

Clearly these were desirable aims, in particular the latter. The Council's proposals for (*a*) were to introduce a graduated structure very similar to that of the Institution of Civil Engineers, with defined qualifications to be demanded of individuals as they progressed through the structure. In short, membership was not to be automatic (subject to paying a subscription) as it has always been.

These proposals came to nothing. Chiefly, I think, for the following reasons. They were certainly reasons which I personally then thought valid.

(*a*) The important thing is the status of the Corps and not that of the Institution. The standing of the Corps depends on our status in the Army as military engineers, which depends on the work we do, the advice we give, the foresight we exercise and the kind of people we are.

(*b*) The major professional Chartered Institutions do not need us as a Corporate Body. However, they welcome individuals who can obtain Corporate membership under their rules.

(*c*) It would be wrong for the Institution to stand in judgement on an officer's worth to the Army. The fairly elaborate procedures to gain membership would have to be reasonably exclusive if civilian recognition were to be obtained. But it is for the Army to decide by Army standards what the demands of Corporate Membership of a Military Institution should be.

Means to enhance the status of the Institution in all our eyes (a more active journal, publishing professional papers, holding of discussions, etc, etc) which were to be a by-product of the 1961 discussions, were presumably supported by all.

It is at this point that Brigadier Finch comes in. Of his points, those I find of greatest interest are:

(*a*) Firstly, I think there must be clear definition of what a Military Engineering Institution has to offer the civilian world. If it has little to offer, because military engineering is merely the application of civilian practice in a different field, then there is no point in trying to create Institutions very much different from those that exist at the moment.

(*b*) In Brigadier Finch's opinion such a Military Institution would have something to offer, and would certainly be worth organizing but only if it embraced civil, electric and mechanical engineering in all their military aspects.

(*c*) The trend among the civilian institutions is to centralize the setting of entry standards, and the future of the smaller institutions may lie more and more in amalgamations.

(*d*) RMCS, RE, R Sigs and REME would all be involved in any worthwhile Military Institution.

It is of interest to note here that Sir Leonard Atkinson (late DEME) in his Presidential Address to the Institution of Radio and Electronic Engineers, in January 1968, said that "If the present trend of equipment development continues and equipment demarcation between the Services, particularly as far as electronics are concerned, becomes less clearly defined, I believe there will be a case for securing integration, or partial integration of the engineering Services in the armed forces" and Sir Leonard foresaw, in the next decade that recruitment in all three branches of the armed Services could be to a single Engineering Service.

Sir Leonard is, of course, here thinking of REME and R Sigs. But this trend between the Services must also be taken into account when considering any trend to a wider Military Institution within the Army itself.

Another point of interest is that it is suggested from time to time that there should be an amalgamation between, eg, RE and R Sigs. Indeed arguments can be produced to support this move, although to date they have not been convincing. However, subject to the others also being concerned as to the future, a closer relationship between the respective Institutions might well be a rewarding move.

One is left with many questions. Among the most important are:

(*a*) Is there really a place for a Military Engineering Institution *vis-à-vis* the Civilian Institutions and what part should the RE Institution play in it?

(*b*) Will membership of such an Institution increase the professional status of the military engineer when he leaves the Service?

(*c*) How should we develop the future of the RE Institution? Does it have sufficient influence within the Corps at the moment?

It is, of course, on this latter point that Brigadier Finch's article is all about. In my opinion the views of the Corps are very much needed. It is the object of this letter to stimulate discussion.—Yours faithfully, M. L. Crosthwait.

Memoir

BRIGADIER MARTIN HOTINE, CMG, CBE

MARTIN HOTINE, who died on 12 November 1968, was born on 17 June 1898, the son of F. M. Hotine. He was to become one of the outstanding surveyors of his generation, with a wide international reputation in the fields of geodesy and air surveying.

After an education at Southend High School and the Royal Military Academy, Woolwich, he was commissioned into the Royal Engineers on 6 June 1917, the top of his batch. As a young officer he saw active service in the First World War in Persia, Iraq and India, and on its conclusion he attended a series of courses at Chatham and then went up to Magdalene College, Cambridge.

In 1925 he was appointed as the Research Officer of the Air Survey Committee, and this gave him the opportunity he needed. Although the subject was new to him, he at once devoted his considerable mathematical ability, experimental aptitude and tremendous energy to devising practical methods of using air photographs for topographical mapping, employing simple procedures and equipment. The Arundel Method, which will strike a chord in the memory of many Sapper officers, was a technique which he evolved during this period and it was in itself a contribution to surveying of no mean significance; it was particularly suitable for use in conditions where the elaborate three-dimensional plotting instruments developed on the Continent were not available, and was very widely used by military units during the years of the Second World War.

In 1929 he joined the Geographical Section of the General Staff, in the War Office, where he remained until 1931. During the six or so years between his appointment to the Air Survey Committee and his departure from the War Office, he wrote four professional papers, each of book length, and also a textbook, *Surveying from Air Photographs*, all of which were based on his own original thought and practical work. His primary aim in these early days had been to develop working methods, but his contributions to theory were exceedingly important and were widely recognized in many countries. His ideas, developed over the years, have been responsible for as much good topographic mapping as possibly those of any other individual.

In 1931 he went abroad again, first to Malta and Gozo, and then to East Africa, where he was engaged in the measurement of a section of the Arc of the 30th Meridian. His mind, being now directed towards geodesy, immediately began to generate new thought in this field. He made important contributions to the procedures for observing geodetic triangulation, and to the precise measurement of first-order bases. In particular, his paper on *The General Theory of Tape Suspension in Base Measurement* led to considerable changes being made in the techniques of using invar tapes, which at that time were the only means of achieving high accuracies of measurement over distances of several miles.

From 1933 until the outbreak of the Second World War he served in the Ordnance Survey, where he was principally concerned with the Retriangulation of Great Britain. That this important work was undertaken at all was largely due to his far-sightedness and powers of advocacy. It began in 1935, and the methods and procedures which were devised under his energetic direction were generally followed until the work was completed in 1962.

When war broke out in 1939, he was appointed Deputy Director of Survey in the British Expeditionary Force and later, after Dunkirk, as Director of Survey Home Forces. He was Director of Survey in East Africa, during the brief 1941 campaign, and then returned home to take up the newly-created appointment of Director of Military Survey in the War Office, at the same time preserving the old title of Chief of the Geographical Section, General Staff, which survives to this day. His responsibility for air charting was also recognized by making his position two-hatted, and he became, uniquely, a Director in the Air Ministry as well as in the War Office.

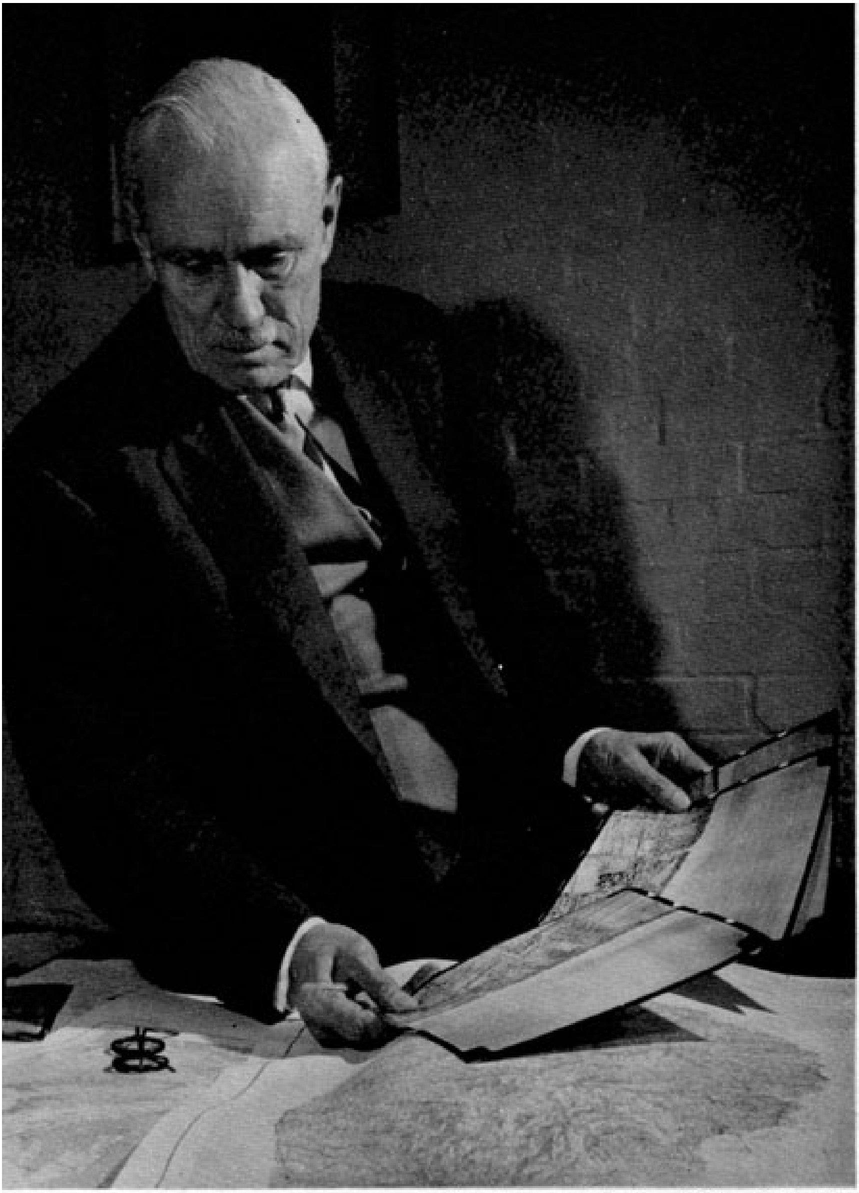

Photo by courtesy of the Central Office of Information.

Brigadier M Hotine CMG CBE

He retained this position until the end of the war, bringing his immense capacity for clear thought to the problem of building up the Military Survey Service for the task which faced it. Typical of him was the close working arrangement which he developed with the United States Army Map Service, from which has stemmed the extensive co-operation and goodwill which exists today between the military surveying agencies of the United States and Great Britain.

He retired from the Army in 1946 to take up the post of Survey Adviser to the Secretary of State for the Colonies, and he became the first Director of Colonial Surveys. His directorate, which is now the Directorate of Overseas Surveys in the Ministry of Overseas Development, was originally designed to provide a central agency to undertake major survey projects in Colonial territories, and in its present form it continues to offer its services to overseas territories as part of this country's contribution to developing countries. The need for such an organization had been realized by Hotine in his pre-war days in East Africa and he once again applied all his ability and energy, in what was in reality a second career, to the development of this concept. Nearly two million square miles of contoured mapping, mostly at a scale of 1/50,000, has been completed in Commonwealth territories since 1946.

Despite his involvement with his new job, he still found time to devote his mind to developments in the science of geodesy, and was a recognized world authority. He made a valuable study of the mathematics of projection systems and later turned his mind to the development of an entirely new and revolutionary system of computing and adjusting triangulation. This was based on observed directions in space rather than on directions projected on to a reference spheroid as had hitherto been the invariable practice. This work called for the exercise of mathematical skill of the most advanced order and, perhaps because of this, his new system has yet to find universal acceptance among geodesists.

He retired from the Directorate of Overseas Surveys in October 1963. The following month he was at work with the US Coast and Geodetic Survey, sharing his wealth of experience with his new colleagues. With the formation of the Environmental Science Services Administration (ESSA), he became a member of the research staff in earth sciences for the ESSA research laboratories, at Boulder, Colorado. During this time, he completed a major scientific publication, *Mathematical Geodesy*. He retired for a third time in August 1968, shortly before his death, to return to his home in Weybridge, Surrey.

Martin Hotine was awarded the CBE in 1945, and the CMG in 1949. In 1947 he became an officer of the Legion of Merit (USA). In 1947 he was awarded the Founders Medal of the Royal Geographical Society, and in 1955 he was the first recipient of the President's Medal of the Photogrammetric Society. In 1968 he was awarded the United States Department of Commerce Gold Medal. The Gold Medal of the Institution of Royal Engineers was awarded to him in 1964. He himself was in the United States at the time, and was unable to attend, but the medal, which was presented by the then Chief Royal Engineer, General Sir Frank Simpson was received on his behalf by Brigadier Lew Harris.

He married Kate Amelia Pearson on 9 August 1924, who survives him with their three daughters.

J.C.T.W. writes:

The death of Martin Hotine is an irreparable loss to the world of survey, to that of geodesy and to the large circle of his friends and admirers in all parts of the world. His life, both before his retirement and after, was marked by a series of great achievements. Whilst still a subaltern at the War Office his name was well known, not only in England but in Western Europe, for his appreciation and analysis of the early problems of air photographic survey. It was at this stage in his career, as one of the only two officers of his rank permitted in those august premises, that a file, initiated by himself and then passed around at stratospheric levels in the building, came back to him. Only Martin could have inscribed it as follows: "Minute 37. Ignoring minutes 2 to 36 and returning to the point at issue . . ."!

His work on the Arc of the 30th Meridian in Africa set a new standard in geodetic survey methods, but seems in retrospect to have been but a preparation for one of his greatest tasks, the initiation, organization and control of the retriangulation of Great Britain. Thousands of Ordnance Survey triangulation pillars throughout the length and breadth of this country stand as memorials to his genius, his drive, and his unrivalled capacity for sheer hard work.

His selection, early in the war, to be Director of Military Survey saw the foundation of a happy and intimate relationship with the US Survey Services and also the design and introduction of the mobile printing equipment which, by the end of the war, was in use in every theatre. The acceptance of his ideas was due, not only to their innate brilliance, but also to his powerful, even robust, advocacy of them. In every situation, and whatever the subject, he inspired his hearers. You might not always agree with his views, but you had to have, instantly available, very good reasons indeed for not doing so. He suffered fools gladly, but not their follies. Working with him was like dealing with the electric wiring of a house when the current has not been turned off at the main. He was, by any standard, a great man. Whether as surveyor or mathematician or organizer, he stood alone. Only those, however, who worked closely with him knew what a deep human concern and sympathy he had for his fellow men and their dependants. A totally convinced Christian, he put these precepts into practice in his daily life. I never knew him to do a mean thing. It was always a joy to be in his society and share in those gales of laughter which were never far absent when he was present. There are very many with whom he worked in all the varied aspects of his brilliant career who can call him a friend. Every one of them will always be proud to do so.

Book Reviews

THE HISTORY OF THE RETRIANGULATION OF GREAT BRITAIN 1935–1962

(Published by Her Majesty's Stationery Office for the Ordnance Survey. 393 + XIX pp. with 24 plates and 20 diagrams. £15 15*s*.)

No brief review can deal adequately with this comprehensive record of a retriangulation; it is not paradoxical to call the task original, since no country of any size has previously been triangulated twice to first order standards. As the Introduction records, the object of publication was "to provide a history of the Retriangulation, and to place on record details of all observations and computations connected with it in such a manner that they will be available for posterity". The same purpose had led Captain A. R. Clarke, RE to publish in 1858 his account of the Principal Triangulation, collected from the records of 70 years; and his successors a century later have more than repaid their debt to him.

The text—and this includes many diagrams and tables—has been compressed into some 240 pages, the remainder of the volume covering the fourteen Appendices; what appears to be a second volume is a container for the twenty large diagrams which could not conveniently be bound. This compression is remarkable, as it has been effected without making the account unreadable; there is still room among the minutia of observation, base measurement and computation for the lighter touches which show that even surveyors are human.

Chapter 1 deals briefly with the history of the Principal Triangulation, which taken by itself was not unsatisfactory; but the secondary and tertiary triangulations, never completely adjusted to it, had outlived their usefulness and gave rise to discrepancies which were becoming more and more embarrassing, and which no patching could rectify. A new secondary triangulation was inescapable, and a new primary a relatively cheap addition. Chapter 2 describes the fieldwork, computation and adjustment of the new primary: a task more involved than an initial triangulation, since it was considered necessary to minimize any shift of the graticule of large-scale plans. A detailed account is given of how the new work was given scale and azimuth to give the best fit at eleven stations coincident with those of the old triangulation. Various supplementary works are in Chapter 3: the Shoran connexions to Norway and Iceland, and those to Ireland and France by angle measurement. The EDM connexion to the Cherbourg Peninsular was too late for inclusion.

Much of Chapter 4 if of historic interest only; posterity may be grateful that they need no longer learn to measure bases in catenary, taking bogs and ravines in their stride. This chapter also gives an account of the subsequent Tellurometer checks on scale, an operation not yet complete, as early work gave some disquieting results. These operations, together with the astronomical observations described in Chapter 5 are needed to meet the demand for the best possible final adjustment for scientific purposes, independent of the old triangulation. These matters are discussed in Chapter 6. Chapter 7 deals briefly but adequately with the more simple tasks of filling in blocks of secondary and lower order trig.

Appendices give observed and adjusted directions of all primary rays; grid and geographical co-ordinates; instructions to observers; a brief diary and bibliography. There is (and perhaps could be) no index. Besides the many diagrams, there is a section of photographs, which will doubtless evoke nostalgic memories.

It is pleasant to find the tributes paid in the book to those who did the work, whether or not mentioned by name; it is stressed that first order triangulation is not a routine task for the Ordnance Survey, and thorough training was necessary. The preface makes clear how much was due to the inspiration and organization of Martin Hotine, who trained the teams and directed operations until World War II interrupted them. The early part of the History has drawn largely on his narrative, and we can be glad that he lived to see the publication of this record of a work which owed so much to him.

The decision to compile the History was taken in 1955, it being rightly held that waiting till all supplementary tasks were complete would jeopardize it ever reaching publication stage. Perhaps a supplement will one day complete it. It was not possible, as it had been in 1858, for one author to assume full responsibility, and the preface lists no less than nineteen names of those writing drafts, examining or checking. Among these, Brigadier J. Kelsey played a major part, on six months' special duty; the multiplicity of other authors made necessary a general editor, in the person of Major-General J. C. T. Willis.

One does not expect a best seller on this subject, and its price will tend to restrict it to libraries; but at 15 guineas it would be cheap to any surveyor needing to avail himself of the experience recorded. It will be read with pleasure too by the less technical, inquiring into the history of triangulation. The Ordnance Survey and the authors' team in particular are to be congratulated on a task so successfully completed.

C.A.B.

THERMODYNAMIC TABLES IN SI (METRIC) UNITS

R. W. Haywood

(Published by Cambridge University Press, Bentley House, 200 Euston Road, London, N.W.I. Price 12*s*)

The author, a Fellow and Director of Studies in Engineering, Fitzwilliam College, and Lecturer in Engineering in the University of Cambridge, was prompted to produce these tables by the decision of the United Kingdom to commence the transition from British units to metric units of the *Systéme International d'Unités*.

The text of 42 pages comprises a particularly useful introductory preface, a page of general data, three tables of calorific values and gases, two thermochemical tables, seven for steam, four for refrigerants, three for air at low temperatures, and five covering the transport properties of various fluids.

As the change-over to metric will take some time and references to British and SI units and tables will be necessary during the transition period the author has included the following appendices: definitions of basic SI units, definitions of some derived SI units, definitions of some non-SI metric units, British units—definitions and conversion factors, temperature, conversion factors for temperature, principal sources of data.

Engineers not practiced in the use of SI units will be encouraged to see in the definitions of derived SI units that a few of British origin have been retained—rather like Olympic medal awards for past British scientific achievements. Nevertheless, the publication of these tables at this time do illustrate how necessary it is for British engineers to get practiced in the use of metric and SI units before the change-over takes place. F.T.S.

PERGAMON PROGRAMMED TEXTS FOR INDUSTRY & COMMERCE

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 76*s*. set)

Critical Path Methods

For the many people who are not clear what the Critical Path Method is or what contribution it can make to project analysis this concise programme provides an excellent introduction.

The pre-test at the start is a useful guide since it covers the whole of the content and those with some knowledge of CPM can readily determine whether they will gain additional knowledge from the programme. There are perhaps rather too many examples of a similar nature but apart from this the text is well laid out.

Unfortunately the method of presentation employed is dissimilar to that used in RETM2. There are variations in the symbolic notation and problems are not tackled on a time scale basis. Nevertheless this is the most useful training programme.

The Industrial Training Act

This programme text which has been prepared for Managers and Executives of all concerns affected by the Industrial Training Act and for supervising staff who are likely to be effected by policy decisions resulting from the application of the Act.

The programme enables the reader to gain a clear understanding of the policy foundations of the Industrial Training Act, the functions of the Central Training Council and the method of collecting levies and of allocating grants.

Although not directly applicable to the Military Engineer it is recommended that all those who are connected with the training of technicians and tradesmen should take advantage of this concise programme to gain useful background information.

Those officers who, after leaving the service, intend to take up a post in industry should make a point of reading through this very good programme.

The Manager and Programme Learning

This programme should be read by all those who are concerned with the management of training and in particular those who are cynical about the value of programme learning.

It provides an excellent introduction to the subject and explains the principles, its use, the relative cost and the value to the user.

The text is laid out in conventional style but utilizes some of the left-hand pages of the book to introduce enrichment material. It is a pity that greater use is not made of this device.

Effective Communication

Bad communications can cause mistakes, misunderstandings, loss of trade, temper and efficiency. This programme text, which is well illustrated, expounds four basic principles concerning the sending and receiving of information. For any communication to be effective the requirement is for correct and relevant information, concise explanation and a knowledge of the receivers background intelligence and expectations. How often are these simple rules forgotten.

The target population for the programme is executive directors and other managers. The military officer will find that the short time required for digesting the programme is well rewarded.

Break-Even Charts

This programmed text explains the use of break-even charts in determining the relationship between income and costs by graphical representation. It defines fixed costs and variable costs and shows how the total cost changes when the volume of production changes. It enables the reader to compare two different projects and decide which is the more remunerative.

The programme is well compiled and has undoubted use to those managers who are concerned with the economics of production but has little direct military application. However the principle of intersecting graphs is well covered and its application to other problems with military connotations is apparent.

Discounted Cash Flow

There is no military application for the method of investment appraisal using the Discounted Cash Flow method. It is recommended reading only for those who intend to take up a position in industry involving financial analysis.

After working through the programme the reader should be able to make capital investment decisions based on the principles of the Discounted Cash Flow method and when given cash flow schedules and discounted cash flow rates of return for investment proposals, know how and why they were prepared and be able to objectively appraise the data presented.

The programme is heavy going for those not familiar with the principles and terminology of accountancy. M.R.R.

PERGAMON TEXT—WORKSHOP MATHEMATICS

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price £15 15*s*.)

Workshop Mathematics is intended for practical use by trainees and craft apprentices in industry and educational establishments and by students at Technical Colleges and Secondary Schools working, or intending to work, in the mechanical trades. The course consists of twenty-three well-illustrated programmed texts, together with pre-test papers and an instructor's manual. The programmes contain both linear and branching sequences and require the student to construct responses. Students are expected to work through the course at their own rate, the time taken will range from 25 to 45 hours depending on the ability of the student.

The whole programme is well devised and gives a thorough grounding in elementary workshop mathematics to apprentices or students at school, but its application to military technical training is limited by the leisurely pace. Some use could be made of the texts as a "back-up" to formal instruction for slow learners and those students who suffer from lack of mathematical knowledge in entry to the Services. M.R.R.

CITIZEN SOLDIERS OF THE ROYAL ENGINEERS TRANSPORTATION and MOVEMENTS and the ROYAL ARMY SERVICE CORPS 1859 to 1965

Former Transportation and Movements Sappers will be interested to learn of the publication this month of a new book telling the story of the Royal Engineer and Royal Army Service Corps volunteer reservists who were re-badged into the Royal Corps of Transport in July 1965.

The story begins with the inception of volunteer service in Britain and ends with the modern Reserve Army soldier of the RCT. It tries to give equal attention to the activities and records of the various components which were merged to make up the new Corps and to treat them as one entity in chronological sequence.

We are deeply conscious of the great achievements and unselfish devotion to the Service which the Reserve Army has displayed throughout its long history. Whether driving horses or operating railways, manning installations or controlling vehicles, improvising supplies or bridging the great rivers of Europe, the activities of our voluntary soldiers are worthy of permanent record.

The RE Historical Society has been working steadily over the past few years to compile historical records of all branches of the Corps, both Regular and Reserve. This volume, the first of its kind to deal exclusively with the Reserves, has been written by a committee member of the Society, Colonel Gerry Williams, OBE, a former Transportation officer now on the Headquarters staff of the School of Transport RCT.

The book is of some 250 pages bound in buckram and illustrated with black and white drawings, the work of Michael Williams, Dip A D, son of the Author.

Because the field covered is so wide and because of the integration of the Reserves into the Regular Army in the two world wars, the book does not set out to be a detailed history of the reservist units concerned, nor would such a record be attractive to the readership for which it is intended.

Nevertheless, students and "amateurs" of military history will find a great deal in the work to commend it, whilst those with actual knowledge of the units and events dealt with will find it an enjoyable and worthwhile souvenir of military service.

The book can be obtained from

"Publications Branch"
HQ School of Transport RCT
Longmoor, Hants.

at a price of 27*s* 6*d*.

Because the publication costs have to be borne initially by RCT funds it is important that they should be recovered as quickly as possible. We ask all our members, therefore, to make a special effort to patronize this project.

ATLANTIC VENTURE

JOHN GROSSER

(Published by Ward Lock & Co Ltd, 116 Baker St, London W.I. Price 30*s*.)

Atlantic Venture is an authoritative account of the 1968 singlehanded Transatlantic Race. The author, John Grosser, is Assistant Sports Editor of the *Observer*, which sponsored the race, and was responsible for its coverage for his paper. He was thus in a position to talk to everyone who had anything to do with it.

The book is well written and extremely easy to read. Obviously a "must" for future singlehanded racers, it is nevertheless a book not only for the expert but for everyone who in any way received pleasure from following the race at the time, and would like now to hear the whole story. J.H.

Technical Notes

CIVIL ENGINEERING

Notes from *Civil Engineering and Public Works Review*, September 1968

STRUCTURAL BEHAVIOUR OF THE WEST STREET FLYOVER, COVENTRY. This contribution by J. B. Menzies, BSc, PhD, of the Building Research Station describes the results obtained following instrumentation of this two carriageway flyover; observations covered the construction period and the first two years of the flyover's life. The author concludes:

(*a*) That composite action between deck and steel girders, under live load, developed to a high degree.

(*b*) That composite action under dead load did not develop fully due to settlement of the props during construction and shrinkage of concrete following construction.

(*c*) That the stiffness of the structure and compression in the girders at the supports increased in the post-construction period.

(*d*) That rises in air temperature induced increased compression in the girders.

(*e*) That the maximum percentage of the total live load carried by any one of the ten girders was 35 per cent.

SEEPAGE UNDER SHEET PILES. R. Herbert, PhD, of the University of Birmingham, describes a development of the resistor network technique for simulating the seepage system under sheet piles. This particular development takes into account the large head loss which occurs under the toe of the pile where the flow lines turn sharply. The technique is presented as suitable for application to multi-sheet pile systems and multilayer aquifer problems.

BCSA CONFERENCE ON STEEL BRIDGES. J. McHardy Young, BSc, MICE, MIStructE. reviews the June conference at which papers on present-day practice and trends were presented. The article is of value in that it emphasizes the directions which the philosophy of bridge design and construction will take.

LATEX-SILICONATE GRANTING FOR MASONRY. Notice is taken of a method of pressure granting damp masonry with a latex-siliconate cement slurry. It is claimed that quite wide cracks can be treated with this slurry which sets to form a gap-filling material retaining the properties of high adhesion and flexibility.

ATTERBERG LIMIT TESTS FOR QUANTITATIVE EARTHWORK CONTROL. An article written by P. M. James, BSc (Eng) DIC FGS from experience gained in Kedah, Malaya while working on the Muda Irrigation Project describes relationships established between the Attenberg Limit tests and Proctor criteria. The author recommends that such relationships could be established and used for effective compaction control.

PREVENTION OF AQUAPLANING ON CONCRETE RUNWAYS. A short contribution describes a method, and diamond grooving equipment, with which the runway at RAF Conningsby was scored. The method is claimed to improve the braking coefficient and reduce the possibility of aquaplaning.

LIGHTWEIGHT CONCRETE. Eight abstracts are included in this month's issue on various aspects of lightweight concrete. J.D.W.

Notes from *Civil Engineering and Public Works Review*, October 1968.

THE main feature of this edition is a series of excellent articles which together make up a comprehensive review of the major tunnelling projects in progress in this country. Despite the disbandment of the remaining tunnelling units in the Regular Army, these articles should prove of great interest to all officers of the Corps with its historic tradition of expertise in this basic civil engineering skill. Tunnelling is still a very specialized task requiring a high degree of experience and skill from engineers and miners alike in addition to physical stamina. There is a limit to the number of skilled men in this country capable or willing to do this type of work. The tunnelling capacity of the Civil Engineering industry at present is only in the region of £5 million worth of work per year for the whole country.

THE VICTORIA LINE. The major tunnelling project in progress at present is the construction of the Victoria Line for the London Transport Board which will provide a south-west to north-east underground railway for London. The first article by G. I. Murray West, who is head of the Computer Department of Messrs Mott, Hay and Anderson, Consulting Engineers, gives an account of the development of computer programmes for its design and construction. The exacting task of setting out a tunnel of this length was helped considerably by the use of computerized survey data. A second short article is included by the London Transport Board which gives details of how they controlled this project by using computerized network analysis. The total cost of the Victoria Line extension is in the region of £63 million.

THE THAMES CABLE TUNNEL. This tunnel was commissioned by the Central Electricity Generating Board in order to provide a crossing under the Thames for the super grid in the area of Gravesend and Tilbury. Investigation showed that a tunnel was a more economic solution than a high level overhead crossing. This well illustrated article is by C. K. Haswell, BSc.(Eng), FICE, MIStructE, of Messrs Charles Haswell and Partners who are the Consulting Engineers for this tunnel. The tunnel, which is 14 ft in diameter and nearly a mile long, was driven using a Calwell tunnelling mole and is lined with precast bolted segmental linings.

FORMWORK FOR IN SITU CONCRETE TUNNEL LININGS. Selection of the methods to be used in constructing tunnels depend almost entirely on the nature of the ground which is traversed. In "soft" ground it is usual to erect cast iron or precast concrete section linings ring by ring close up behind the tunnelling shield. In hard rock tunnels the erection of linings (if they are necessary at all) is often carried out well behind work at the face and linings are often cast *in situ* concrete. This extremely comprehensive article by J. F. C. Gayner, BSc (Eng), MICE, describes how formwork for *in situ* concrete tunnel linings is designed and constructed.

THE CHANNEL TUNNEL. This article by J. B. Manson, BSc (Eng), ACGI, FICE, considers the implications of this enormous project for British Rail and outlines in some detail the dimensions of the finished tunnel. The formal design stage of this project has not yet started pending a decision from Government on which of the contending consortia will be requested to pursue development of financing and tendering arrangements for it.

MOTOR UNDERWAYS by A. E. T Mathews, ARIBA, ANTPI, FRIAS, considers the planning considerations and relative merits of using short tunnelled "motor underways" instead of elevated motorways in some of the projected plans for the motorway "box" around the Greater London Area.

THE SECOND MERSEY ROAD TUNNEL. This well illustrated article describes the construction of a second Mersey Road tunnel required to cater for the great increase in traffic density since the first road tunnel was built in 1934. The author is T. M. Megan, MSc, MICE, a director of Messrs Mott, Hay and Anderson—the Consulting Engineers for the project. R.C.G.

THE MILITARY ENGINEER

SEPTEMBER–OCTOBER 1968

There are articles of interest on the following subjects:

Nuclear Excavation. Various practical experiments are described and the uses of Nuclear explosives are discussed in respect of: Canals, Dams, Quarries, Ports, Flood Control.

Ammi Bridge. A new Class 60 bridge for use with pontoons or trestles is described. This is a follow-up equipment rather than an assault one.

Delta base. The problems of building a base on low lying, floodable, ground are discussed. Useful points are made on soil erosion and dust control.

Tunnel destruction. Techniques used in destroying Viet Cong tunnels are described.

P.W.H.

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