THE ROYAL ENGINEERS JOURNAL SEPTEMBER 1968 VOL LXXXII NO 3

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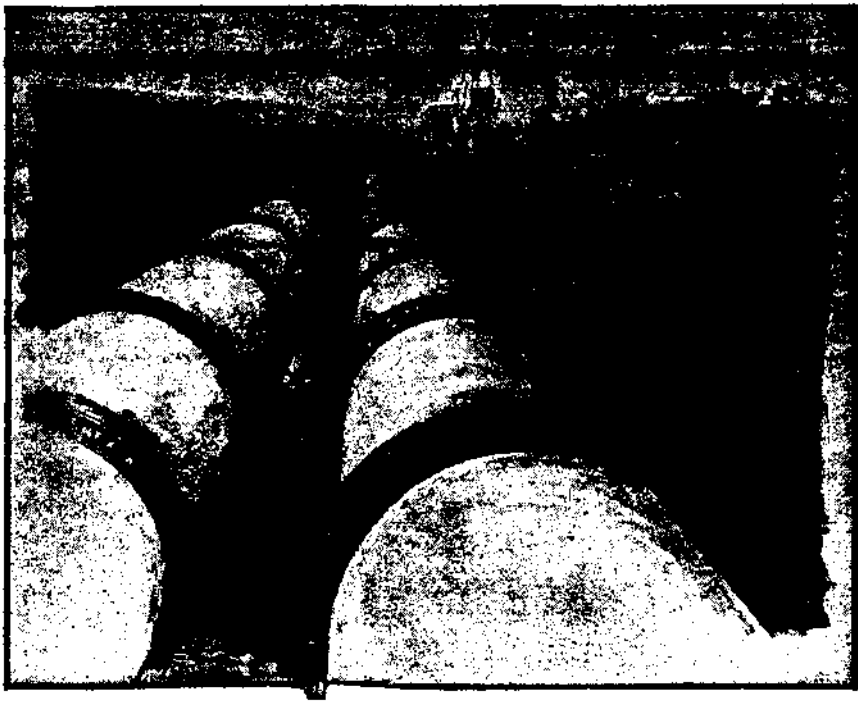

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SEPTEMBER, 1968

The Engineer-in-Chief's Address to the Annual General Meeting of the Corps of Royal Engineers on 26 June 1968

INTRODUCTION

CHIEF ROYAL ENGINEER AND GENTLEMEN: Some of you who may have heard, or read, my address last year may think that I misled you somewhat by presenting too optimistic a view of the effects on the Corps of the defence cuts. My remarks were made knowing what would be in the July White Paper which shortly followed and which, I think, justified them. All I can say is that I was not the only one misled. The Prime Minister's Statement on Defence of 16 January last took everyone by surprise and created a new situation.

In the Army field, this situation is still in some respects unclear, but I will try to give you an idea of what I think the effects are likely to be, so far as one can yet tell.

THE OUTLOOK

The Defence Cuts

The 1967 Defence Review envisaged two phases of run-down in the Army—of about 13,000 by 1971, and a similar amount by 1976. This is now to be accelerated, so that the second phase will start in 1970 and end in 1972. There may also be further reductions, so that with cuts in headquarters, static installations and the training machine, I imagine that the Army could, by 1974, be reduced by something like 15 per cent.

So far as the Corps is concerned, under the 1967 scheme we were to lose a nominal regiment's worth by 1971. This consisted of a field squadron, a field park squadron, and some logistic cuts. Compared with others, this meant that we were getting off relatively lightly. Advancing this phase by a year makes, in fact, very little difference, as most of the losses were due by then anyway. But after 1970 the story could be a little different. We still hope that our cuts in field units will be broadly similar to those of the first phase but it is not yet possible to forecast what will happen in the training organization and in static units. I believe myself that we shall be able to make a good case for being let off comparatively lightly.

The earlier evacuation of Singapore and Malaysia by 1971, instead of the mid-seventies, will not make very much difference to our field Order of Battle, as it had been planned from mid-1967 that by the early 1970s the British forces in Singapore and Malaysia would be mainly naval—including an amphibious element—and air. Some reduction, following evacuation of the Persian Gulf, seems inevitable, but it should not be great. We hope very much to retain our link with the amphibious force, in its affiliated field squadron.

An encouraging feature is the greater interest being taken in the flanks of NATO, especially the Mediterranean. But the big question mark is the Strategic Reserve. No one yet knows exactly on what scale we shall be expected to operate outside Europe—and this must influence the Sappers in the Strategic Reserve. In spite of these uncertainties, I have reason to hope that the Corps will again, proportionally, not come out too badly.

You will deduce from all this that redundancies will be moderate, up to 1970; but after that we should expect a rather increased rate. Naturally we hope to cover them as far as possible with volunteers. However, I must warn you that, although our total percentage reductions will probably not look too bad compared with others, the officer and warrant-officer percentage is likely to be rather more because of the logistic cuts in overseas bases, and in the UK base, where many civilians are employed.

I am particularly concerned about the losses in brigadiers' appointments which are already happening as a result of the run-down in the command structure at

home and abroad. Of course, this is a thing which affects all the arms and services as well as us, and it is the business of the Manners to maintain a proper promotion pyramid throughout the Army, which no doubt they will do as soon as things are clearer. But in the meantime, there is unavoidably some loss of prospects in senior posts within the Corps. I hope this will be mitigated by the generally high quality of our officers giving us a good share of the brigadiers' appointments outside. At the moment, we are not doing too badly.

The Attitude of the Corps

Defence priorities change with astonishing rapidity, depending on the political and financial climate of the moment, and often unrelated to basic strategic factors. They have been stood on their head during my own time as E-in-C. Equipment is now being developed—this generally takes ten years—on a "European" justification which, two years ago, would only get by on a "non-European" ticket.

This is just an illustration of how careful we have to be in the Corps always to take a very long-term view, and to preserve our capability to operate anywhere, come what may. We must not jeopardize the future in the interests of immediate expediency.

But there are certain long-term trends which are unlikely to be reversed, and I touched on some of these in the Conclusion to my last address—notably the progressive abandonment of overseas bases, and the consequent need for greater skill and speed in construction for any expeditionary force we may mount, and for overseas projects to acquire this skill. And above all the need to provide challenges to attract the best young men into the Corps.

Overseas Training

I shall expand a little on the matter of overseas training.

I said last year that the most promising field for the Corps was that of overseas development. The outlook is hopeful. Already we have undertaken two large projects overseas with no direct military object, in Thailand and in the Carribean, and I shall say more about these later. There are plenty of requests for help by Sappers, and the limiting factors are firstly money and secondly our resources of professionally trained engineers and technicians. There is no lack of opportunities, but unless we can widen and deepen the professionalism of the Corps, we shall be unable to take full advantage of them. This, therefore, we are seeking to do as one of our most important objectives. The present complete lull in operations, the first since the war, provides a golden opportunity for improving the professional status of our officer cadre, and the skill of our technicians and tradesmen.

Anyone who thinks that the Army, let alone the Corps, has any intention of becoming "Europe-bound" is making a big mistake. It may surprise some of you to know that in the financial year 1968–9, 144 different Army units will be training abroad in twenty-five different countries. As for the Corps, we shall have fourteen different regular UK-based units exercising in nine different countries, some of them more than once, making twenty-one unit trips abroad for periods ranging from a few weeks to nine months. Of the Reserve Army, we expect to have eighteen units going overseas, ranging as far as Penang. I need hardly say how popular these visits are, as they always leave something of value behind. Indeed, far from being short of tasks, we are having to take care that we do not get overstretched, as we were two years ago by operations.

One of the factors which will weigh heavily with a greater incidence of unaccompanied tours overseas is that of family separation. If it is overdone, one tends to lose many of the best young married NCOs, from family pressures, however keen they themselves may be. On the other hand, there has been much local family separation in theatres having resident units such as the Far East, and this is a good deal harder to handle, besides being much more expensive. We shall have to maintain a delicate balance between stimulating the sapper's enthusiasm and preserving his domestic bliss.

And now, having waved a broad brush for some time, I shall be more particular. First I shall cover some general matters, and then go on to discuss some of our efforts round the world.

ORGANIZATION

The main organizational changes during the past year have been as follows:

(*a*) HQ 37 Engineer Regiment was raised at Longmoor, to command 33 Field Squadron, which returned from Cyprus in August last, and 66 Plant Squadron, raised in April. This unit is made up largely from the old command plant troops and has one troop detached at Ripon. On present plans 10 Field Squadron is to join from the Gulf in early 1969.

(*b*) 8 Field Squadron was raised at Tidworth, to complete 3 Division Engineers.

(*c*) 3 Training Regiment was re-formed at Cove. There are now two training regiments, 1 and 3, under lieutenant-colonels, replacing the very large 1 Training Regiment, which was found to be too unwieldy.

(*d*) 513 Specialist Team (Roads) was raised in November 1967.

(*e*) 10 (Airfield) Squadron was reorganized as 10 (Gulf) Field Squadron on moving from Aden to Sharjah, on a special establishment to support both Army and RAF; and 63 (MELF) Park Squadron as 63 (Gulf) Support Squadron, also at Sharjah; CRE Gulf was raised.

(*f*) 51 (Airfield) Squadron returned from the Far East to UK last March to join 39 (Airfield) Regiment at Waterbeach, at the start of the run-down. It was a pity, as they had gained the full confidence of Far East Air Force, who are now left without their own support, though they will, of course, continue to receive support from other units as far as possible. However, this move does make it easier for 39 Regiment, with all their UK commitments, to detach a squadron overseas, as they are now doing to the Carribean.

(*g*) 7 Field Squadron returned in January with 6 Brigade from BAOR to UK. They are at Ripon, but remain under operational command of 2 Division.

(*h*) There have been some changes in the engineer command structure in the UK. The Commanders of 29 and 30 Engineer Brigades (V) have assumed in addition the duties of Chief Engineer Northern and Western Commands respectively. The Chief Engineer Southern Command has become CE Army Strategic Command, and the Chief Eastern Command is now CE of the new geographical Southern Command, which embraces the old Eastern and Southern Commands. His appointment has been downgraded to colonel.

(*j*) 59 Field Squadron in the Far East has been affiliated to the Commando Brigade, and we hope they will do Commando training and wear green berets.

(*k*) HQ E-in-C returned to Whitehall on 15 December last and this is to be permanent. Because of pressure on headquarters numbers, some of the E-in-C's staff had to be left at Chatham, including the training branch at any rate for the time being. This is inconvenient, but much less so than complete rustication.

EQUIPMENT

Development of the new family of equipment bridges has been satisfactorily completed. The Medium Girder Bridge and Class 16 Airportable Bridge have both been accepted for service and we hope will go into production soon. These will be supplemented by a new German amphibious bridge the M2B which has been accepted and ordered and the new 75-ft clear-span Armoured Vehicle Launched Bridge, which is under development and showing great promise.

Development of the Bar Mine is progressing, but not as quickly as we would like.

The Lindsell range of plant is now beginning to enter service. We have started receiving nearly 300 items valued at £M2.5 for delivery over the next two years and the casting system for older plant is coming into use.

The new system for the repair of plant has now been approved and is being implemented. This is based on the principles of dovetailing and co-operation between

the two Corps RE and REME, and great flexibility in forward areas, to make the best use of our combined resources. In particular it provides RE commanders with REME workshops under command, with strong Sapper participation. It also eliminates the artificial distinction between unit and field repairs. Repair of engineer construction plant becomes the complete responsibility of the Corps from front to rear, but in practice engineer commanders in forward areas will be free to deploy their REME and RE fitter resources as the situation requires. In certain large static installations REME and RE workshops are to be completely integrated. REME C Vehicle fitters are to be trained at our own Plant Roads and Airfield School at Wainscott.

This new system is designed to fit in with a new plant trade structure in the Corps which I shall discuss presently.

TRAINING

During the past five years or so the Corps has been so stretched with operational commitments, and beset with uncertainties about future functions that it has been unable to devote very much detailed attention to individual training. Now we have the chance to take stock and put our house in order.

Trades Training

I mentioned last year the setting up of a Training Inspectorate. This is now largely established and is reviewing our standards and methods. In particular the timing of trades training is being investigated, to enable us to get better value out of our tradesmen earlier, and to give the man more incentive to improve.

I also mentioned the Standing Committee on RE Trades. The first fruit of this Committee has been a reorganization of the plant trades. As you know, we already have an A trade of Plant Operator Mechanic and this is to be followed by a new A trade of Equipment Operator Mechanic, to do for construction equipment what the POM does for plant. There will also be a new trade of Plant Mechanic RE starting at AII level and deriving from both. The existing trades of Engine Fitter Plant, Engine Fitter IC&P and Construction Plant Operator will disappear. The effect of this is that the POM and EOM have the option of either continuing in their existing A operating trade or of becoming Plant Mechanics embracing both as fitters. Eventually, the RE members of REME regimental workshops will all be Plant Mechanics AII and above, and they will also man our own engineer production and repair workshops. By this means our mechanics will gain very much wider and deeper experience than they can do under present conditions, and this should provide a more fruitful source of Clerks of Works Mechanical and Military Plant Foremen, who are so important to us. All being A tradesmen, the general quality will improve.

The remaining trade groups are being considered in turn, but changes of this nature can only be put into effect gradually over a long period if too much turbulence is not to result.

Training Attachments

In addition to the normal training attachments to civilian firms, we now have five officers from brigadier to major, seconded to the Ministry of Transport with their Road Construction Units. The brigadier has complete responsibility for motorway development in three counties, to a value of nearly £M50. I hope this will give the kind of experience in large-scale high-quality work which we must now be able to provide on airfields.

We have two officers attached to the US Corps of Engineers Civil Works Organization on two-year tours, and they are getting great value. We still have an officer in the Snowy Mountains Scheme in Australia, and are looking for a suitable successor project there.

We also have two officers and a clerk of works attached to the PWDs in the South Pacific, supervising the construction of airfields, and we look like sending

more. Their resourcefulness, as well as their engineering knowledge, is being fully taxed.

There are many other opportunities for civil attachments, but we are limited by the number of professionally trained officers we can produce, which at the moment is too small. We are seeking to increase the attendance at RSME Long Courses which should be encouraged by the fact that officers with AMICE are now exempt from attending Divs I and II of the Shrivenham leg of the Staff course. This should make it easier for officers to become "double-jointed".

RESOURCES

All the "Park" units in the Corps have been redesignated as "Support" units, except when they are truly static parks, as at Long Marston, which is now the Central Engineer Park. HQ ESE has now become HQ Engineer Support Group. These new titles are more descriptive of their true functions, and they may help to avoid misunderstandings by the Staff, which have so plagued us in the past, of their role as an integral part of the engineering entity.

2 ESD at Liphook closes at the end of this month after twenty-four years' life.

The workshop at Long Marston will have a strong military content, which will enable tradesmen to get experience not easily available elsewhere. The past year has seen much work on the transfer to Long Marston of stores and reserves we shall require from closing depots, and at the same time very full support was given to overseas theatres, and particularly promptly to Aden.

I shall now report on some of the happenings during the past year in different parts of the world, starting with the United Kingdom.

U.K.

RSME

The outstanding event of the year was the visit to the RSME of Her Majesty the Queen, as Colonel-in-Chief of the Corps, accompanied by Prince Philip, on the 28 March. The visit has been fully reported in the *RE Journal* and in *The Sapper* and I shall not repeat the story now. However, I would like to record a departure from normal custom which was made at the suggestion of the Chief Royal Engineer. It was decided to place an officer of each rank from brigadier to subaltern at the top table with the the Royal Party for lunch. The same pattern of mixing ranks, from the most senior to the most junior, was followed throughout the dining-room. There is no doubt that this arrangement was very well received both by the Royal Party and, I think, by the generality of officers of the Corps, and it contributed to the free and informal atmosphere that prevailed throughout the visit. Great credit is due to the RSME for their meticulous staff work and thorough preparation, which made this glorious day such a success. This gracious visit also gave a great lift to our morale. The visit marked the completion of the modernization project of the Brompton half of the RSME. After all the upheavals of past years, the RSME are now back to their full training programme and during the last year 400 officers and 2,800 soldiers passed through the school under training.

The Royal Tournament

The newly re-formed 3 Training Regiment is jumping straight into the limelight by providing part of the Corps contribution to the Royal Tournament this year. In this, we are providing three elements: the Arena Display which is centred round the construction of the Medium Girder Bridge, with brief glimpses of Corps history including ballooning, kiting, Army aeroplane No. 1 and the 1875 FA Cup-winning Team; the resident Arena Band which will be the Aldershot Band; and the Army Static Display in the entrance, which will include divers demonstrating underwater welding.

The Reserve Army

The Independent Units have made a good start, and are about 70 per cent recruited. A welcome feature is that they carry out much of their training in BAOR

and elsewhere abroad. This year two regiments, a brigade headquarters and 131 Para Squadron trained in BAOR, and a squadron in Cyprus.

A notable event was the presentation of a sword to the Lord Provost of Edinburgh, who is the Honorary Colonel of 104 Field Squadron (V), an account of which has been given in the *Supplement* to the *RE Journal* and *The Sapper*. During the hurricane damage in Glasgow in January 71 Engineer Regiment (V) turned out 150 men for clearing blown-down trees.

Sponsored Units

The sponsored units (the old AER) are fully up to strength because they have been able to take on a number of members of the old TA units which have been disbanded. Indeed, 111 Regiment has been allowed a temporary overstrength.

We have managed to get plenty of overseas training for the Specialist Teams RE and the Engineer Specialist Pool. In addition to the training in Singapore, Aden, Cyprus and Malta that they carried out last year, visits by Specialist Teams RE are planned to Masirah, the Persian Gulf and possibly Libya this year. From the Engineer Specialist Pool of twelve officers, visits will have been made this year and last year to eight different countries. 111 Engineer Regiment will be going to Cyprus in two parties each of 200 men during September and November.

THE STRATEGIC RESERVE

The Strategic Reserve consists of 3 Division Engineers, and 12 Engineer Brigade. The latter is now a very large brigade including three field engineer regiments, an airfield regiment, a survey regiment, a CRE (construction) and a number of specialist teams. All the units on emergency operational tours overseas have come home to roost, but the activities of the Strategic Reserve on training exercises and projects at home and overseas are too numerous to cover. Suffice it to say that they have included Gibraltar, Cyprus, Malta, Canada, Australia, Singapore, Masirah Island, the Carribean and Kenya. They have also undertaken a number of tasks in Scotland, notably an airfield at Unst in the Shetland Islands. There is a great deal of scope in Scotland, where we have had some ninety requests for development work, and a variety of tasks are being undertaken, including roads, bridges, water supply and airfields.

39 Regiment (Airfields) has been undertaking many tasks for the RAF, including major ones at Aldergrove, Locking, Shawbury and Brize Norton, and there is a growing commitment for the installation of Rotary Hydraulic Arrester Gear, at home and abroad. There has also been activity by the crashed aircraft recovery team.

But by far the most important task undertaken by this Regiment is the Beef Island project. This consists of a £200,000 airstrip for use by the civil authorities of the British Virgin Islands, to help to open up the tourist trade. 53 Field Squadron (Airfields) left Marchwood in the Landing Ship (Logistic) *Sir Lancelot* last March, and the project is due for completion by the end of the year. This project is important, as it is in the nature of a pilot one in support of the Ministry of Overseas Development. I very much hope that it will be followed by a series of developments in the Caribbean. We have already had requests which we are exploring.

62 CRE Construction has undertaken a bulk petroleum project in Masirah Island, and a reconnaissance has just finished in the Northern Frontier District of Kenya for well drilling which will start later this year. A detachment is supervising Congolese labour rebuilding Bailey bridges damaged in the troubles and 524 STRE Construction are on a two-year accompanied tour in Malta, assisting the PWD in planning various projects arising from the Robens Report on the economy of the island.

Various other gambits by the Strategic Reserve will appear when I describe activities in different theatres, but you will deduce from the little I have said that their commanders are much travelled men, and their units do not stay in UK for long. I shall conclude by mentioning the prompt help given by 38 Engineer Regiment

in hurricane relief work in the Glasgow area in January and February, and the very neat operation performed by 36 Engineer Regiment in demolishing the Sunk Head Tower off the East Anglian coast last summer.

BAOR

The Engineer organization in BAOR is being given a new look, partly resulting from the increased part to be played by the two Reserve Engineer Brigades in the Corps and Rear Areas and partly by the need for more regular units at divisional level. The proposed reorganization has been approved by the C-in-C, and is now under consideration at the Ministry of Defence. It involves in the main a rearrangement rather than an alteration in size of the engineer force. At the same time the major problem of works planning for war is being tackled by a team from 62 CRE Construction from 12 Engineer Brigade. The advent of the Harrier aircraft poses new problems of engineer support, and may require further reinforcement from the UK.

The January statement on defence made it clear that commitments overseas would in the main have to be met from forces in Europe, and this implies that forces assigned to NATO may be used elsewhere in the world more frequently than in the past. We have already done this in sending two field squadrons last year from BAOR to Aden on operational tours, with great success. But because of this commitment, and because of the general requirement to improve the engineering standards of the Corps at large, units in BAOR will in future be undertaking rather more construction work as part of their training than hitherto. Experience has proved to the hilt that the policy, long since adopted by the Corps, of having all-purpose field squadrons, assisted when necessary by specialist teams, is the right one. The problems and aims of the engineers in BAOR are similar to those elsewhere, but though there are opportunities for construction engineering and trades training, they mainly have a combat engineering flavour. All that is happening now is a slight change of emphasis. The present urge to save deutschmarks is also increasing demands on the Sappers for minor construction work.

MEDITERRANEAN

Gibraltar

In November 1965 the last 3,750-ft tunnel to be built in Gibraltar was started. On 8 September 1967, HE the Governor fired the final break-out round.

The Tunnelling Troop of the First Fortress Squadron disbanded on 1 April 1968, ending a long association of 197 years with the interior of the Rock. However, we have already had requests for assistance in maintenance from MPBW, and if this goes on we shall have to consider preserving a small cadre of tunnellers. Partly because of the trouble with Spain, and partly to improve amenities, Gibraltar has been reinforced by a light Field Squadron from the Strategic Reserve.

Near East

I mentioned that 33 Field Squadron returned to UK in August 1967 and as a result 62 (NEARELF) Support Squadron was reorganized, to include only one field troop. We said at the time that this was not enough, in view of the RAF commitment, and experience has shown that we were right. And as a result of representations from the GOC a field troop from the Strategic Reserve will shortly go to Cyprus on a six-month emergency tour to reinforce them. It was fortunate that when the last Greek/Turkish crisis arose in November, 3 Field Squadron of 3 Division happened to be working at El Adam, and a troop was sent over to Cyprus to reinforce. In the meantime, CRE Cyprus is being greatly helped by a series of visits from both regular and reserve army units for training. There is plenty for them to do, especially in view of the current financial restrictions on works services. 3 Field Squadron spent six months unaccompanied in El Adam on a variety of tasks, principally accommodation. I am glad to say their effort was enthusiastically received by the RAF, both in El Adam and in Cyprus, from the C-in-C downwards.

Since July last year 3 Division has maintained a detachment under a subaltern with UNFICYP, and they have been doing a great deal to make the living conditions of the British battalion with that force more tolerable.

Planning has started for the extension in concrete of the main runway at El Adam, and this is to be done next winter by an airfields unit.

Malta

I have already mentioned the stationing of 524 STRE Construction in Malta on development work. In addition there has been, and will continue to be, a series of visits from specialist teams of the Reserve Army, and it is encouraging to find that a coastal road project, planned last year by one of these teams, has already been completed by the Malta engineers, so that this year they can see the fruits of their labour.

MIDDLE EAST

It is possible to have more than one view as to the degree of honour with which this country emerged from South Arabia. However, there can be no two views about the honour with which the armed services emerged, and there is no doubt that the Corps earned a memorable share of it. Road building and most other activities upcountry were completed in June, when all units withdrew to Aden itself. Among the last to leave were the Well-drilling Team from the MELF Park Squadron, who left behind them twelve wells, totalling 3,273 feet in depth. The Clerks of Works who were dispersed throughout the country building barracks for the Federal Army were the last of all to leave, and for some time they had no British protection whatever. It says much for the goodwill they had generated by their many actvities apart from building, such as acting as trades trainers, school teachers, doctors, and even midwives, that they were immune to the end from attack.

Action then centred in and around Aden with 60 Field Squadron, and later a troop of 50 Field Squadron, supporting the Aden Brigade. The excellence of their support is testified by the number of battalion commanders who put Sappers up for awards. A quaint and symbolic task was the removal of Queen Victoria's statue from its time-honoured position in the Crescent to the purlieus of the new British Embassy.

Throughout the emergency something like a third of all Sappers in Middle East were deployed on tasks for MPBW, including all work outside Aden itself. As the situation inside Aden deteriorated the Royal Engineers became increasingly involved and the first instance of a Military Works Area being set up occurred on 15 October 1967. This operation was entirely successful. A few specialists of MPBW remained running the power station at Khormaksar, and co-operation was excellent in all phases.

10 Field Squadron (Airfields) found themselves with tasks ranging from Majunga in Malagasy to the Gulf, and with the impending demise of the Beverley, it became urgent to improve airfields in the Trucial Oman States and the Sultanates of Muscat and Oman, to take Argosies and Andovers. This task again was undertaken on behalf of MPBW.

These activities in Aden were taking place at the same time as the closing down of the theatre, the despatch of stores and equipment to the UK and to the Gulf, and the reorganization and redeployment of units to the Gulf. CRE Gulf was set up in Bahrein in September 1967, and 10 (Gulf) Field Squadron and 63 (Gulf) Support Squadron were established in Sharjah, with a field troop of 10 Squadron detached to Bahrein. The work in the Gulf has mainly consisted of airfield improvement and maintenance, and road and track development in eastern Arabia. The Chief Engineer left Middle East in September 1967, and was succeeded by a CRE until the final departure on 20 November. During the evacuation phase, a troop of 59 Field Squadron from FARELF lay off Aden in a carrier with 42 Commando, and took some part in operations ashore.

During the thirteen months from October 1966 to November 1967 the Corps

won forty-nine awards in the Middle East. Last year I told you that a troop of 39 Field Squadron from BAOR had acquitted themselves well in an action in the Wadi Matlah. I am glad to say that this was recognized by the award of a Military Cross to Lieutenant Conroy and a Military Medal to Sergeant Scott. I had reports in the most glowing terms from the GOC in Aden about the efforts of the Sappers, and the thing which impressed him most was the enthusiasm with which his Sappers could turn their hands to widely differing tasks at no notice at all. This, of course, is our stock in trade.

FAR EAST

The main events in the *Far East* have been the completion of the Post Crown road in Thailand and the border troubles in Hong Kong.

Thailand

Based on the Crown Airfield at Leong Nok Tha, which was finished as a permanent airfield at the end of 1966, a project of road development towards the west was undertaken, designed to link up with certain Thai development working eastwards. Nine different RE units have been employed on this project, including a field squadron from the Strategic Reserve. It has been an outstanding success. By the middle of April this year they had completed nearly forty kilometres of road—fourteen more than planned—and fourteen bridges, and completed the link up with the Thais. The work was to a high standard and the cost per mile was something like a third of the normal cost of doing similar work by a civil contract in that area. As a sideline the units engaged did a great deal of village improvement work such as making and improving wells and making access roads. The local goodwill generated was enormous and the decline in Communist subversion in the area very sharp. Traffic and trade has built up rapidly. Unfortunately the British Government would not agree, for political and financial reasons, to our continuing this valuable kind of development work, and all Sappers had to be out of Thailand by the end of April. But on 18 April there was a handing-over ceremony which was something of a "tour de force". It was attended by some 150 visitors, including the British Ambassador, the Chief of Staff of the Thai Armed Forces, and numerous senior British and Thai officers and officials. The Army Commander, who attended, subsequently wrote to the CGS, and I will quote from his remarks upon the Sapper effort:

"You will be more interested to hear the part played by the Royal Engineers and their supporting units in all this. Although practically every engineer troop in FARELF has had a hand in the project, 54 Squadron, under command of Major P. R. T. Driscoll, was in charge of the operation at the time of the completion of the road. The night before the hand-over ceremony, the Squadron gave a cocktail party and buffet supper to the visitors from Singapore and Bangkok and numerous local Thai dignitaries and their wives.

"The Squadron had trained up a Corps of Drums and Fifes, which Beat Retreat in an exemplary manner, and was hard to tell from regulars. They were drawn from members of the Squadron; plant operators, storemen and the like, who had learned their instruments in their very limited spare time over the past four months. The drum-major was the Quartermaster's corporal storeman and he returned to two hours' work on his books after the evening ceremony.

"At the parade on the next day the Drums and Fifes played again in support of a contingent of three troops, all very smart in No 3 dress. They showed up magnificently and were enterprising enough to march past Air Chief Marshal Dawee in line. The Thai officers had great difficulty in believing that these were the men who had been operating the plant and carrying out other duties on the road, and had not been flown in specially from Singapore for the occasion. It was clear from their bearing on parade how proud they all were of their achievement. Great credit is due to all those from all RE squadrons who have taken part in the project and I think I have probably had the cream of the Royal Engineers commanding my units and acting as project officers. They certainly are a very high-grade lot.

"I am certain that these types of project are of inestimable value in under-developed territories in overcoming, in a most effective way, the conditions that produce a breeding-ground for Communism. At the same time, they enhance our prestige, which at the present time can hardly be said to be in the ascendant in SE Asia, far better than large sums of aid, as they bring us physically into contact with the local nationals, and in this context the British Soldier is still an admirable ambassador."

54 Squadron's private Corps of Drums and Fifes so impressed the Ambassador that he invited them to Beat Retreat at his Queen's Birthday Reception in Bangkok, which they did.

The Army Commander's report was circulated widely in Whitehall, and the Prime Minister asked for his appreciation to be conveyed to all concerned.

This project was undertaken entirely on the personal initiative of the Chief Engineer Far East, and I think that its success should greatly improve the prospects of our getting similar worthwhile tasks in future. It also provided good publicity for the Army, with features on television, radio, and the national Press.

The disturbances in Hong Kong placed a very heavy load on 69 Gurkha Field Squadron, who were closely involved, and found themselves undertaking practically the whole gamut of combat engineering support of the infantry on the border. This included field defences, mine laying and mine clearing, improvements to accommodation, the erection of a wire barrier 32,000 yds long behind the frontier, and hundreds of calls to deal with explosive devices. In the course of these, WOII R. B. Christison was wounded and has been awarded a bar to his BEM, and Lieutenant Humphrey, who lost several fingers dealing with a device, received the Queen's Award for Brave Conduct for his gallantry on another occasion.

69 Squadron operated without relief for several months, and were then reinforced by a troop of 68 Gurkha Field Squadron from Malaya. I found on my recent visit to Hong Kong that their reputation was very high indeed, and it is good to know that their efforts have been recognized in the award of the MBE to Lieutenant (QGO) Minbahadur Gurung. It has only been since March that they have had any let up from working seven days a week at their operational tasks, which started in August last year. Since then they have been able to give a little time to training.

Units in FARELF are likely to be involved soon in "hearts and minds" projects for which the Hong Kong Government is now pressing.

Brunei

67 Gurkha Field Squadron remains in *Brunei* until the middle of this year, when it returns to Malaya without replacement. It has been engaged in supporting the Gurkha battalion in Seria, and in road construction in a particularly difficult location in the Temburong district. It has also undertaken a number of "hearts and minds" projects for the Brunei government, including bridging, bomb disposal and building a school.

Malaysia and Singapore

Many exercises take place in West Malaysia and Singapore, and the Chief Engineer has arranged that these invariably include some useful work in aid of local development. We hope also to be able to undertake some work on a larger scale as a form of "mitigatory aid" in view of the impending evacuation.

The Gurkha Engineers

In line with the run-down of the Brigade of Gurkhas from 15,000 to 10,000, the Gurkha Engineers are to be reduced by this autumn from three to two field squadrons. These will be initially in Malaya and Hong Kong; but after 1971 all Gurkhas will be in Hong Kong.

In the current reduction 69 Squadron is due to disappear as such. This unit has had a short life but a remarkably useful one. It had just been raised, and was actually in North Borneo, when the Brunei trouble started in 1963. It was, there-

fore, the first Sapper unit on the scene, and spent longer in Borneo than any other unit in the British Army. It has now greatly distinguished itself in Hong Kong.

I found on my recent visit, as their Colonel, that the spirit of the Gurkha Sappers was quite terrific, in spite of the cuts. They are a very tough and irrepressible lot, and the quality of the rank and file is higher than it has ever been.

SPECIALIST ACTIVITIES

Postal and Courier Communications

Postal and Courier Communications Units are continuing to provide an efficient world-wide service to the Royal Navy, Army and Royal Air Force, including exercise support in many countries. Operational support continues to be given to the Royal Navy in the Beira Straits. During the last year the Forces Long Range Courier Service has been extended to Singapore, Hong Kong and Majunga.

The other day a detachment from the P&CC Depot at Mill Hill distinguished itself by doing a remarkable job in salvaging and redirecting the mail from the BOAC 707 which burnt out at London Airport. Many letters of thanks have shown how much this was appreciated at the receiving end in Singapore.

Survey

Topographic troops have been deployed in Malaysia and BAOR throughout the year. The most notable survey completed was a connection across the Malaya/Thai border carried out in liaison with those two countries.

Many surveys have been undertaken in UK for all three Services and also some for the Ministry of Technology. One of these was connected with the Concorde project.

512 STRE (Geodetic Satellite Survey) continues to be based on Washington DC. The optical tracking team is in South Georgia in the Falkland Islands, and the electronic team is on Ascension Island. Both teams are working in support of American worldwide geodetic projects.

It was gratifying that during her visit to Chatham the Queen met some members of the Chile/Argentine Boundary Demarcation Party, whose work was based on her Award. She showed a great interest in their experiences and was pleased to hear that both sides thought they had got the better of the argument.

Bomb Disposal

The largest total of beach and anti-tank mines for twelve years were recovered and made safe in the UK. The team in Penang has gone on clearing that interminable Japanese bomb dump.

RECRUITING

I have left this subject to last, because it is so important.

The uncertainties of the last few years, and in particular the depressing statements of 16 January last, have had a bad effect on recruiting, and this has now become one of our principal preoccupations.

I think the main source of the trouble is the amount of misinformation and indeed misrepresentation which goes on about the future of the Army, the life in it, and about career prospects. During the run-down period redundancy will take a complete slice out of the rank pyramid, and new entry will be tailored to the new size. This means that the prospects for those at the bottom will be as good as ever. Of course, it is impossible to predict what will happen to the strength of the Army in the next decade, but there must be a certain level below which it cannot remain viable, and it is a matter of opinion what this level may be, and what are the factors which determine it. But any Government must maintain a viable Army, which offers an attractive career. Looking at the state of the world, one might be inclined to guess that the level is more likely to rise again rather than fall further. The next point that people should realize is that the Corps in particular will continue to offer much adventure, unrivalled managerial experience, opportunities for advanced studies, promotion prospects based solely on merit, pay and perks at least as good

as the general run outside, and very good prospects of employment on leaving. Moreover, the Army is and will be the best-trained, best-equipped and most efficient we have ever had; it offers above all, a life of service in the congenial company of like-minded men with no axes to grind, which some think, with good reason, is the most important thing in life. Though based on Europe, there is likely to be more movement and travel than ever before and the future will certainly not be peaceful. So I hope you will all help in spreading these thoughts and not allow young men to be put off by ill-informed and unnecessary gloom.

Of course, there will be some loss of prospects and disappointment for some of those now serving, particularly those in the middle bracket. This is unavoidable and regrettable. But it is our duty to safeguard the future and ensure that the young are not discouraged.

Officers

At the present time we are getting an adequate entry of officers, but not as many as I would like of the new University Cadetships. I doubt whether the particular advantages of this scheme are widely realized. We must also remember that under the long-term career structure there are to be 60 per cent regular and 40 per cent non-regular officers. Unless we get this 40 per cent non-regular we shall be seriously short. It is a matter partly of finding the right sort of men in units and partly of encouraging suitable men from outside to take Short Service and Special Regular Commissions. There are many young men who are uncertain what to do with their lives, and all I can say here is that nothing but good can come to such a man from taking one of these commissions, whether he eventually decides to stay or go. If he goes for, or transfers to, a Special Regular Commission, he will come out at an age when the value of his training and experience on the open market will be at its greatest—at about 37—and of course he can apply for a Regular Commission if he wants to stay.

Other Ranks

Eighteen months ago we were 4 per cent over-recruited, and six months ago 2 per cent. Today we are actually down to strength and going down. This is a bad situation, and it is partly due to the general uncertainty caused by recent events, which affects the whole Army, and partly to restrictions placed on our recruiting by the Ministry of Defence, because of our past overstrength and the shortages of some others. We have succeeded in getting some of these restrictions removed and are taking a number of steps to improve the situation. But at the moment we do not look like meeting even the reduced target for the year. Other adverse factors to be reckoned with are men maturing from lower birth-rate years, gradual expansion of Government training schemes in popular building trades long associated with the Corps, and the effects the raising of the school-leaving age may have in further reducing the field. It is clear that we now have once again to make a major drive on recruiting and the great problem is how to obtain adequate and favourable publicity for the Army and for the Corps. This is no easy matter in a country where the organs of publicity are not well disposed towards the armed forces. It is one thing to give them favourable material—quite another to induce them to publish it—or to get it right. As you can imagine, this is a matter of great concern at the Ministry of Defence, and is engaging much of the attention of my own staff. Here again, I believe that individuals can do a great deal by spreading by word of mouth the achievements of the Corps and the kind of life it offers, and dispelling misconceptions.

The Reserve Army

Officer recruiting in 1967 was excellent and most units were full. As to soldiers, the position is not quite so good, the overall strength being about 80 per cent of establishment. However, there is a considerable shortage of Special Army Volunteer Reservists for 102 Field Squadron (V)—the "every ready" unit—and today it stands at about half the requirement.

CONCLUSION

I hope you may have been encouraged by what I have told you today, and have the impression that things are a good deal better than they may at first appear. In particular, you will note that the Corps has to its credit some considerable achievements during the last year, which could hardly have been attained without the highest state of morale in units. From my own observation, this has indeed been so, to a most remarkable and moving extent. When one considers that there must be many officers and warrant officers and NCOs who have personal worries about their future, it is greatly to their credit that they have not allowed any such feelings to make themselves felt in the unit, or to interfere in any way with the efficient and cheerful carrying out of their duty. As to the future, I am absolutely confident. This is a very ancient and tough Corps, a stiff ship not easily knocked over by passing squalls. We are certainly in for a difficult period ahead, with much turbulence, disruption and reorganization. But we have had bad periods before—much worse ones —and have come through much improved. We shall have to reduce canvas for a bit, but shall maintain our appointed course and momentum.

I cannot end my last address to an audience of this sort without remarking what a constant joy it has been to feel the instant and whole-hearted support given to me by all members of the Corps, both serving and retired, and of every rank, and by all its supporting organizations. The encouragement and extra power to his elbow this gives to an E-in-C has to be experienced to be believed.

For this, gentlemen, any thanks I can express must be as inadequate as my debt is deep.

Earth Dams for Military Engineers

MAJOR R. JUKES-HUGHES, MICE, RE

INTRODUCTION

"WATER is perhaps the most essential ingredient that the Engineer can help to provide"—so said the Chairman of the Southern Association of the Institution of Civil Engineers in his address to the Association on 20 October 1966. Few would disgree with him. It has been estimated that two thirds of the world's population are suffering from malnutrition, and much of this can be directly related to drought and poor irrigation. The need for water conservation throughout the world is enormous. Although India, for instance, has built about 400 large dams for irrigation since 1945, only 20 per cent of her agricultural land is now irrigated—the remainder relying on the monsoon. When the latter fails, as it has done for the past three years, the result is widespread famine which cannot be relieved entirely by importing food from elsewhere. Unfortunately the countries where the need is greatest are often those who are least able to afford the capital expenditure involved. It is believed that in such countries the Corps could make a valuable contribution. We have the organization, equipment and technical ability to construct quite large earth dams, and it is the aim of this paper to show that this could be accomplished.

GENERAL FEATURES OF EARTH DAMS

All earth dams have two basic features: a foundation, which is treated to form a water barrier below ground-level; and an embankment, which forms the water barrier above ground-level. They also have a number of ancillary works which enable the dam to function efficiently. These features are described below, and most of the points mentioned are illustrated in Annexes A and B.

(*a*) *Foundations*. Foundations may be broadly classified as rock, coarse grained (sand and gravel), or fine grained (clay and silt), although they often consist of a mixture of these. They generally require some treatment to make them safe, and to eliminate or greatly reduce seepage under the embankment. The type of treatment varies greatly, and is dealt with more fully later in the paper.

(*b*) *Embankments*. An embankment will either be constructed of homogeneous impermeable material or it will be constructed largely of pervious material together with an impermeable core or membrane to form a water barrier. It will generally require some form of slope protection. The most common form of upstream slope protection (especially in the USA) is dumped "riprap"—a layer of large durable rock fragments which effectively dissipates wave action. Soiling and sowing to prevent scouring by rain is normally sufficient for the downstream slope. Rock toes are usually incorporated to prevent sloughing of the embankments when they are saturated. The drainage blankets seen in the section at Annex "A" are there to assist in draining water from the pores of the clay during the construction period. The reason for this is that the stress induced by the weight of the embankment is distributed in the soil partly as stress in the soil grain structure, and partly as pore water pressure. If the latter is allowed to become too high, the soil will flow and result in failure of the embankment. The condition is critical at the end of the construction period, as thereafter seepage slowly reduces the pore pressures. It does not occur with pervious soils.

(*c*) *Ancillary Works*. These will include a spillway and outlet works. The purpose of the spillway is to release surplus or flood waters so that the dam cannot be overtopped. The structure will consist of some form of weir leading into an artificial conduit or channel which empties into a river or other natural drainage channel. A stilling pool at the lower end of the artificial waterway may be necessary to dissipate the force of the flood water before it enters the river. The outlet works of a dam regulate the discharge of the impounded water for the purpose for which it is to be used, and generally include scour pipes to empty the reservoir completely.

TYPES OF EMBANKMENT

The scope of this paper is limited to rolled-fill earth dams. In these the major portion of the embankment is constructed in successive, mechanically compacted layers. The material is excavated from borrow pits and taken to the site in trucks or scrapers. It is then spread by dozers or graders, and sprinkled with water if necessary to form thin layers of the correct moisture content. These layers are then thoroughly compacted and bonded with the preceding layer by rollers of the proper design and weight for the soil. This method of construction is eminently suited to military plant and organization, and the procedures are very similar to those of road and airfield construction. Other methods of construction include dams with puddle-clay cores, and hydraulic-fill earth dams. In the latter method the soil is pumped into the dam in suspension in water, and the soil allowed to settle out. These methods are used less frequently nowadays, partly because they are less reliable than rolled-fill dams and partly because modern earth-moving plant and soil mechanics enable rolled-fill dams to be constructed more rapidly than formerly.

Rolled-fill earth dams can be broadly classified into three types: homogeneous, diaphragm and zoned. These are illustrated in Annex "C", and described below.

(*a*) *Homogeneous Type*. A homogeneous dam is composed of the same material throughout (except for the slope protection), which must therefore be impermeable. The slopes will be fairly flat; the upstream slope to ensure stability if the water-level in the reservoir is lowered rapidly ("rapid drawdown"), and the downstream slope to prevent excessive pore pressures at the end of construction. It is normal to introduce some pervious material in the downstream part of the dam to prevent seepage affecting the downstream slope. This may be placed either as a downstream rock toe or as a filter drain under the downstream half of the dam. Both methods are illustrated in Annex "C", Figures Ia and Ib. Homogeneous dams are used

where impervious soils (clay, silt-clay) are readily available, but more pervious soils are scarce or difficult to obtain.

(*b*) *Diaphragm Type.* The diaphragm type of dam is constructed from pervious materials (sand, gravel, rock) and has a thin diaphragm of impermeable material to form the water barrier. The diaphragm may be of reinforced concrete (normally laid in sections joined by water bar to allow for settlement), timber, steel plates, asphalt, or an impermeable membrane such as Butyl synthetic rubber, PVC or polyethylene. Impermeable membranes are particularly suitable for military projects due to their light weight and ease of construction. Diaphragms are normally located on the upstream face of the dam, where in the case of asphalt and concrete membranes they will also provide wave protection. Plastic membranes must be covered to protect them from the sun, and from damage by animals, vandalism, etc. Diaphragms can be positioned internally, but this has the disadvantage that they cannot easily be inspected and repaired. Diaphragm-type dams are used where there is no impervious soil readily available.

(*c*) *The Zoned Embankment Type.* In this, the most common type of rolled earthfill dam, a central core of impermeable soil is flanked by zones of more pervious soil which support the core. There may be a number of zones becoming progressively more pervious towards the outsides of the dam, in which case the dam will be termed a multi-zone type; or there may be a single outer zone of pervious material on either side of the core. In the latter case a transition filter of graded material will probably be necessary to prevent the fine-grained material of the core being washed out into the pervious shells. The core may be either vertical or sloping; a sloping core requiring more impermeable material, but giving increased stability. This type of dam will generally be used where there is a variety of materials available, because it invariably gives the most economical solution.

THE PLANNING OF A PROJECT

A thorough investigation of all the factors involved is essential to the planning of any water-conservation project. Inadequate information may lead to delay, needless expense, and sometimes to failure. However, detailed investigation is expensive and time consuming, and it should therefore be planned so that the probable soundness of the project will be determined as early as possible. To achieve this objective, the planning and design is likely to be divided into the following four stages:

(*a*) *Reconnaissance.* To find the most suitable site for the project on the basis of available knowledge, and from a study of the surface features. The information obtained will be used in planning subsequent investigations.

(*b*) *Feasibility.* To determine the essential features of the project, and their cost in relation to the benefits obtained. Sufficient soil and rock investigations should be carried out to enable a preliminary design of the dam to be completed. A report on the feasibility of the project will probably be called for at the end of this stage.

(*c*) *Detailed Investigation.* To secure accurate data on the engineering properties of the soil and rock strata to be used as a basis for detailed dam design and specifications.

(*d*) *Detailed Design of the Dam.* To produce a satisfactory functional structure at a minimum total cost, using the available materials.

A military aid project might originate either at governmental level or it might conceivably originate from an approach to an engineer commander in the field. An instance of the latter occurring in the Aden Protectorate was quoted by Major D. A. Knight in his article in the June 1967 issue of this *Journal.* If the dam is to be a very small one, and the geological conditions are simple, the investigation and design could be undertaken by military engineers. It is far more likely, however, that the army would come in as the "contractor", and that an experienced dam engineer would have overall responsibility for the project. In Great Britain, for instance, the Reservoirs (Safety Provisions) Act 1930 states that for all reservoirs impounding 5 million gallons (800,000 cu ft) or more above original ground-level the engineer

responsible must be a member of a panel of engineers set up by the Home Secretary. If the project design has not yet been completed, a Specialist Team RE might be assigned to this engineer to assist in the final site investigation for the dam. This team, with a mobile soils laboratory, would then become responsible for controlling the earthworks during the construction of the dam.

DETAILED DESIGN

The detailed design of the dam is based partly on precedence, and partly on an analytical study of the information obtained in the investigation stages. The procedure is essentially one of trial and correction. Trial designs are assumed, analysed for safety during all phases of construction and operation, modified as necessary, and costed. The design which is finally selected is that which seems to offer the best combination of safety, economy, and convenience in construction. However, it is generally possible to build a variety of dams at a given site which would be safe and economical, and the personal experience and preference of the designer have considerable bearing on the final result. The procedures for designing earth dams are outside the scope of this paper, and the reader is referred to the several excellent textbooks on the subject which are listed in the bibliography. The criteria which must be met in the design are as follows:

(*a*) The embankment must be safe against overtopping during occurrence of the inflow design flood, by the provision of adequate spillway and outlet works capacity. The magnitude of the design flood selected will depend on the consequences of failure, but in Great Britain it is taken as being twice or two and half times the Normal Maximum Flood for the size of catchment area involved.

(*b*) The slopes of the embankment must be stable during construction, and under all conditions of reservoir drawdown. Mohr's "slip circle" method, which supposes the surface of rupture to be cylindrical, is generally used for analysing embankment stability.

(*c*) The embankment must be designed so as not to impose excessive stresses on the foundation. The bearing capacity of the foundation will have been computed from the field and laboratory tests done in the detailed investigation phase.

(*d*) Seepage flow through the embankment, foundation and abutments must be controlled so that no erosion takes place, and there is no sloughing in the area where the seepage emerges. Seepage is computed from Darcy's law and the Laplace equation, and is plotted on a flow net diagram.

(*e*) The embankment must be high enough to prevent overtopping by wave action. There are a number of formulae from which the wave height can be calculated for given values of wind velocity, duration and fetch (the length of open water in the direction of the wind).

(*f*) The settlement of the dam and foundation must be calculated, and an allowance made for it by cambering the crest of the dam.

(*g*) The upstream slope of the dam must be protected against erosion by wave action, and the crest and downstream slope by erosion due to wind and rain.

THE CONSTRUCTION PROGRAMME

The safety of an earth dam depends as much on proper construction as on sound design. Adequate supervision, testing and recording are essential from the start of construction. The designer must keep in intimate contact with the construction work, since much more information about the foundation and borrow materials will become available than was known in the design stage. This information will be used in planning the foundation treatment, and could lead to changes in the design of the dam. The construction programme may be divided into three phases:

(*a*) Site preparation and diversion of the stream.
(*b*) Preparation of the foundation.
(*c*) Construction of the embankment.

The construction of the spillway and outlet works may run concurrently with the last two phases, and soil excavated in connection with these will frequently form part of the embankment material. These phases are discussed in turn below.

SITE PREPARATION

This will include the setting up of the site organization, living quarters and any static plant, such as quarrying machinery, which is required. Access roads to the construction site may have to be built, and trees, roots, boulders and buildings, etc, on the dam site and borrow-pit areas will have to be cleared. Materials of value are recovered, and waste materials are normally dumped upstream of the dam. The top-soil over the dam site and borrow-pit areas is then stripped, and it will probably be stockpiled for use on the downstream face of the dam. The earth-moving programme will also be planned during this phase.

DIVERSION

Diversion is the re-routing of the river or stream around the construction area. It is normal nowadays to achieve this either by driving a tunnel through the hillside around one abutment of the dam or by constructing a conduit under the dam. The stream is led into the tunnel or conduit, and away from it, by open channels. Head and side walls are generally constructed at the junction between the tunnel or conduit and the open channels, and a heavy screen is necessary at the mouth of the tunnel or conduit to prevent debris from entering. If the valley is very flat, a temporary cofferdam may be required to collect the water before it enters the diversion works. This is generally constructed of waste materials from the site clearance, and it is sometimes incorporated in the upstream toe of the dam proper.

The diversion tunnel or conduit must be made large enough to take flood flows during the construction period. However, it is now normal practice to house the supply pipes and reservoir scour pipes in this tunnel or conduit, and it is convenient to make it large enough to allow ready access to these pipes. If this is done, the tunnel or conduit is plugged with concrete upstream of the valve-control gear shortly before impounding starts. Specialist knowledge of tunnelling is now limited in the Corps, and the driving of a diversion tunnel might have to be subcontracted to a specialist firm.

FOUNDATION PREPARATION

The foundation of an earthfill dam requires treatment to ensure, firstly that it provides stable support for the embankment under all conditions of saturation and loading, and secondly, that no undue seepage takes place through it or along its surface. Inadequate foundation treatment has resulted in a number of failures of earth dams, particularly through 'piping' along the contact surface between embankment and foundation. Special treatment for different types of foundation is described below.

Rock Foundations. Rock and shale foundations do not present any problem of bearing strength for small earthfill dams, but they may require extensive treatment to bond the impervious section of the dam to the rock, and to control seepage through cracks and fissures in the foundation. The treatment of these two problems is as follows:

(*a*) *Scaling.* The best way of obtaining a tight bond between the impervious core of the dam and the foundation is by making the rock surface regular enough to permit each embankment layer to be compacted directly against the rock, preferably with pneumatic-tyred rollers. Soft rock foundations and abutments can be trimmed with earth-moving equipment. Overhangs and promontories in hard rock foundations and abutments are removed by compressed air tools or by careful blasting. Local depressions in the rock surface are filled with concrete or hand-compacted clay. Steep abutments should be cut back to the flattest practical slope, as the flatter the slope the better the compaction obtained. The final trimming and cleaning of the

rock surface must be done by hand, and the surface should be wetted before the initial layers of material are placed.

(*b*) *Grouting*. The object of grouting is to seal with grout all the open cracks in the bedrock for a narrow width along the axis of the dam. This procedure is necessary on most rock foundations, and is termed "curtain grouting". Portland cement grout is normally used. If the surface bedrock is badly weathered it may be necessary to dig a cut-off trench into it, which is backfilled with concrete or hand-compacted clay. This was the case with the dam illustrated in Annex "A". The concrete spearhead above the cut-off wall in this dam, however, is not always incorporated, because it is difficult to compact the soil around it. Successful grouting requires considerable experience, and it is often subcontracted to a specialist firm on civil dam projects.

Sand and Gravel Foundations. The foundations for earth dams often consist of recent alluvial deposits of pervious sands and gravels overlying the bedrock. Three basic methods of foundation treatment are possible:

(*a*) Eliminating the seepage or reducing it to a negligible amount by constructing a complete vertical cut-off. This is the best and most common method of treatment. It is generally accomplished by extending the impervious zone of the dam down to the bedrock as in the dam section illustrated at Annex "A", but sheet pile cut-off and cement-bound curtains are also used.

(*b*) Reducing the seepage either with a partial vertical cut-off or with an upstream impervious blanket (to lengthen the seepage path) as shown in Annex "C", Figures 2a and 2b.

(*c*) Taking no steps to reduce seepage, and providing for its control by means of downstream horizontal drainage blankets or relief wells. This is the least common method of treatment. Relief wells were installed adjacent to the downstream toe at the recent Tryweryn (1965), Balderhead (1965) and Derwent (1966) Dams.

Complete and partial cut-off trenches are excavated by face shovels, draglines or scrapers. The main problem is generally the dewatering of the excavation, and holding down the water table until the trench is backfilled. This is done by pumping from sumps dug just outside the trench line so that the pumping does not interfere with foundation preparation. In unstable sand foundations it will probably be necessary to lower the water table ahead of the excavation by deep well pumping. Compaction of sand and gravel foundations is not generally required.

Silt and Clay Foundations. The main problem with foundations of fine-grained soils is stability, and the dam will therefore have been designed to keep the foundation pressures within safe limits. The construction procedure for hard clays is generally confined to stripping the organic top-soil, and to cutting a key trench as illustrated in Annex "C", Figure 1a. Scarification with harrows is sometimes necessary to ensure proper bonding with the embankment materials, but compaction of the initial layers by sheepsfoot rollers is generally adequate for this purpose. Soft clays must either be removed and replaced with satisfactory material, or the rate of construction must be controlled so that the pore-water pressures (and thus the shear strength) are kept within safe limits. A relatively new form of treatment for soft clay foundations is the sinking of a system of vertical sand drains through the foundation. This enables the pore water to drain out horizontally, thus increasing the rate of dissipation of the pore pressures and the consolidation of the clay. This method has been used in the UK recently at Selset (1960) and Derwent (1966) Reservoirs, but is only suitable for large dams.

EMBANKMENT CONSTRUCTION

The construction procedure for an earth-dam embankment is similar to that for roads and airfields, and the same high standard of supervision and control of earthworks is required. Detailed written records must be kept of all activities and laboratory tests; both to ensure that proper supervision is being exercised and to provide for the analysis and correction of any unforeseen difficulties which may

require design changes during construction. Piezometers will usually be installed during construction to keep a continuous check on pore-water pressures. The construction procedure consists of excavating the material, mixing it if necessary to a predetermined water content and uniformity of material (either in the borrow pit or on the embankment), spreading it in layers, and compacting it to the required density. The procedure is covered in more detail in the ensuing paragraphs.

Borrow-pit Excavation. Excavation on a military project would be carried out by face shovels, draglines or scrapers. The method selected will depend on the nature of the material, the configuration of the borrow pits and the haul distance. The main characteristics of each type of plant are as follows:

(*a*) *Face Shovels.* These are suitable for most materials from soft soil to boulders and broken rock. They are most efficient when working in deep borrow pits above the water table, and provide the best means of mixing soils of different properties and water contents in the excavation.

(*b*) *Draglines.* Excavation with draglines is slower than with face shovels, and they cannot be used to excavate sticky clays or hard materials. They are best suited to excavating pervious sands or gravels from deep deposits, including those below the water table.

(*c*) *Scrapers.* Tractor-towed scrapers are efficient only in long borrow pits where the haul distance is fairly short. They can be used on most soil types, and are particularly useful for chewing up stiff clays and soft rocks. They are not efficient mixers, and are therefore best suited to borrow pits where the soil is uniform or where it is necessary to select materials from stratified deposits.

Supervision in the borrow pit will be primarily concerned with material control and moisture-content control. The areas and depths of cut will be selected, and the zone of the dam to which the material is to be allocated will be determined. The water content of the material should be adjusted as near as possible to the optimum water content prior to delivery to the embankment. Water may have to be added by sprinkling or hosing, or taken away by stock-piling and draining. Laboratory tests required in the borrow-pit area will be soil classification tests (sieve analysis, plasticity index, etc) and rapid moisture content tests.

Placement of the Fill. The fill is generally placed on the embankment in layers which will be about 6 in deep after compaction. Scrapers can often achieve this without assistance, but dozers or graders will be required for levelling material which has been dumped by trucks. It may be necessary to mix different materials on the embankment with ploughs or harrows. In diaphragm-type embankments, and in the pervious shells of zone embankments, the coarser materials should be placed towards the outsides of the embankments. The main items requiring supervision will be line and level, material control and moisture content. The material will be inspected to ensure that it is properly mixed, that the layer thickness is correct, and that no boulders, tree roots, etc, are present. The moisture content will be finally adjusted prior to compaction either by sprinkling to increase it or by harrowing and allowing for evaporation to decrease it. It is important that the soil is at the correct moisture content throughout prior to compaction, especially with impermeable soils. The laboratory tests will be similar to those in the borrow-pit area.

Compaction—Impervious and Semi-pervious Zones. The compaction of impermeable soils in an embankment is one of the most important aspects of construction. On it depends the uniformity of the embankment, and its compressibility, shear strength and permeability. The method and degree of compaction is selected as a result of laboratory tests and from trial strips on the site. For a given compactive effort a soil will be compacted to a certain density at each water content. The density of the compacted soil increases with increasing water content until "maximum dry density" is achieved at an "optimum moisture content". At this point the dry density begins to decrease as the moisture content continues to increase. The laboratory tests used to determine the method and degree of compaction are the Standard and Modified Proctor Tests, which are described in B.S. 1377 and in

M.E., Vol V, Part II. A density of 95 or 100 per cent of the Modified Proctor Maximum will probably be specified. The two types of military compaction plant suitable for impermeable soils are the Sheepsfoot roller and the 10-ton Pneumatic-tyred Roller. Vibratory rollers can also be used on some clays. The sheepsfoot roller produces better bonding between layers than the pneumatic-tyred roller, and it tends to break up the soil and mix it together. The moisture content can be adjusted if necessary during compaction. Pneumatic-tyred rollers generally require fewer passes than sheepsfoot rollers, but the surface must usually be scarified before rolling the obtain bonding between layers. Construction proceeds more rapidly during a rainy season with pneumatic-tyred rollers, since there is less trouble with water soaking into the upper soil layers, on account of the water-shedding surface. Pneumatic-tyred rollers obtain better compaction against hard rock foundations and abutments. Hand compaction equipment, or drop weights suspended from cranes, will be necessary for compaction in confined spaces, for instances around conduits. Supervision will be concerned with ensuring that all layers receive the number of passes ordered, and that no soft pockets are left untended. Soft pockets must be dug out and replaced with good material. Field density tests will be taken at frequent intervals to ensure that the specified dry density is being achieved.

Piezometers are now installed in all large homogeneous earth dams during construction to measure pore-water pressures at critical points. The purpose of these is to ensure that the pore pressures developed during construction and operation do not exceed appreciably the values assumed by the designer. They also provide a basis for the analysis of any difficulties that may develop. There are two basic types:

(*a*) Hydraulic Piezometers, in which the water pressure is obtained directly by measuring the head in a standpipe or by using a Bourdon Gauge, and,

(*b*) Electric Piezometers in which the pressure deflects a calibrated membrane, and the deflection is measured electrically.

The former method is generally considered the more reliable.

Compaction—Pervious Fills. The compaction of pervious fills presents few problems, and it is generally sufficient to spread the material in 12-in layers, wet it thoroughly, and run tractors over it. Better compaction can, however, usually be obtained by using vibratory rollers, such as the 4-ton Stothert and Pitt type held in the Corps. Pneumatic-tyred rollers may also be effective. Sheepsfoot rollers are of little value except for breaking up soft rock. Rockfill embankments are sluiced thoroughly, but are not usually compacted.

Diaphragm Construction—Asphalt Membranes. A number of dams with asphalt membranes on the upstream slope have been successfully completed in recent years, notably in Germany and North Africa. The membranes are placed in layers by standard road-paving machines of the type held in the Corps. The machines can either work along the face of the dam, secured by a line from a heavy tractor on the crest; or they work up and down the face, in which case they are assisted by winches at the crest and toe of the embankment. The asphalt is compacted by smooth-wheeled rollers operating in a similar way.

Diaphragm Construction—Artificial Membranes. This is a relatively new form of construction, and experience of it is limited. However, it has many attractions from a military point of view. The main ones are lightness (airportability) and ease of construction where, as in many parts of Asia and Africa, impermeable soils are difficult to obtain. The most suitable material is Butyl rubber sheeting, which for 0.06 in thick material weighs 3 lb per sq yd. The construction procedure consists of removing sharp rocks from the face of the embankment and covering it with a few inches of sand. If gas is present in the foundation, drains will have to be provided under the membrane to relieve the pressure. The sheets are spread out over the sand layer and joined together with special solutions. The membrane is anchored at the upper edge by burying it in a trench along the crest of the dam. An initial covering of about 12 in of fine material will then be placed by draglines or light trucks, followed by coarser material for wave protection.

CONCLUSIONS

The construction of an earth dam involves the application of a wide range of technical skills, most of which are common to military engineering. The main items of earth-moving plant required are all held in engineer squadrons. Subsidiary equipment, such as mobile soils laboratories, compaction rollers, quarrying equipment and concreting machinery, are obtainable from Engineer Stores Depots. It is difficult to determine what size of dam could be constructed by a military unit. However a Field Support Squadron or Field Squadron (Airfields), with its normal complement of plant, should be capable of placing and compacting at least 1,000 cu yds of earth per day on an average site. Allowing, say, one year for setting up the site organization and for diverting the river, and one and a half years for construction, the Squadron should be able to complete a dam of about 300,000 cu yds fill during a two and half year period. This could correspond to a dam of 60 ft in height, with a crest length of 1,500 ft or more on an average site. While the Plant Troop was involved in earthworks, the Stores Troop would be procuring materials, and the Workshops Troop would be constructing the spillway and outlet works. The Workshops Troop would require some plant support, and might require additional labour from a Field Squadron depending on the size of the structures involved.

The construction of a typical earth dam would probably employ every trade and every item of plant in a Field Support Squadron or Field Squadron (Airfields). Control of the construction would form an excellent task for a Specialist Team RE. An earth-dam project could be one of the most useful and valuable forms of civil-aid project which the Corps is able to provide.

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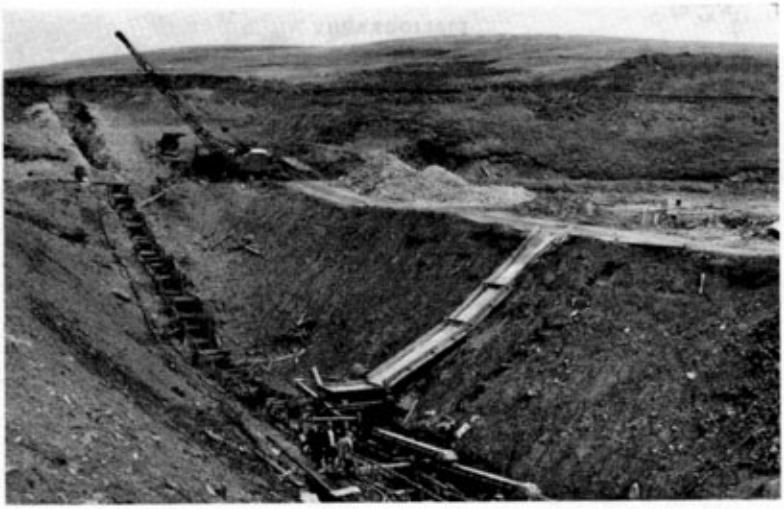
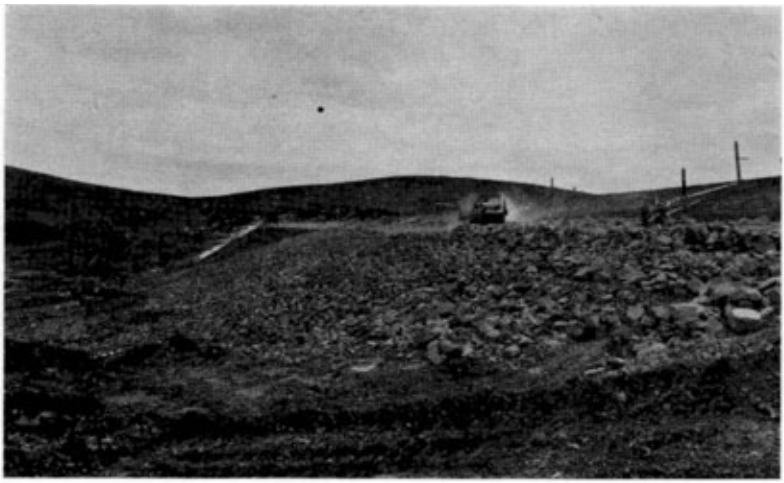
A. *Diversion Works*. The upstream end of the Diversion Tunnel, with the channel leading into it under construction. West Water Reservoir 1963.



B. *Cut-off Works*. The Cut-Off excavation, with the cut-off trench down the centre being concreted. The concrete cut-off will eventually be drilled for grouting. West Water Reservoir 1963.

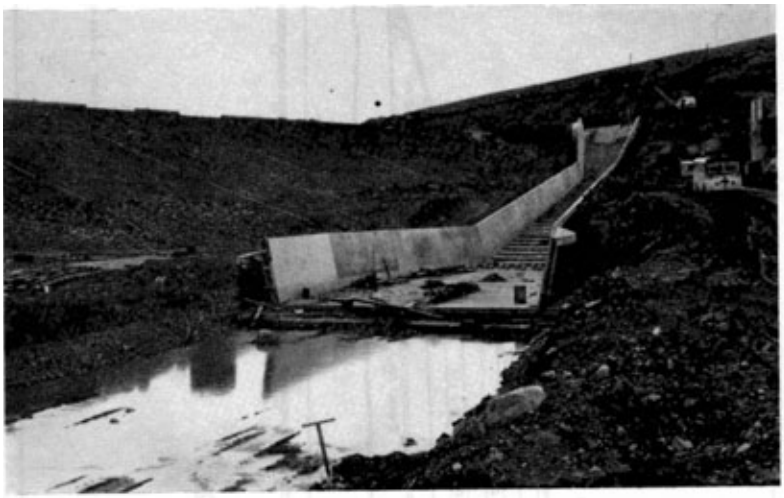
C. *Borrow-pit Excavation*. Two 1¼ cu yd face shovels are being used. The soil was spread on the embankment with a grader, prior to compaction. West Water Reservoir 1964.

D. *Embankment Construction*. Two tractor-towed scrapers and a pneumatic-tyred roller are being used. Black Esk Reservoir 1961.

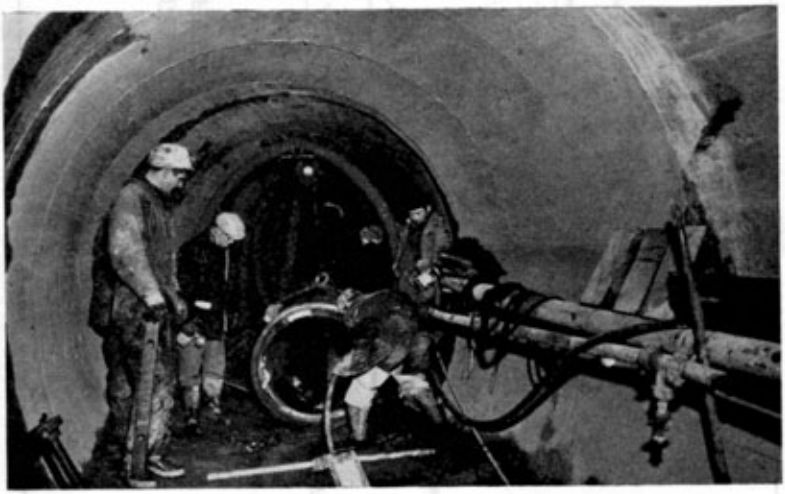


E. *Slope Protection*. Spreading riprap on the upstream slop. West Water Reservoir 1965.

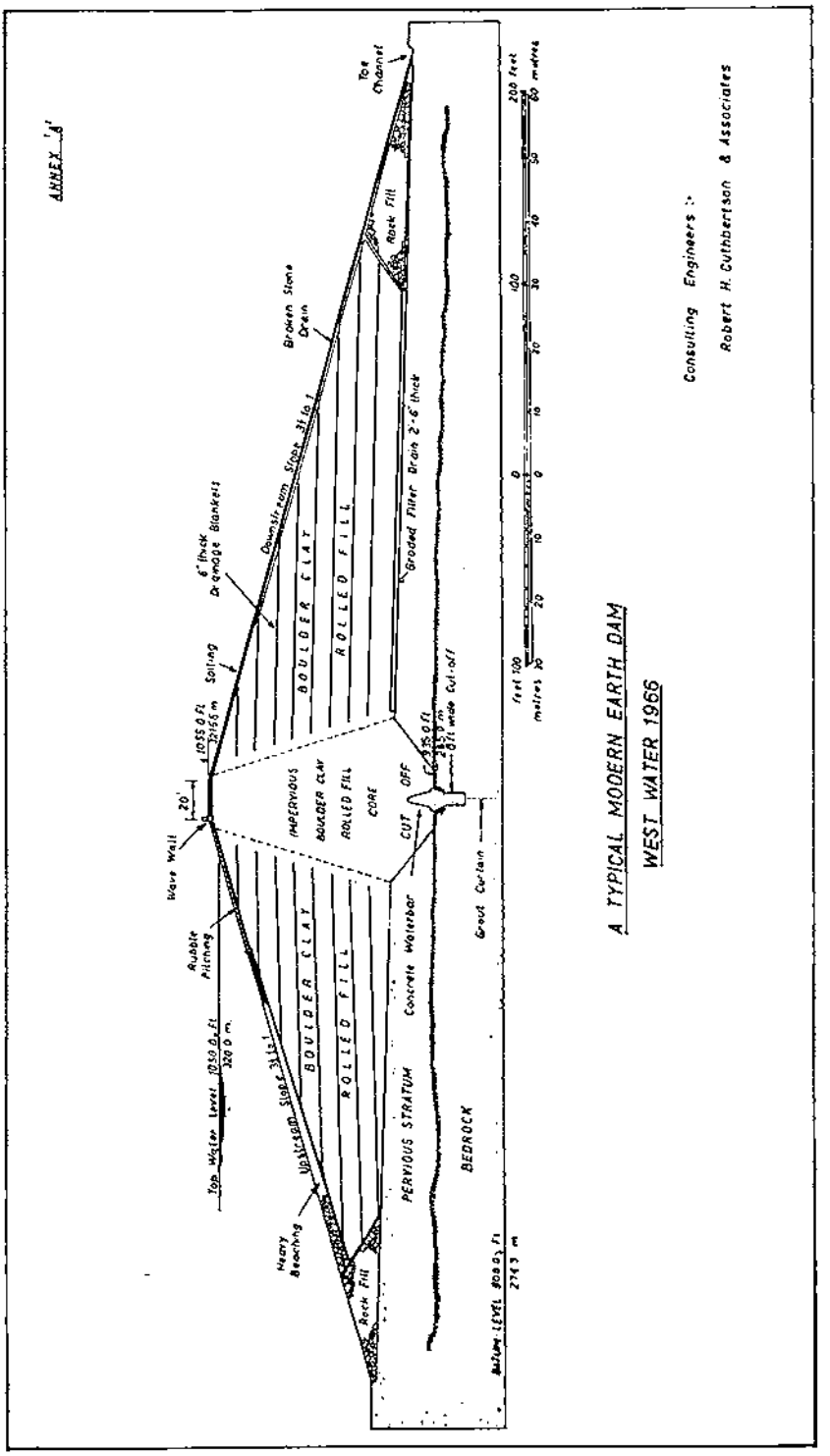
F. *The Embankment nearing Completion*. The downstream slope has been soiled ready for sowing. The spillweir and spillway channel can be seen in the background. Fruid Reservoir 1967.

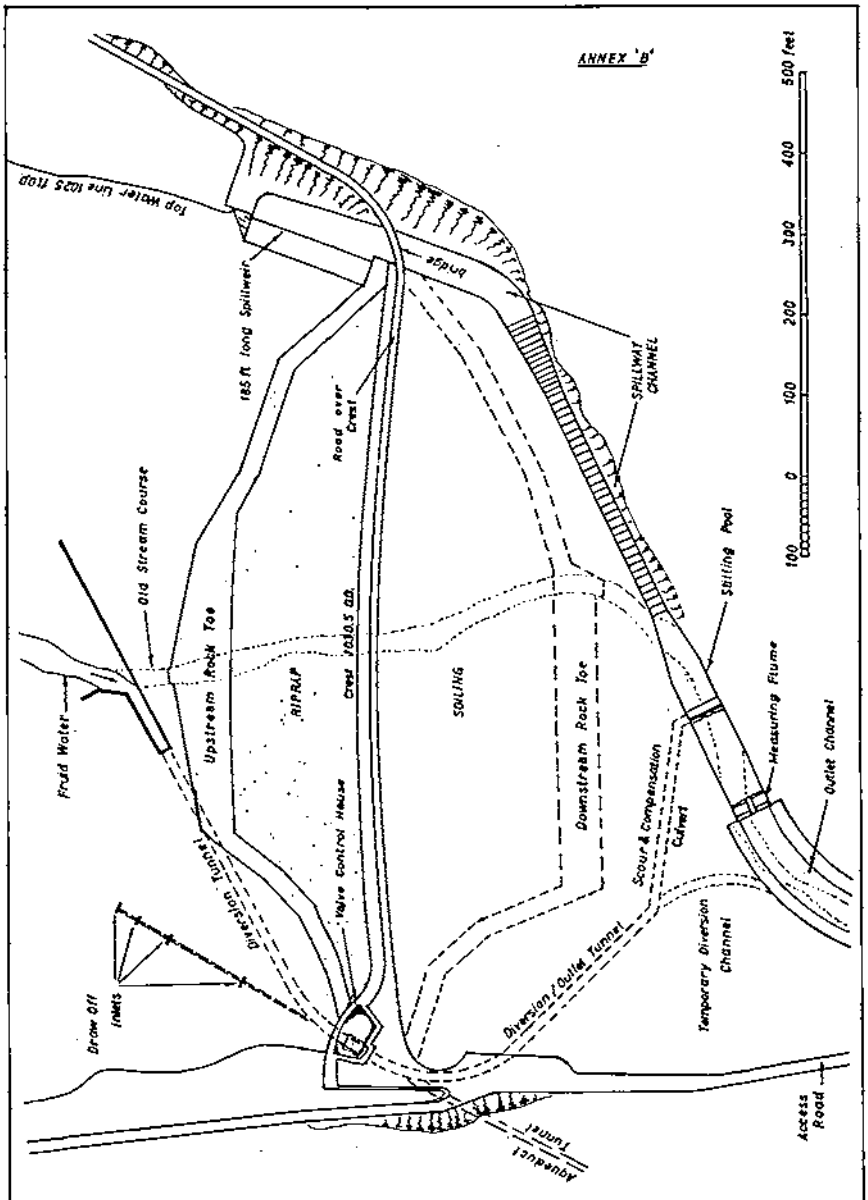


G. *Spillway Works*. The spillway channel leading down from the spillweir. The stilling pool in the foreground is not yet complete. Fruid Reservoir 1967.



H. *Outlet Works*. The 30-in diameter supply pipe being placed in the diversion/outlet tunnel. West Water Reservoir 1964.

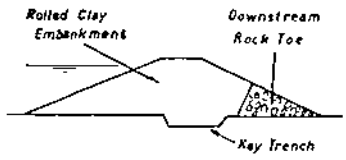

ANNEX 'A'
A TYPICAL MODERN EARTH DAM
WEST WATER 1966
Consulting Engineers :-
Robert H. Cuthbertson & Associates
Toe Channel
Rock Fill
Broken Stone Drain
Downstream Slope 3½ to 1
6" thick Drainage Blankets
Sealing
BOULDER CLAY
ROLLED FILL
Graded Filter Drain 2'-6" thick
1055.0 Ft 321.55 m
20'
Wave Wall
Rubble Pitching
Top Water Level 1050.0 Ft 320.0 m
Upstream Slope 3½ to 1
IMPERVIOUS BOULDER CLAY ROLLED FILL CORE
CUT OFF
Concrete Waterbar
Grout Curtain
PERVIOUS STRATUM
BEDROCK
Heavy Beaching
Rock Fill
Bottom Level 808.0 Ft 246.3 m
feet 100 0 100 200 feet
metres 30 20 10 0 10 20 30 40 60 metres



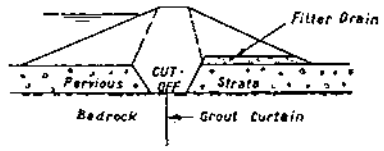
GENERAL PLAN OF
A TYPICAL MODERN EARTH DAM
FRUID 1967

ANNEX 'C'

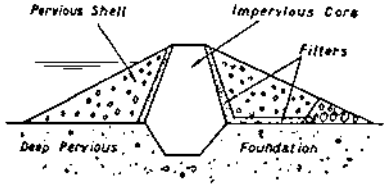
TYPES OF EARTH DAM EMBANKMENT AND FOUNDATION TREATMENT



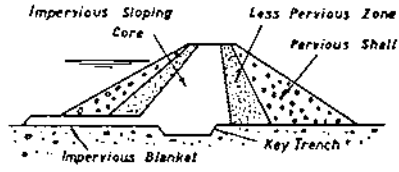
1a. HOMOGENEOUS DAM ON IMPERVIOUS FOUNDATION



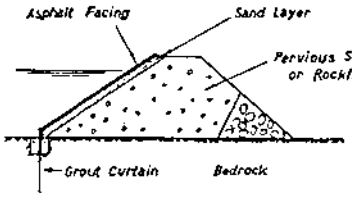
1b. HOMOGENEOUS DAM ON PERVIOUS FOUNDATION WITH COMPLETE CUT-OFF



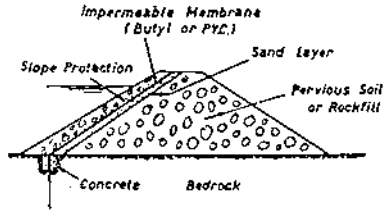
2a. ZONED EMBANKMENT WITH PARTIAL CUT-OFF



2b. MULTI-ZONED EMBANKMENT WITH UPSTREAM BLANKET



3a. DIAPHRAGM TYPE WITH ASPHALT FACING



3b. DIAPHRAGM TYPE USING IMPERMEABLE MEMBRANE

Use of Prilled Ammonium Nitrate as an Explosive

2ND LIEUTENANT I. J. K. McLEAN, RAE
11 INDEPENDENT FIELD SQUADRON, RE

BACKGROUND

SERVICE high explosives are essentially designed to carry out wartime demolitions rapidly and efficiently. Demolition tasks demand a "shattering" explosive that has a high rate of detonation to produce the cutting effect required. The current service high explosives comply with this criteria extremely well. However, in peacetime Sapper units consume far more explosive on construction projects than they do on demolitions. During the construction of roads, airfields and helipads explosive has many uses. In quarrying, the use of explosive is undoubtedly the only economical method. For clearing rocks from a construction site, blasting is frequently the cheapest and fastest means. When the cutting down of trees is insufficient and the stump and roots must also be removed explosive is again valuable. All of these tasks will be best accomplished by a "lifting" explosive. Unfortunately the gas ratio produced by service high explosives is very low. Consequently they have little "lifting" or "heaving" power and are, therefore, far from ideal.

INTRODUCTION

An explosive better suited to these tasks is in use with the United States, Australian and Malaysian Armies. Probably it is used by a great many other armies throughout the world. This explosive is produced by mixing a specified type of ammonium nitrate with fuel oil. The resultant explosive is commonly called ANFO (Ammonium Nitrate/Fuel Oil). Currently ANFO is undergoing tests at RARDE and temporary approval has been given by MOD (Army) for its use in the British Army. It is intended that this article will provide sufficient information on ANFO to interest the reader in its possibilities. ANFO mixtures were first introduced in the United States as commercial explosive in 1954. There is still a great deal to be learnt about them.

Most of the information contained in this paper has been derived from civilian and Army usage in Australia and experience gained by 11 Independent Field Squadron RE on engineer training in Malaysia and whilst employed on the Post Crown Project in Thailand. The methods of use and formulae given here are as accurate as our present experience allows. Whilst these techniques produce practical results, they have not been checked by RARDE and are most probably open to improvement.

It is extremely probable that MOD (Army) will give full approval for the use of ANFO by RE units later this year. However, it is unlikely that Army Texts will be available on the subject for some considerable time. It is hoped that the information contained in this paper together with previous articles on the subject will be useful as working guide lines in the interim period.

CHARACTERISTICS OF ANFO

For use in ANFO, ammonium nitrate is manufactured in prilled form and is called PAN (Prilled Ammonium Nitrate). The PAN is formed by spraying a concentrated heated solution of ammonium nitrate down the inside of a tower in which an updraft of cold air has been set up. The droplets of spray solidify into small spheres having an appearance similar to sago. To improve the strength of the prills in crushing, the surface of each is hardened. In good quality PAN the prills are

uniform in size, there is no clotting and there is a complete absence of fines or dust. AN (Ammonium Nitrate) has a great affinity for moisture of any description and absorption of large quantities of moisture renders the AN useless as an ingredient in explosives. Therefore the harder the surface of the prill the longer life it will have. For commercial use PAN is normally sold in 66-lb bags.

PAN is not an explosive and whilst it is highly corrosive it is non-toxic. This means that there is no civil restriction on the purchase, transport or storage of it. This is extremely important when the method of procurement is local purchase. It also means that a large magazine is not required on the construction site. However the PAN must be stored in a dry place and damaged bags rejected.

In Malaysia the retail price for top-quality PAN is approximately 9*d* per lb. It is unlikely that this price varies greatly throughout the world. Consequently, if the Army adopted ANFO as a service explosive, the purchase price might be somewhere around 7*d* per lb. The Army rates the cost of the CE TNT and PE at over 9*s* per lb.

Although it is normal to use PAN when making ANFO explosives, as an expedient normal crystalline AN may be used, and is readily available as superphosphate. This material cannot compare in effectiveness with the PAN form. However, when thoroughly mixed with fuel oil in the correct proportions, it forms a usable explosive. With this form of ANFO the greatest disadvantages are the difficulty in maintaining it free from excessive moisture content, and its exceptionally short life when mixed.

The normal ANFO mix produces an explosive having a rate of detonation between 2,500 and 3,200 metres per second. This compares with 8,000 metres per second for PE 3A. It therefore has poor cutting and shattering properties. However, it produces a gas ratio of 20 to 1 compared with a gas ratio of 8 to 1 for AN 60 gelignite. This demonstrates its value as a lifting explosive. Prior to detonation it does not produce toxic fumes. It is extremely difficult to set fire to and has a critical mass of approximately 125 tons. In comparison with other explosives it has a high resistance to shock and is not detonated by small sparks. Therefore it is not dangerous to use ferrous metals in contact with it. Also because of these factors it is practicable to use mechanical loaders for the charging of holes. If these are available the time required for charging large numbers of holes, such as in a quarry, is greatly reduced and it becomes much simpler to regulate the charge density in each hole. As diesel oil is a lubricant, its addition to PAN increases the free-running properties of the prills. This again simplifies hole charging and virtually guarantees freedom from blockages within the hole.

The greatest problem encountered when using ANFO is its propensity for absorbing water. When the moisture content of the ANFO exceeds 12 per cent the explosive becomes unreliable and if the moisture content is in excess of 16 per cent it is rendered totally inert. Due to the ambient humidity encountered in Asia the problem of keeping the ANFO dry is greatly increased. However, even this produces an advantage. Misfires with explosives have in the past been a troublesome part of any blasting operation, especially if the charge is buried. With ANFO, misfires can rapidly be rendered safe by flooding the charge with water. Even if the charge is buried, all that is required is a high-pressure jet of water from a small pump. Today 80 per cent of all quarrying in the USA is done by using ANFO explosives.

METHODS OF PREPARATION OF ANFO

The ideal mix for ANFO is 94·4 per cent PAN to 5·6 per cent diesel oil, by weight. This percentage produces maximum power output. However, the ANFO will detonate if the diesel content ranges between 1·6 per cent and 10 per cent by weight, provided that the ingredients are thoroughly mixed. Until recently a common mix was 2 per cent diesel, as this was said to give maximum sensitivity. Tests carried out in the USA and Europe during the past five years now show that this mix is not practical. Whilst it is true that its sensitivity is at a maximum, it is extremely difficult to ensure a thorough mix of only 2 per cent diesel when the PAN will absorb any-

thing up to 40 per cent of its own weight of diesel. This unevenness of mix causes a high incidence of misfires which greatly outweigh gains in sensitivity. Because of this a 2 per cent mix is no longer used commercially and it is felt that it has no real value to the Sappers.

To make best use of the many advantages of ANFO as an explosive it is best for it to be delivered to the blasting site in its constituent form and mixed *in situ*. This enables it to be stored as a non-explosive and excess quantities of the PAN can then be returned to store when the job is completed. Mixing *in situ* also reduces the security risk on site, as very little explosive needs to be kept. The supply of sufficient quantities of diesel to the site is not likely to ever produce problems in a Sapper unit.

So far, proportions have been given by weight, but weight batching always provides difficulty in the field. Therefore it is much more convenient if volume proportions can be calculated. To do this it is first necessary to calculate the specific gravity of the PAN and the diesel oil. This is fairly constant for diesel oil at approximately 0·8. Unfortunately, the density of the PAN differs with each manufacturer and ranges from 0·75 to 1·10. If the specific gravity of the diesel and the PAN is the same, then obviously the volume proportion is the same as the weight proportion and is approximately equal to 17 to 1. The most convenient volume proportion to use in the field is 16 to 1. This represents 2 gallons of PAN to 1 pint of diesel oil. If this proportion can be used without straying far from the ideal mix of 5·6 per cent, then it is well worth while, the minute variations in power output being more than compensated for by the ease and accuracy of batching.

The simplest and most efficient method of mixing large quantities of the ingredients is to use a concrete mixer. If restrictions are placed on ferrous metals coming in contact with ANFO, then the concrete mixer bowl should be lined with polythene. However, if the amounts involved are small and a suitable concrete mixer is not available, a plastic container can be used. A 12-gallon plastic garbage bin with a tight-fitting lid is an efficient mixer. When the correct quantities of ANFO and diesel are placed inside, the lid is clamped on and the whole container is tumbled on a soft surface to produce the mixing. If neither of these items is available, use a plastic-lined bowl large enough to contain the required amount of PAN plus half again. This allows room to agitate the contents (see Figure 1). The most suitable container for measuring accurate quantities of PAN and ANFO is a 2-gallon plastic bucket graduated on one side to ¼ pints and the other side to ¼ lb. A satisfactory measuring device for the diesel is a transparent polythene quart jug graduated to ⅛ fluid oz.

When mixing ANFO four problems arise. The first is that because the PAN will absorb up to 40 per cent of diesel it is difficult to obtain an even mix using only 5·6 per cent diesel. To overcome this use a shallow wide-mouth mixing bowl, and ensure that the diesel is spread slowly over the entire surface area of the PAN, stirring the mix the whole time. Mixing should be complete within three minutes and the mix should then be allowed to stand for at least one hour before being detonated. This allows the diesel time to penetrate the individual prills. The second problem is that when mixed the ANFO shows little apparent change from the dry PAN. Consequently inexperienced operators tend to add excessive amounts of diesel oil, thus damaging the properties of the ANFO. To overcome this it is necessary to add a small quantity of diesel soluble dye to the diesel. This produces a colour change in the mixed ANFO, greatly simplifying the operation. The third problem is caused by the tendency of the diesel to adhere to the sides of the polythene mixing bowl. Care must be taken to scrape diesel off the surface of the bowl and return it to the mix before completion. The last problem is that the PAN tends to burn broken skin, which can be quite painful. Prolonged contact with diesel can produce a form of dermatitis. To overcome this it is best to wear rubber gloves during the mixing operation.

If the above steps are followed, mixing is a rapid and simple procedure, but good visual quality control is essential. Lumps or damp patches must all be broken up and

spread throughout the mix. After the ANFO has been mixed it should be returned to the plastic bag, the air expelled and the bag resealed until it is to be used. The life of the mixed ANFO varies considerably depending on the quality of the PAN and the humidity present during storage. However, in Borneo it was found that mixed ANFO was still effective after a storage period of two months.

If the ANFO is to be used in wet conditions where there is standing water, an attempt must be made to waterproof it. The most efficient method of doing this is by the use of suitable diameter polythene bags or tubes. If these are not available wax mouldable wrapping paper, as used for packing around weapons in transit, is a suitable alternative.

Once the ANFO has been mixed it becomes an explosive and normal safety precautions must be taken.

PREPARATION OF CHARGES AND DETONATION

Because the rate of detonation of ANFO is relatively low and the heaving power is great, it is possible for the ANFO immediately surrounding the point of initiation to detonate and displace the extremities of the charge before they have a chance to detonate. To overcome this it is always necessary when using ANFO to run detonating cord the full length of the charge. Where a charge is over 5-ft long it is also necessary to add a booster charge of 5 per cent to 10 per cent of PE or CE TNT. This percentage varies for different tasks, but a 6 per cent booster has been adequate for all circumstances encountered so far. If the ANFO charge is exceedingly long it may be necessary to split the booster into two or more parcels, and place them equidistant along the charge. If water is present in the hole, place a booster charge just above the water-level.

If detonating cord and booster charges are used, primers are not necessary. Whenever detonating cord is placed down a hole, a thumbknot should be tied at the bottom to ensure that the cord is not accidentally pulled back through the charge. Initiation is equally successful using either safety fuze or electric means.

SAPPER TASKS FOR WHICH ANFO IS SUITABLE

From the experience already gained in the use of ANFO it appears that the tasks most suitable to its use are quarrying, rock blasting, tree and root clearance, ditching in rock and firm earth and cratering. However, trials have shown that it is practical to use ANFO for all Sapper tasks due to its low cost and the ease with which charges can be placed. It appears that the application of ANFO is only limited to one's imagination and the accessories available.

In an article entitled "Mass Blasting in Malaya using ANFO", published in the September 1965 edition of the *RE Journal*, Major A. J. D. Hughes, RE, describes in great detail the methods used for quarrying with ANFO. If these are adopted, success is ensured. It is when using ANFO for quarrying and rock blasting that the greatest saving in time and explosives are made.

Frequently it is necessary to break up rock formations on a construction site and generally the techniques used for quarrying are applicable. Further economies are possible if bulldozers are available to remove the broken rock, as it then becomes unnecessary to blast the rock into such small pieces. Yields for rock blasting are considerably greater than those obtained in quarrying due to the above and also to the fact that normally there will be a greater number of free faces. In formations such as sandstone a yield of 4 cu yds per lb of ANFO would not be unusual. When rock blasting it is advisable to charge two thirds of the hole and stem the remaining one third. This is because of the shallow depths involved (see Figures 2 and 3).

Because of the efficiency of current chain saws it is no longer practical to use explosive for cutting trees down. This means that the only time explosive is required for tree felling is when the stump and major roots must also be removed. An important improvement has been made to the method given in the RESPB No 4.

By placing half the charge under one side of the tree an overturning movement is produced which causes the tree to fall towards the side on which the charge is placed. This has the advantage that it is no longer necessary to cut the tree down before blasting the stump and also that the tree can normally be made to fall in a desired direction. The method adopted using ANFO provides simplicity with few calculations. If the tree is more than 30 in in diameter, prepare four holes in the ground at 30 degrees to the horizontal, to meet the tap root approximately 3 ft below the ground. If there is no tap root these holes will meet under the centre of the trunk. These holes should be between 4 and 6 in in diameter and approximately 90 degrees apart around the tree. It is an advantage if each of these shafts runs close to a major root. One hole should be in line with the required direction of fall of the tree and on the same side. Into this hole place half the total charge of ANFO with a 5 per cent booster charge in the centre. Into each of the other three holes place one third of the remaining ANFO. Detonating cord should be laid to the bottom of all holes and the uncharged portion of each hole tamped with stemming. All holes must be fired simultaneously. For trees less than 30 in in diameter the method is the same, except that only three holes are required with a spacing between them of 120 degrees. Regardless of the size of the tree it is found that 2 lb of ANFO per 3 in of diameter of the tree trunk is an adequate total charge. Precutting the major lateral roots by some other method reduces this to 1 lb per 2 in of diamter (see Figures 4 and 5).

COST ANALYSIS

The cost of PE 3A is approximately 9*s* per lb. The cost of PAN in 9*d* per lb. For the amounts of diesel required in ANFO it is not worth while considering its cost. For a rock-blasting job of 1,000 cu yds of sandstone, PE 3A would give a yield of 2½ yds per lb of explosive. Therefore 400 lb of PE 3A would be required. It would cost £180. Using ANFO the yield would be 4 yds per lb and 250 lb of explosive would be required. Of this 6 per cent would be PE 3A. The cost would then be £7 for 15 lb of PE 3A and £9 for the ANFO. This is a total cost of £16. The ANFO would also require less detonating cord, because the higher yield would mean fewer holes.

CONCLUSIONS

ANFO is a relatively new explosive and consequently there is much which still must be learned about its performance. However, it is hoped that this article will give readers sufficient interest in ANFO and enough information to carry out practical tasks using explosive. In the past it has always been necessary to compromise explosive efficiency in peacetime tasks by using an explosive designed for wartime demolitions. If ANFO is accepted we will have the use of an efficient lifting explosive for the first time. To the Army at large its greatest advantage is its unbelievably low cost. For Sappers it provides safety, ease of handling, high efficiency and rapid placement of charges. These factors make ANFO too valuable to ignore.

FURTHER INFORMATION

11 Independent Field Squadron RE has produced a report containing much greater detail on ANFO and its various uses. Any reader who would like further information on the subject can obtain a copy by writing to the Squadron.

Note by Editor. An article by Major A. J. D. Hughes, RE was published in the September 1966 issue of the *RE Journal*, describing a mass blast yielding more than 80,000 tons of well-fragmented rock at the PWD quarry at Bukit Ruloh, North Malaya, employing ammonium nitrate mixed with diesel oil as the main explosive. The 108 boreholes used were 3 in in diameter and nearly 100 ft in depth.

Fig 1. *Hand Mixing of Anfo.* Note the wide mouth, polythene mixing bowl; two-gallon polythene measuring bucket; beer can for measuring diesel and rubber gloves.

Fig 2. *Drilling a Ditchline on Post Crown Project in Thailand.* This ditch was 150 yards long and had a maximum depth of 7 feet.

Fig 3. *Blasting the Ditchline shown in Fig* 2. Foreshortening makes the bulldozer appear much closer than actually was the case. However this demonstrates the lack of scatter when using *Anfo* to blast rock.

Fig 4. *Tree Blasting During Post Crown Project.* The tree trunk was approximately 3 ft 6 in in diameter, lateral roots were not pre-cut and 28 lbs of *Anfo* were used.

Fig 5. *Tree Blasting During Post Crown Project.* This is the fallen tree and cavity resulting from the blast in Fig 2. Note the extent of the root mass removed from the ground and the lack of damage to the tree trunk.

Use Of Prilled Ammonium Nitrate 4 & 5

The French Engineers

LIEUT-COLONEL A. G. T. SHAVE, MBE, RE

EVERY year there are a number of exchange appointments for officers between the British and French Armies; these normally include a small number for Engineer officers.

From personal observation, these exchanges are of extremely good value. They enable the visiting officer to see how another Army works, and to meet some of the different solutions adopted to problems which exist in his own Corps; they also provide an inexpensive opportunity to see the local countryside and to sample French hospitality.

The French units which accept exchange officers take considerable trouble to look after them and are invariably outstanding in their entertainment and hospitality. However, two weeks is not a very long time in which to get to know one's hosts, and some of the more interesting aspects can be lost through not understanding the different basic organization and methods used in the other Corps.

The following outline of the French Engineers may, therefore, be of help to an officer who finds himself in the fortunate position of going on one of these exchange visits and thus provide him with a little more time in which to study those subjects in which he is particularly interested.

Strength

The strength of the French Engineers is over double that of the Royal Engineers. This is due to the fact that France maintains a conscript army of about 330,000 men, including 60,000 gendarmes, and also because the Engineers still retain a Works responsibility, and man the Brigade of Sapeurs-Pompiers of Paris, numbering some 6,000. They do not have a Postal commitment, and in 1968 lose their Resources element.

Leaving aside the "Service" or Works element, and concentrating on the arm function, the Engineers have to provide support for six divisions forming the Force de Manoeuvre and Strategic Reserve; in addition they provide the support required in the seven Regions forming Metropolitan France, and for such areas as the nuclear testing site in the Pacific.

Role

The principle role of the French Engineers is little different to that of the Royal Engineers; it is defined basically as "To organize and improve the ground with the object of facilitating the manoeuvre of friendly forces and hindering that of the enemy". Within this role, five main categories of mission are defined, as follows:

Assault, or inter-arm operations, including the reduction of strong-points, street fighting and cave clearing, requiring such special weapons as flame-throwers, explosives and armoured assault vehicles.

Communications. The re-establishing of existing routes, construction of new ones, passage or by-passing of obstacles, crossing of wet and dry gaps and the general maintenance and repair of roads and airfields.

Obstacles and Demolitions. Including the laying of minefields, construction of barriers and belts of obstacles, road blocks, etc.

Protective. Reducing the vulnerability of friendly forces by the construction of all types of protective works, and the use of camouflage and deception.

Logistical. The maintenance and provision of plant, and improvement of infrastructure installations, including the construction of airfields.

Because of the multiplicity and variety of these tasks, two basic types of unit exist in the Engineers. First, the general-purpose or combat-type unit, capable of performing most of these missions to some degree. Second, the specialist units which can be used either to back up the combat units, or to serve in their own

particular specialist role. These latter are further subdivided into four categories, specialist operating, specialist support, construction and maintenance units.

THE COMBAT UNITS

The Divisional Engineers

The Engineer Organization in the present 1959 Type Division contains the following units:

At Divisional level — One Engineer Regiment consisting of:
RHQ and HQ Company
One equipment and bridging company
Two combat companies

At Brigade level — One combat company

Thus, in a division of three brigades, the Engineer element consists of a total of five combat companies in addition to the equipment/bridging company and the HQ Company. The RHQ is normally divided into forward and rear elements, the latter being commanded by the officer responsible for technical administration, i.e. vehicles, weapons and equipment.

The companies, all commanded by captains, have a total strength of 146 for regimental companies, 157 for brigade companies and 164 for the equipment and bridging company.

The main difference between the regimental combat company and the brigade combat company is in the plant section, the brigade company having a tank dozer and a medium wheeled CR8 dozer, two bridge layer tanks and a third bridge on a transporter, while the regimental company holds only a medium wheeled CR8 dozer. Both companies have three field troops, each of three sections, with a total troop strength of one Officer, four NCOs and thirty-four men, and two compressors.

The HQ company is purely an administrative and command company with practically no engineer capability, except that it contains an engineer liaison team and does carry some demolition stores and mines. The equipment and bridging company holds the main regimental plant and the main bridging equipment of the division (M4T6); it is also responsible for the repair and maintenance of all regimental vehicles and plant.

Due to their small size, it is almost inevitable that under operational conditions the brigade combat companies have to call upon the regiment for additional engineer assistance, both in men and equipment. When a brigade is reinforced by a regimental combat company in addition to its own organic engineers, then a major is normally attached to brigade from the Engineer RHQ to take command of the two companies, and he comes directly under the tactical control of the brigade commander.

Combat Engineers at Corps and General Reserve Level

The engineer combat regiments allocated to Corps or General Reserve consist of two battalions each of three companies, totalling between 1,000 and 1,200 men with about 200 vehicles. Each battalion is equipped with the following plant:

2 light excavators
2 wheeled dozers
3 tractors fitted with buckets/shovels
1 hydraulic shovel
1 crane
2 truck mounted compressors

The combat engineers also include an airborne engineer regiment of three companies, and one independent beach company whose role is somewhat greater than in our beach troops, in that the company commander is responsible for beach control and organization, including recovery and clearance.

THE SPECIALIST UNITS

Specialist Operating Units

Amphibious (Gillois) Companies. Each company is composed of two ferry troops and two bridge troops. The ferry troop has six Gillois ferries which can be used singly or side-coupled; and each bridge troop consists of four travure and two ramp/travure units. Thus a company can provide either twelve Class 30 or six Class 60 ferries and either 96 metres of Class 50/60 bridge or two rafts of Class 80/110. For the future, it is possible that each company will also have a troop of six Gillois motorized bridge units (PAM); this equipment is at present under experimentation.

Motorized Bridge Companies. This type of company is provisionally equipped with six sets of infantry footbridge (the US DI M2) giving 50 metres of Class 8 bridge or 40 metres of Class 12, plus a half set of Class 60 Type US 60T floating bridge (on pneumatic pontoons) giving 90 metres of bridge.

Company d'Organization du Terrain. This is basically a plant unit which at a later date may also have a mine-laying capability. It is composed of four plant troops each holding:

4 heavy excavators
2 bucket-mounted dozers
2 hydraulic shovels

The fifth troop will eventually have four mechanical mine-layers, but this equipment is still only in prototype form.

Camouflage Units. Normally of troop size, this unit is responsible for advising and instructing all arms in both camouflage and deception, and for actual tasks at Brigade and Divisional HQ level.

Administrative Units. These include lighterage companies, plant companies of the maritime transport battalion, and depots.

Firefighting Units. These compose the Brigade of Sapeurs Pompiers, which is organized on a regimental basis and is responsible for all the firefighting in Paris and its suburbs, replacing the normal civil fire service. There are also a number of smaller units, usually of troop size, responsible for firefighting duties in depots and similar military installations.

The Construction Units

Infrastructure Units. These include heavy works battalions, such as the railway battalion in the 5th Regiment, plus the airfield engineers consisting of one regiment and two battalions in France and one company in the Pacific. These units are capable of earth-moving, and the construction, maintenance and repair of airfield pavements of all types, but they are not equipped to deal with E and M installations.

E and M Units. Normally of company size, these units work closely with their civil counterparts to provide the Services with lighting and power.

Water-purification Units. Usually of troop size.

The Support Units

These are designed basically to reinforce the capabilities of combat and construction units, but are incapable of operating on their own; they include:

Equipment Companies. Found in the General Reserve, and equipped with earth-moving plant, rollers and trenchers, twelve Benoto drills and thirty 4-ton tippers; they will also probably receive four mechanical mine-layers at a later date.

Equipment Bridging Companies. These companies carry and maintain one of the following types of equipment bridge, plus any special plant required in the construction.

US—M4 (floating)	— 80 trucks and 50 trailers carrying 130 metres of Class 50 or the equivalent in rafts/ferries.
US—60T (floating)	— 90 trucks and 40 trailers carrying 183 metres of Class 60 or equivalent.

US—M4T6 (floating) — 25 trucks carrying 47 metres of Class 50 (as in the divisional equipment and bridging company).
Bailey — 80 trucks carrying 80 metres of Class 40 (i.e. two lengths of 40 metres of DD).

The Maintenance Units

These were designed to produce and maintain engineer materials for all arms, and in particular the engineer units; as a result of the loss of Resources, part of these will now presumably disappear. They include:

Supply and Repair Companies. Composed of:

Two troops — administration and accounting.
One troop — transport and maintenance—responsible for the evacuation of plant which cannot be repaired in its unit to the repair troop and re-delivery forward after repair.
One troop — spare parts provisioning.
One recovery troop — ten recovery teams each with a vehicle.
One repair troop — four mobile workshops and a 3rd echelon workshops section, capable of base repairs.

Mechanical Workshops Units. These, of company size, normally support the Resources depots.

ORGANIZATION AND TRAINING

Organization of Units

Despite the large number of types of unit in existence, mostly of company size, the organization of the French Engineers is almost entirely on a regimental basis.

Apart from the six divisional regiments which are on the standard DIV 59 organization, and excluding the airfield engineers, there are a total of twelve regiments in France and the FFA (equivalent to BAOR). These are basically General Reserve (Corps troops) or Infrastructure (Regional) regiments, containing between five and ten companies of varying types. As an example, the 5th Regiment has a battalion of three companies of railway engineers, plus five companies for training, works and local duties in the Paris area; the 4th Regiment has two NCO training companies, two recruit companies, a combat company trained in support of the 27th Alpine Brigade (specializing also in teleferiques) and a works company.

The regimental organization is of interest in that all the majors are held centrally, controlling specific functions. The "Major", equivalent very roughly to our regimental QM, deals also with all accounting and financial matters, pay included; there is a major, or sometimes lieutenant-colonel as second-in-command. A major controls all technical administration and another deals with training, ranges and exercises. Frequently within a regiment certain of the companies may be grouped into a battalion, in which case a major is nominated as commander. The nearest equivalent to adjutant is the "capitaine-adjoint" who is a personal staff officer for the CO.

The French Sapper

Because of the exigencies of modern war, engineer units must be prepared to move and work under isolated conditions. All French sappers are therefore required to have the same basic knowledge, skills and reactions as an infantryman, in addition to being trained as sappers.

Since most sappers are conscripts serving only sixteen months, later probably to be reduced to twelve months, their basic training is now reduced to two months. Any specialization necessary thereafter, such as plant operator, is kept to a minimum and is concentrated on one piece of equipment. In general this specialized training takes place in instructional centres run by specific regiments so that the training is standardized.

NCOs

About half the established NCO posts require specialists, and in these posts, because of the length of training involved, three- to five-year regulars have to be used. It is possible for the best regular recruits to become sergeants after ten to twelve months' service.

For regular NCOs, the system of courses and exams for promotion is as follows:

CA1	Certificat d'Arme 1st degree	— for caporal.
CA2	Certificat d'Arme 2nd degree	— for caporal chef or sergent.
CIA	Certificat d'Arme (Inter Arme)	— sergent.
BA1	Brevet d'Arme, 1st degree	— Chef de section (troop sergeant)
BA2	Brevet d'Arme, 2nd degree	— troop sergeant instructor.
BS1	Brevet d'Arme, Specialiste 1st degree	— Usually in the rank of adjudant
BS2	Brevet d'Arme, Specialiste 2nd degree	— or adjudant-chef, equivalent to WOII or WOI.

In general, the first three certificates are obtained during the NCOs' course run at the EAG[1] and an exam has to be passed for each. The CA1 and CA2 include only engineer subjects plus combat and physical fitness, whilst CIA, being an interarm certificate, includes such subjects as grammar, administration, military law, minor accounting, vehicle maintenance and repair, use of weapons and minor tactics.

A similar set of exams, of somewhat lower standard, exists for the conscript sapper who is capable of becoming an NCO. However, these are taken in the unit and not at the EAG.

After ten to twelve months' service, all spent under instruction, the regular NCO arrives in his unit with the rank of caporal, caporal chef or more frequently sergent. During the next two years he does a certain amount of preparatory work in the evenings for his BA1, for which there is a one-month course at the EAG followed by an exam. If he passes this he becomes chef de section (troop sergeant) and can then go on to take his BA2 under the same system some two years later. These two exams are special to arm and equivalent to a level slightly below combat engineer B2 and combat engineer B1. At the same time, if he intends to be a specialist and continue in the service, the sergent can apply to take the BS1, and later the BS2 in the same subject as his BS1. To do this he has to pass a written qualifying exam in his unit, after undergoing suitable preparation, which in turn entitles him to attend the oral exam at the EAG. Having qualified at the oral he attends the course of five to six months, depending on the subject chosen, passes the final exam of one week duration and then completes two months' practical work in his specialist capacity, usually in a different workshop or unit to that from which he came. The aggregation of marks obtained during the course, the exam and the practical period then determine whether he passes BS1/BS2.

The choice of specialities is quite wide ranging and includes:

General electricity	Railway construction/repair
Plant repair	Roads and airfields
Equipment bridging	Construction and maintenance of teleferiques
Mines and explosives	
Diving/underwater demolition	Equipment bridging
Surveying	Timber bridging
Works administration	Accounting (resources)

The preparatory courses run in regiments for the BS1 and BS2 are quite detailed, and frequently involve three periods of two hours per week for the three to four months before the qualifying exam, much of this taking place after normal working hours.

In addition, certain NCOs who have the necessary specialist technical qualifications can be commissioned directly as technical officers, selection for which is on a competitive exam basis.

[1] Ecole d'Application du Génie—equivalent to the RSME.

Officers

After completing two years at St Cyr-Coetquidan, the young officer who has chosen the Engineers completes the YO course at the EAG; this takes about a year, including leave. Despite a certain amount of theory and mathematics, this course is basically oriented towards producing an intellectual soldier, less than half the total instruction being concerned with engineering subjects. He is then posted to an engineer unit.

Some seven years after leaving St Cyr the subaltern is normally promoted captain, at which time he completes his four months' course for captains designed to fit him as a company commander in the same rank.

The top officers in the order of merit from this course are selected for the Ecole d'Etat Major or basic staff officer course, which lasts six months; subsequently the majority of these staff-trained officers sit for the entrance exam to the Ecole Supérieure de Guerre and if successful follow a two-year interservice course.

Those showing more of a bent towards the scientific or technical side usually miss the captains' course and go instead to the Ecole Supérieure Technique du Génie at Versailles to follow either the Diplome Technique (two-year) or Certificat Technique (eight-month) course, after which they are employed in the Works or Materiel side of the Engineers. The most successful of these technical officers then complete the Brevet Technique Course, which includes a six-month attachment to a civil firm. Outstanding brevet techniques are usually selected for the course at the Ecole Supérieure de Guerre and exempted from the entrance examination.

Conclusion

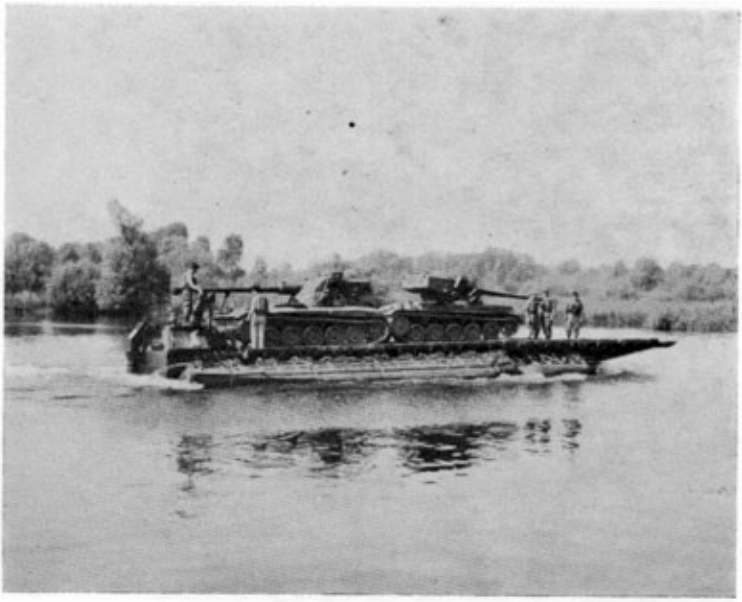
With the major share of the Armed Forces Estimates going to the "Force de Frappe" and the development and production of a nuclear deterrent, the French Army must for the time being continue with a strictly controlled budget which does not permit any grandiose re-equipment projects. Nevertheless, in the Engineers new French equipment is now steadily replacing the older American aid items. With about three squadrons' worth of Gillois equipment already in being, the Gillois ferry and bridge units are now being produced in France for the first time. Demolition techniques are continually being improved; all divisional engineers are equipped with the AMX 13 bridge layer tank, complete with spare bridge-spans, and shortly the Combat Engineer Tractor developed from the AMX 13 will also be in production. Experimentation continues in such subjects as the mechanical mine-layer, a new bridging tug with raisable stern for operating in shallow waters and a new and lighter version of the Matenin trencher for digging field defences. Considerable effort and thought is being given to recover the *esprit* and *élan* lost at the end of the Algerian campaign; to this end the French Engineers in particular devote a large amount of time to commando-type operations, where the emphasis on physical fitness and flexibility is much greater than on pure engineer techniques.

In view of their deployment, now almost entirely confined to the Metropole and the FFA, and to the difficulties imposed by a sixteen-month system of national service and a reduced budget, the problems facing the Engineers are more difficult than in most other arms and services. That they are met with and, in general, resolved satisfactorily can only be attributed to the officers, who, whatever their origin (and many are ex-cavalry, infantry or artillery officers who have transferred in recent years as a result of reductions in the service), are so evidently dedicated to their work.

Class 50—M4T6 Bridge.

60T Raft.

The French Engineers 2



Gillois Ferry (Bac).

New Infantry Footbridge.

Transporter with CD8.

CR8 Dozer.

Combat Engineer Vehicle (VCG) based in 13T AMX.

Griffet G8 Crane (8 tons).

Lieut-Colonel P. Norbury, RE, leads the procession of Councillors, Aldermen, Mace Bearer, Town Clerk and Mayor of the Borough of Gillingham across Brompton Parade Ground to the RE Museum.

The McCudden Commemoration Ceremony

On 9 July 1968 the Corps of Royal Engineers and the Borough of Gillingham commemorated the fiftieth anniversary of the death of a gallant, young man—2nd Lieutenant/Acting Major James Thomas Byford McCudden, VC, DSO*, MC*, MM, Croix de Guerre, RE, RFC, RAF, Freeman of the Borough of Gillingham, born in the Military Family Hospital, Brompton Barracks, and killed flying on active service in France on 9 July 1918 when only 23 years old.

Commemorated also were the famous Sapper and Gillingham McCudden family, three of whose sons gave their lives flying in the First World War, and those Royal Engineers who for fifty years, between 1862 and 1912, pioneered military flying until the formation of the Royal Flying Corps (Naval and Military Wings) on 13 May 1912 from the Air Battalion Royal Engineers.

The Commemoration Ceremony was held in the Royal Engineers Museum, Brompton Barracks, and was attended by a large and distinguished gathering. The Mayor of Gillingham, preceded by the Mace Bearer, the Town Clerk and the Aldermen and Councillors of the Borough, in their full robes of office, were escorted by Lieut-Colonel P. Norbury, Commanding Officer The Depot Regiment RE, through the Crimean Arch and across the Brompton Parade Ground to the Museum.

When all were seated and the Mace had been placed before the Mayor, the President of the Institution of Royal Engineers, Major-General T. H. F. Foulkes, welcomed those present and in his address said that the Borough of Gillingham and the Corps of Royal Engineers were that day primarily commemorating the fiftieth anniversary of the death on active service of James McCudden, a famous fighter pilot of the First World War, a famous offspring of the Corps of Royal Engineers and a famous citizen of Gillingham.

James McCudden was the son of Sergeant-Major W. H. McCudden, RE, an Instructor in Survey and Astronomy in the School (now Royal School) of Military Engineering. He was born in Brompton Barracks and with his three brothers and two sisters he attended the Infants' School in the Barracks. In 1910, at the age of 15, he became a bugler in the Royal Engineers. Following his elder brother, he transferred at the end of his boy service to the Royal Flying Corps in 1913 as an air mechanic. With his elder brother he went to France with the British Expeditionary Force in August 1914, and later he became an observer and air-gunner in an artillery co-operation squadron. He soon demonstrated his skill in aerial combat and was awarded the Military Medal and invested with the Croix de Guerre by General Joffre in January 1916. He was accepted, in the rank of flight sergeant, for training as a pilot early in 1916, and in July of that year he fought his first single-handed combat action as a pilot. He was commissioned on 1 January 1917 and became one of the most outstanding and highly decorated "Air Aces" of the First World War. He was a perfectionist both as a mechanic and as a tactician in aerial combat.

He commanded B Flight of No 56 Squadron RFC from August 1917 until March 1918. During that period B Flight shot down 77 enemy aircraft with the loss of only 4 of their own pilots. James McCudden's personal share was 52 enemy planes. His Victoria Cross citation, of 2 April 1918, recorded that as a patrol leader he at all times showed the utmost gallantry and skill, not only in the manner he attacked and destroyed the enemy, but in the way he protected less experienced members of his flight, thus keeping casualties to a minimum.

After being invested by King George V with his Victoria Cross he flew to France to take command of 60 Squadron RAF. He never reached his destination and was tragically killed in a flying accident at Auxi-le-Cateau airfield on 9 July 1918, at the early age of 23 years.

Major-General Foulkes went on to say that not only was James McCudden being commemorated but also the McCudden family—three of whose sons had been killed flying in the 1914-18 War—and those Royal Engineers who over a period of fifty years, between 1862 and 1912, had pioneered and developed military flying.

He welcomed in particular to the Commemoration Ceremony the immediate members and the descendants of the McCudden family present in the Museum, the Mayor, Mayoress, Town Clerk, Aldermen and Councillors of the Borough of Gillingham and the Mayors and Town Clerks of the City of Rochester and the Borough of Chatham and the Chairman and Clerk of the Strood Rural District Council. The Fleet Air Arm was represented by Commander C. R. V. Doe, RN, who for the last eighteen years had been a Naval flyer and was now Officer Commanding HMS Troubridge. The Royal Air Force was represented by Air Marshal Sir William Coles, who had a most distinguished flying record in the Second World War, and by Wing Commander C. H. Bidie, the present commander of No 56 Squadron RAF (James McCudden's Squadron), who had flown for the occasion from Cyprus, where his squadron was stationed, and he was flying back that night. Also present were Wing Commander T. E. Guttery and R. W. Ware of the Shuttleworth Collection, from which we had been kindly lent some most interesting exhibits for the ceremony, and Wing Commander H. F. Brundle, the Officer Commanding the Gillingham Squadron of the Air Training Corps.

Major-General Foulkes explained that Field-Marshal Sir Gerald Templer, the Chairman of the Executive Council of the National Army Museum, had intended to be present at the ceremony, but unhappily, due to a family bereavement, he was unable to come. He welcomed Major-General B. P. Hughes, President of the Royal Artillery Institution, and Brigadier P. W. Mead, its Secretary, who had been so closely connected with the development of the Army Air Corps, and Brigadier R. G. Thurburn, Secretary of the Army Ogilby Trust, from which Fund the Royal Engineers Museum had in the past received such generous grants. He was also delighted to welcome Major H. R. P. Reynolds and Brigadier F. R. S. Gervers, who had both many years ago served in RE Balloon Sections. Brigadier Gervers was the doyen of the Corps, the oldest retired Sapper officer, and now "95 years young". The RE bugler boys of James McCudden's day were symbolically represented by six Royal Engineer Junior Leaders in scarlet uniform, and with them were three cadets of the Gillingham Squadron of the Air Training Corps, each of whom had won a Duke of Edinburgh Award and was a qualified glider pilot. Finally he welcomed Father Castelli, a priest of St Michael's Catholic Church, Chatham, and the Officiating RC Padre to the Chatham Garrison. St Michael's Church was built just over a hundred years ago largely from money donated by Irish Infantry Regiments stationed from time to time in Lower (now Kitchener) Barracks, Chatham, and other Catholic soldiers of the Garrison. James McCudden's father and mother were married in St Michael's Church in 1890 and the family regularly attended Mass there.

He welcomed one and all to the Royal Engineers Museum, that strangely beautiful place so in keeping with the Sapper mystique, on such a proud and historic occasion.

In her speech which followed Her Worship the Mayor of Gillingham (Alderman Miss G. F. Sladden) said: "For most conspicuous bravery, exceptional perseverance, keenness and a very high devotion to duty.

"These were the words with which is late Majesty King George V in April 1918 approved the award of the VC to James Thomas Byford McCudden, twice DSO, twice MC, MM, Croix de Guerre. From a man of only 23 years of age what borough —no, what nation—could have asked more? On 4 June 1918 Gillingham Borough Council unanimously voted to James McCudden its highest honour—admission as an Honorary Freeman of the Borough. Regrettably he was not to receive it in person, as his life came to an untimely end on 9 July. His mother, whom we know to have been a woman of tremendous fortitude, visited Gillingham the following September to receive formally the Freedom Scroll and Casket bestowed on her son.

"Today, 9 July 1968—fifty years later—Gillingham joins both his family and the Royal Engineers in paying tribute to one of its greatest sons. Today, we acknowledge once again the great debt owed not only by this borough but by the whole country to the McCudden family, of whom James was one of the three brothers who lost their lives fighting in the cause of Peace and Freedom. We are indeed proud to have been invited to this Commemoration Ceremony, and we are pleased to have the opportunity to join with you all in expressing our pride and our affection for so gallant and brave a young man. I personally feel very unworthy at this moment of time, for on this Council there are several members who have had intimate associations with both the Royal Air Force and the Royal Engineers and they most certainly would be able to pay a far more adequate tribute. Nevertheless I do assure his family that their brother is constantly in our thoughts, for there, in a most conspicuous place in the Municipal Buildings, majestically hangs his photograph. We in Gillingham have always been very proud that from our midst came so revered and honoured a person although we originally had some difficulty in establishing that James was a Gillingham man. In fact his actual birthplace became the subject of a most undignified wrangle between the Boroughs of Chatham and Gillingham. (Let me hasten to assure you though that such a thing like that would never happen today.)

"Actually any lingering doubts were resolved by a letter from James McCudden himself in which he said that, although he had many friends in Chatham and appreciated the interest that Borough was taking in him, he was proud to belong to Gillingham, in which town he recalled most pleasant boyhood memories.

"I repeat we are indeed proud and honoured to be associated with this historic event and, as I stand here, I recall to mind the immortal words of Lawrence Binyon.

> 'At the going down of the sun and in the morning,
> We will remember them.'

"We of Gillingham certainly remember James Thomas Byford McCudden. We remember him for his bravery and courage, for his talents of the first order, for his superior knowledge and understanding of air fighting, for his vehement enthusiasm and for his short life in which so much was accomplished.

"None has left a more splendid name."

Major-General Sir Gerald Duke, the Representative Colonel Commandant Royal Engineers, who spoke after the Mayor, said that there were four aspects of the ceremony on which he would like to dwell.

First, the great dual honour bestowed by the Borough of Gillingham on the McCudden family and on the Royal Engineers by the granting of their Freedom to James Thomas Byford McCudden on 4 June 1918 and to our Corps on 1 July 1951. The two Freedom Caskets were proudly on display in the Museum side by side for all to see.

Second, the birth of military flying. As far back as 1862 Royal Engineer and other officers realized the potential of air power in war. At first they received little encouragement from official sources, and they had to finance their development work out of their own pockets. In 1878, however, authority was given to set up at Woolwich an experimental factory for the production of balloons, and in 1880 an operational RE Balloon Detachment was first formed. RE Balloon Sections took part in operations in Bechuanaland and around Suakin in 1885. They were used, together with a photo reconnaissance section, in the South African War of 1899–1902, and No 4 Section was sent to China during the Boxer Rebellion in 1900. This Section did not return home, but was sent to India to form a nucleus of the Bengal Sappers and Miners Experimental Balloon Section—the forerunner of the present Indian and Pakistan Air Forces.

During the early 1900s progress was rapid. Man-carrying kites were developed for use when the wind was too strong for captive balloons, and free ballooning was brought to a fine art. The internal-combustion engine made possible the powered

airship and, later, the aeroplane. Experiments in aircraft wireless communications were carried out in 1909–10, and in early 1911 the Royal Engineer Airship *Beta* was able to transmit messages up to a range of thirty miles. Air photography became vastly improved and, in the early aeroplanes, air-speed and height-recording instruments and elementary bomb sights were developed. The pioneering days were over and military flying had become a going concern.

In 1911 a War Office Committee under Lord Kitchener, himself a distinguished Sapper officer, recommended that, as military aviation had emerged from the experimental stage, it should no longer be included in the functions of the Royal Engineers. As a result the Air Battalion RE was organized into a headquarters and two companies, one for balloons and airships and the other for aeroplanes, and on 13 May 1912 the Royal Flying Corps was formed, the personnel of the Air Battalion RE being absorbed into the new Corps, which was at first divided into a Military and a Naval Wing, from which the present Royal Air Force and Fleet Air Arm were descended. From the RE Balloon Factory on South Farnborough Common had grown the present Royal Aircraft Establishment. Photographs of the early Royal Engineer aeronauts, and the equipments in which they took to the air, were on display in the Museum.

Third, the Victoria Cross; in all 46 Victoria Crosses had been awarded to Royal Engineers, of which 13 were to be seen in this Museum. When James McCudden was a boy at Chatham the Commandant was Major-General Hart, who, as an RE Subaltern, had won the VC in the wilds of Afghanistan in 1879. It is doubtful if the two ever met, but no doubt young James became determined to emulate the General's gallantry. The Quartermaster of the Air Battalion RE was Captain F. H. Kirby, who, during the South African War as an RE Mounted Corporal, had won the VC on 2 June 1900, saving the life of a comrade under heavy fire at close range. He later became a Group Captain in the Royal Air Force and retired in 1926. He died on 8 July 1956 at the age of 85. There is a Memorial Tablet in his honour in the Chatham Garrison Church. We did not claim James McCudden as a Royal Engineer Victoria Cross holder: he was a commissioned officer in the Royal Flying Corps when he won it. However, several Royal Engineer officers were seconded to the Royal Flying Corps during the First World War and of these Captain L. G. Hawker and Major E. Mannock were awarded Victoria Crosses. They were both subsequently killed in action flying.

Fourth, the McCudden family, so closely linked with the Borough of Gillingham, the Corps of Royal Engineers, Military Flying and the Victoria Cross.

The McCudden family had greatly honoured us in that Mrs Cobley, the elder sister of James McCudden, had entrusted to us on loan the decorations and medals of her father and three of her brothers for display in our Museum. It was an incomparable collection and told a wonderful story of heroism, service and self-sacrifice. It comprised the decorations and medals of:

Sergeant-Major W. H. McCudden, RE, who enlisted in 1872 as a bugler boy in the Royal Engineers at the age of 14. He was awarded the Royal Humane Society Medal for saving life at sea when only 16. As a corporal bugler he was present at the Battle of Tel El Kebir on 13 September 1882. He later became a Sergeant-Major Instructor in Survey and Astronomy at the School of Military Engineering. In 1890 he married Amelia Byford. They had four sons and two daughters, both of whom, Mrs Cobley and Mrs Robertson, were present at the ceremony.

William Thomas James McCudden who enlisted as a bugler boy in the Royal Engineers in 1905, aged 14, and on becoming a sapper joined a Balloon Section RE in 1910. He was later posted to the Air Battalion RE and transferred to the Royal Flying Corps on its foundation on 13 May 1912. He was one of the first NCOs to obtain a Royal Aero Club pilot's certificate in August 1912. He went to France with the British Expeditionary Force in August 1914. He became a flying instructor and, as a flight sergeant, he was killed on a training flight in May 1915.

2nd Lieutenant/Acting Major James Thomas Byford McCudden, VC, DSO*, MC*, MM, Croix de Guerre, about whom both General Foulkes and the Mayor had spoken.

2nd Lieutenant John Anthony McCudden, MC, who enlisted as a bugler boy in the Royal Engineers in 1912, aged 15. He transferred to the Royal Flying Corps and was accepted for pilot training in August 1916. He was killed in action flying on 18 March 1918.

Mrs Cobley's mother was selected to represent the Mothers of Britain at the inaugural ceremony of the Tomb of the Unknown Warrior in the United States of America. No more worthy representative could have been selected. She wore, as a brooch, the miniatures of the decorations and medals of her VC son.

The Corps of Royal Engineers was proud to cherish and display this unique medal collection, which surely would be a constant source of inspiration to all who visited the Museum.

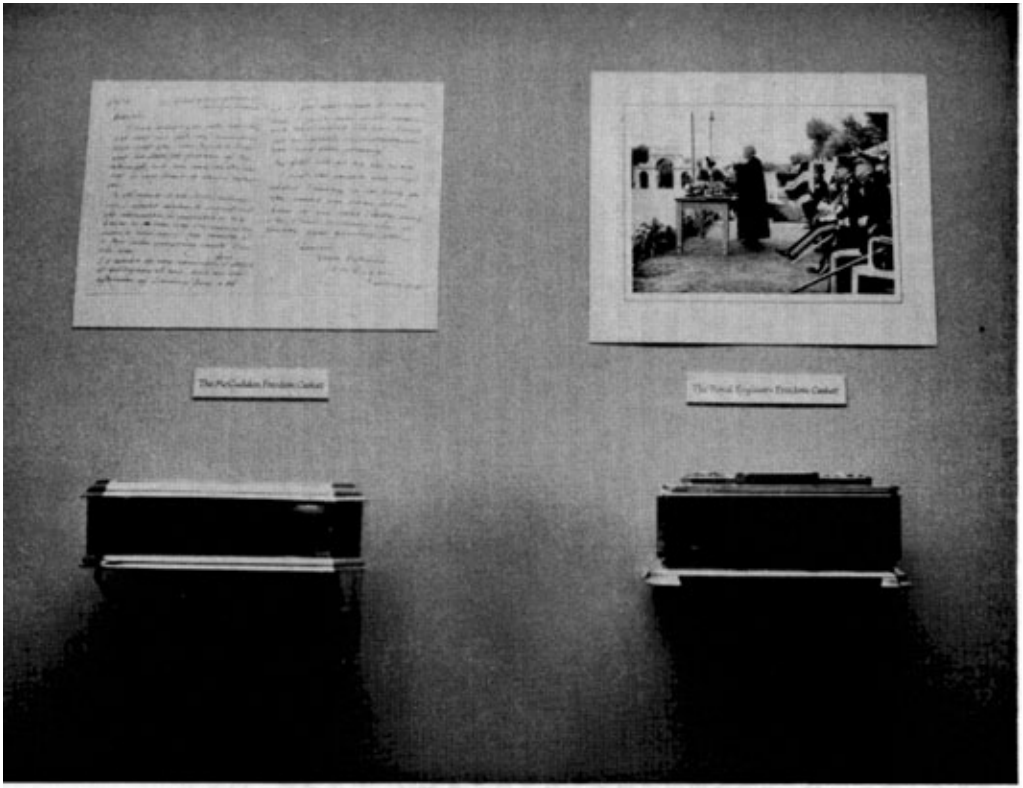
He then asked Mrs Cobley to unveil the medal collection, which she did with great dignity and composure to the general acclamation of all present.

The unveiling ceremony having been completed, those present inspected the exhibition of the McCudden medal collection, the Freedom Caskets, photographs of the McCudden family and of Mrs McCudden at the Tomb of the US Unknown Warrior in Arlington Military Cemetery, Washington, DC, kindly supplied by the Battalion Historian, the 1st Bn 3rd US Infantry (Old Guard), Fort Myer, Va, a sketch in oils by Sir William Orpen, RA, of James McCudden, kindly lent by the Imperial War Museum, and a most comprehensive exhibition of photographs, drawings and models of Royal Engineer-operated balloons, kites, airships and aeroplanes and a gallery of photographs of early military aeronauts.

Luncheon was then served in the Headquarters' Mess—after which Brigadier W. M. Inglis, the Commandant, the Royal School of Military Engineering, who seems to have such a magic control over the weather on important occasions, invited the McCudden family, twenty-three of them including a serving and a retired squadron leader RAF and a Franciscan monk, to the sunshine of the Mess garden and laid on the RSME photographer to take what must have been a most historic family group to commemorate a great day for the McCudden family, for the Borough of Gillingham and for the Corps of Royal Engineers.

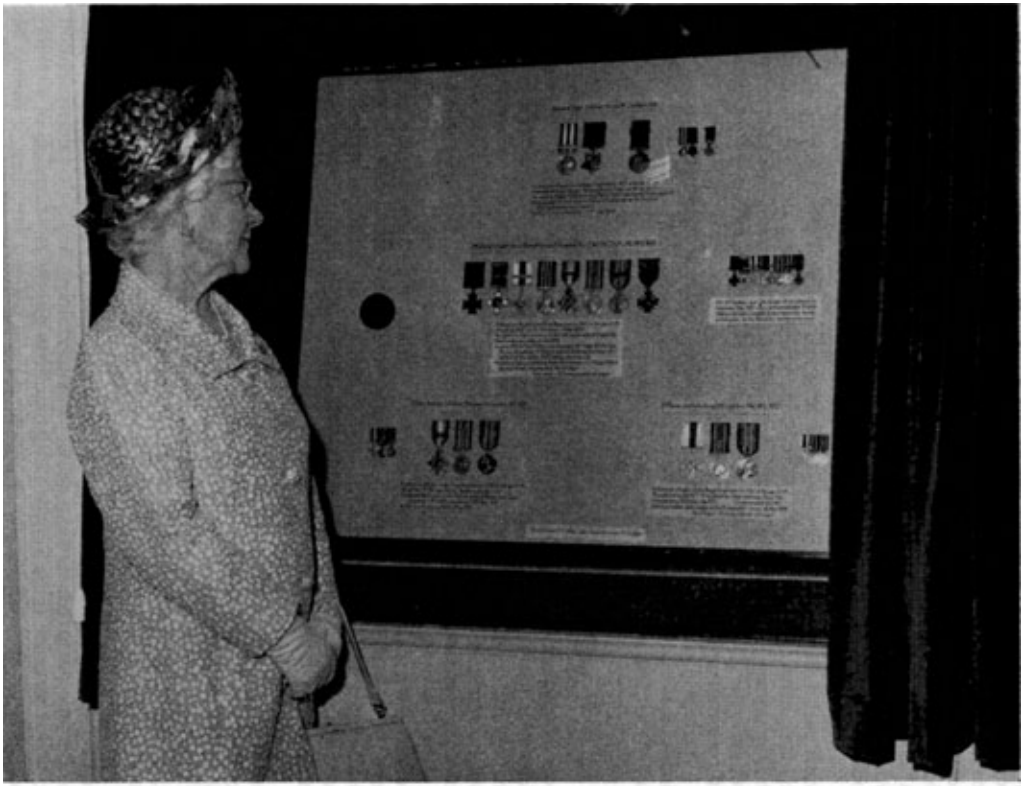
The Exhibition in the Museum was kept open throughout the week, and during the Royal Engineer Veterans' Week-End. It attracted many visitors and during the RSME Open Day on Saturday 13 July over 2,250 came to see the McCudden medals. Many of the Sapper veterans had personal memories of that famous family and to them their visit to the Museum was in the nature of a pilgrimage.

As the Mayor of Gillingham said: "We shall remember them", and we in the Corps, to whom this unique medal collection has been entrusted, will remember the valour, glory and tragedy of the McCudden family and take strength from their example.



The Freedom Caskets of James Thomas Byford McCudden and of the Corps of Royal Engineers.

The McCudden Commemoration Ceremony 1



Mrs L. Cobley with the decorations and medals of her father and three of her brothers.

The McCudden Commemoration Ceremony 2

The Art of Committee Fencing

MAJOR B. R. LAMBLE, RE

THE importance of Sport in Service life has never been underrated, and many sporting terms have found their way into common usage. Few discussions take place between officers without some sporting similie or metaphor frequently occurring in the conversation. Over past years cricket and hunting have tended to dominate the field, but with the increasing possibility of annual limitations on defence expenditure, the sword may once again become the basic weapon of war for an officer in the Armed Forces. Since the sword still has its place in Ceremonial and Insignia, it would appear right that the noble and ancient art of fencing should not be overlooked.

An increasingly important facet of Service life is the art of committee work. Most professional officers devote much time and energy to the study of war, but the same cannot be said of their studies concerning the skill and tactics required for the committee. Since little can be achieved nowadays, in a profession of arms, without the committee, it would seem that this is a serious weakness in the professional officer's training.

The aim, therefore of this paper is to consider the art of fencing and to see what similarities exist that are applicable to committee work. The subject is considered under the headings of Equipment and Tactics.

EQUIPMENT

Three weapons are used in fencing: the foil, the sabre and the épée. Each has its own characteristic, and the experienced swordsman will choose his weapon dependent upon the opposition. This may be compared to the approach used by the Service delegate towards any particular committee. Choice of the wrong approach will undoubtedly result in the Service Delegation being defeated before the committee is ever assembled.

The foil is a light academic weapon with its use governed by a set of clearly defined conventions. The target is extremely limited and much intricate thought is required in order to use this weapon. Thus, the foil approach should be used when the Service aim is to achieve a limited proposal against academic opposition. It is particularly recommended for the technical and scientific committee, where a gentlemanly approach is required with no loss of prestige to the vanquished.

The use of the sabre has certain similarities, being again governed by convention, but having a larger target to hit. It is a swashbuckling weapon, and gives much scope for the cut and the thrust. Sabre fights rarely last long, and are usually accompanied by warlike cries and an attempt to beat the opponent into the ground. This committee approach should only be used when the Service Delegation is convinced of its unanswerable case, and is sure that the opposition will be defeated swiftly and surely. Care must be taken to guard against over-confidence.

By far the most difficult and lethal weapon is the épée. This is the duelling weapon, and is unchanged from the days of "The Grey Eminence". There are few rules and no limitation of target. Its use requires patience, cunning, and a rigid determination to win at all costs. If the Service Delegation is to discuss any question of vital importance this approach should be chosen. Almost without exception, it should be used against financiers and members of the Treasury. Invariably, the fight will be long, hard and bitter, and fought to the death.

TACTICS

In olden days a duel was arranged by the "seconds", who decided the location, and whether or not the fight was to be to first blood or to the death. A strip of paper corresponding to the length of the opponent's blade was always given to the

challenger. In committee work, little can be done to influence the place of discussion, though it is clearly of an advantage to have it take place on one's home ground. However, great attention must be paid to the agenda circulated beforehand.

An examination of the opponent's blade is often a profitable exercise, since worn areas may give an indication of the type of movement he most favours. Before a committee, it is clearly difficult to examine the files of the opposition, but every effort should be made beforehand to gain maximum available information on his line of attack.

Having made their preparations, both contestants or delegations gather at an agreed place to commence battle. The contest is always preceded by the Salute. It deceives none, but is supposed to signify sportsmanship and mutual respect. The Service committee member must always maintain his guard against sentiments to arrive at a satisfactory agreement. These are often expressed by the opposition over coffee beforehand.

Many a fencing contest has been prejudiced by failure on the part of one of the contestants to control his attitude to the President and Judges. Whilst in important competitions a little temperament is excusable, excessive excitability is guaranteed to have an adverse effect upon the President. Thus, the attitude of the Service committee member towards the Chairman is of paramount importance. Small unimportant defeats must be acknowledged respectfully, and with tact and good humour. Only when the vital point is reached should the determination to win take precedence over the Chairman's ruling.

Obvious though it may be, no paper related to fencing or committee work would be complete without mentioning the relative skills of the contestants. Nothing takes the place of detailed preparation and practice, and a comprehensive knowledge of the subject is essential in order to stand any chance of success.

A debatable factor is the relative value of the first hit. In fencing it is often advantageous to lose it in order to assess the opponent's skill and weakness. This tactic is to be used with caution in committee, but is worth considering if the particular subject under discussion is not of great importance. It sometimes has the effect of giving the opposition a false sense of security, and may well give the Service Delegation a chance to revise its tactics.

Of prime importance, however, is the question of Offence or Defence. Here, the choice of weapons has a great bearing. As has already been explained, both the foil and the sabre are weapons of convention. Once the attack has been launched, the defender must first successfully parry before he in his turn gains the right of attack. Even if he places his point on his opponent before the attacking point arrives, he will still have the point awarded against him. This is not so with épée. Here, the first point to arrive wins the hit. Thus, it would appear that the right service tactic for the scientific or technical committee is the parry and riposte, whilst the all-out attack is required against the financial committee.

Allied with the above is the question of simple or compound manoeuvres. It is a great mistake to meet a simple attack with an involved and complicated defence. If it is noticed that the opposition adopts this tactic, one is guaranteed success. Naturally, compound attacks necessitate compound defence, but even here, if the attack is slow, there is room for the simple winning thrust. Generally, therefore, simplicity is to be preferred against complexity.

The greatest care must always be taken when engaging the professional. It rarely happens in fencing that the pupil is able to beat his professor, irrespective of the time that has elapsed between instruction and combat. If, therefore, the Service delegate has at one time served under the leader of the opposing delegation, it is better that he be replaced by another whose weaknesses are unknown.

Finally, it is necessary to investigate the Timing Factor. Without doubt, this is the crux of the problem. No swordsman has ever left the novices piste until his timing was perfect. Similarly, many a vital service requirement has been defeated in committee because the subject has been discussed at the wrong time. Service

committee members must always look further than the actual subject under debate. Change of Ministers, industrial unrest and elections all have their effect.

CONCLUSION

It would appear therefore that there is a great similarity between the art of fencing and the art of committee work. Many comparable factors exist, but four in particular are of the greatest importance. These are Approach, Knowledge, Simplicity and Timing.

The Phillimore Room, Dehra Dun

INFORMATION has been received from the Surveyor-General of India that, to commemorate the memory of the late Colonel Phillimore and in appreciation of his outstanding work for the Survey of India, it has been decided to name one of the rooms in the Survey of India Library at Dehra Dun, where the Colonel used to work, the "Phillimore Room".

Colonel Phillimore, CIE, DSO, who died on 30 October 1964 in Gulmar, Kashmir, in his eighty-sixth year, was a previous Surveyor-General of India. Although his career was a most distinguished and fruitful one, he will perhaps be best remembered as the author of the five volumes of the *Historical Record of the Survey of India*, each beautifully annotated and illustrated, which record the story of an enterprise in which for nearly 200 years Royal Engineer officers played a leading role and, when Independence came to India and her sister nations of Pakistan and Burma in 1947, the subcontinent was in many respects the best-mapped area of comparable size in the world, an advantage whose value to the successor countries of the old Indian Empire was incalculable. The task of compiling these volumes occupied all Colonel Phillimore's spare time for twenty years.

The Phillimore Room will contain a large portrait of the Colonel and a citation of his work, reference books, etc, that he used to study, papers, records and books presented by the late Mrs Phillimore, who died on 28 March 1968, and the five volumes of the *Historical Record of the Survey of India*, Volume V of which has recently been published.

Correspondence

Lt Col D. E. Townsend-Rose, RE,
62 CRE (Construction),
B Camp, Barton Stacey,
Winchester, Hampshire.
10 July 1968

RELATIONSHIP BETWEEN FIELD SQUADRONS AND SPECIALIST TEAMS

Sir,—As Commander of the five Specialist Teams in the Strategic Reserve, I would like to add some comments to Major Cave's article.

Major Cave has made a strong case for a Field Squadron to be placed in direct support of a Specialist Team. He has based his argument on the particular case of a Field Squadron installing the Limited War POL Set—shortly to be renamed Emergency Fuel Handling Equipment (EFHE)—with the Specialist Team (Bulk Petroleum). It could well be the correct solution in this case, but other projects involving one complete Field Squadron with one Specialist Team will be rare.

There are four different types of Specialist Team in the Strategic Reserve: Roads, Bulk Petroleum, Well Drilling and Construction. The Well Drilling Team does its own work, and should, where possible, work under command of a Field Support Squadron. With construction work a Field Squadron is unlikely to require the assistance of a whole Construction Team, and the OC of the Team will have other work to supervise at the same time. This is also possible with the Bulk Petroleum Team. There is, therefore, a good case for the OCs of these two Teams to be senior Majors who have already commanded Squadrons. The Roads Team seems the most likely one to work as a complete Team with a Field Squadron.

Part of a Specialist Team may be under command of a Field Squadron. This happened recently in North Africa, and Specialist Team members had to learn to accept a non-specialist officer as commander of a technical project. Similarly part of a Field Squadron may be under command of a Specialist Team. There is such a project just about to start. The actual organization for any particular project must be laid down very clearly by higher authority before the project starts.

Just as important as the chain of command, is to get the two units working together, and the more integration that can be achieved, the better. The Specialists must be used to guide and assist the construction unit. The unit must fit the Specialists into its organization at the appropriate levels and the Specialists must feel themselves as part of the unit.

It is perhaps of interest that there is in the eyes of Specialist Teams a distinct difference between Field Squadrons and Field Squadrons (Airfields). The latter have professionally qualified OCs and 2ICs and are regularly employed on project work to civilian standards. Field Squadrons training is aimed at speed in carrying out set "drills" with standard equipment; the attitude this engenders is the wrong one for carrying out project work, and re-training is needed. Thus a Field Squadron seems to take longer to get into the swing of a construction project than an Airfield Squadron, but with adequate training, and properly used Specialist assistance, a Field Squadron can produce just as good results.

Finally, the Consultant/Contractor analogy; this is an obvious but dangerous one, and should be avoided. A better analogy, if one must be drawn, is that the two units together compare with a Contractor offering a package deal.—Yours faithfully, D. Townsend-Rose.

Major D. R. Whitaker, RE, MA, MINucE,
The Fortress Squadron RE, Malta, BEPO 51.

12 June 1968

Sir,—The officer who wrote in the June 1968 issue of the *Journal* on the working relationship between field squadrons and STREs is, I am sure, seeing a problem where none exists. For a start it is, as always, wrong to generalize. There is a world of difference between, say, a peacetime community relations job and an emergency combat task both done by a sqn/STRE combine, and it would be strange if the degree of participation by the latter were the same for both tasks. Having made one philosophical point I may as well make another. Will people please stop comparing soldiers and their ways to civilians and theirs. This has been done for purposes of computing our pay with disastrous results for the soldier, and it is safe to make such comparisons only where it is quite certain that service conditions are not the paramount factor. In this case the problem, if there is one, is the military one of command.

It is not until he reaches his summary that the author of this article openly shows why he feels that the relationship he examines may require defining in Queens Regulations. "It is a fact of life", he asserts "that officers of equal rank responsible for parts of a single project are liable to quarrel." Nonsense, unless he is referring to one of the "promotion-hungry majors", whom he says command bulk petroleum STREs, or to one of the "ambitious officers" commanding field squadrons. If such a couple made a pig's ear of a project, which they both regarded as a mere stepping-stone, it would be unfortunate. Luckily, however, such officers are rare in our Corps. The latter certainly must be very weak if he avoids putting the true, unpalatable position just because this is "an unpopular and dangerous pastime".

I think that, if we assume the friendly and co-operative relations that normally exist between Sapper officers, the command set up under discussion is very straightforward. The

squadron (or regiment) commander is given a project to execute by whoever commands him, and he must do it the best way he thinks fit. Nowadays he may get the tremendous help afforded at all stages of the job by an STRE, and he would be a fool not to take their technical advice. If the STRE commander (who is at present established as a major but could equally well be a subaltern or a lieutenant-colonel if he were technically acceptable) is seriously concerned with the conduct of the project, then he must, if he can, say so to whoever gave him his brief. One could quote innumerable parallel situations which have worked for generations.

One last comment. If ever they get to the state of exchanging the dates of their commissions it will be because they are being attacked by vandals and the finer technicalities of their project will not be uppermost in their minds!—Yours faithfully, D. R. Whitaker.

Major J. E. Kitchings,
HQ Army Strategic Command,
Wilton, Salisbury, Wilts.

4 July 1968

CORPS NOMINATED ADVISERS

Sir,—I believe that the article in the June *Journal* on "Corps Nominated Advisers" describes an excellent scheme. However, the sort of advisers you may well get might be described as enthusiastic amateurs, when what the Corps needs is some really experienced professional men. Could not, therefore, the scheme be widened to include the T & AVR, and, possibly, even willing civilians.

At present it may well be that the volunteers will not, between them, cover all the specializations that the Corps might need. I suggest that a comprehensive list of our requirements be made, and initially those not filled by officer volunteers should be filled by invited civilians. If this works well, then further invitations might be sent to others to become additional advisers on subjects already covered by regular officers.—Yours faithfully, J. E. Kitchings.

Major J. N. Cormack, MBE, MC, RE,
All Arms Tactics Wing,
The School of Infantry,
Warminster,
Wilts.

24 June 1968

"WITHER" THE CORPS?"

Sir,—I read the article by Captain C. G. B. Brodley, MBE, RE (RE *Journal* of June 1968), with considerable interest. I do not agree that demolition mine warfare, equipment bridging, water supply, and field defences are secondary functions. It is precisely for these functions, as well as roads and airfields, that we exist to support our fellow "teeth" arms. Our firm commitment to NW Europe merely serves to underline the importance of these traditional tasks.

The first question we must ask ourselves is "What do the other arms and Services expect from us?" The next question is "How best can we be organized and trained to achieve this?" Finally we should ask ourselves "What else we can do for the Army, and the Civil community, which will benefit them and improve our experience and training?"

Although Infantry units can be and are trained in mine warfare and field defences and are willing to help the Sappers whenever they can, it is clear that they will never be in a position to shoulder a significant portion of this sort of commitment.

I do not feel that the educational gap between the Engineer Troop and the Infantry Platoon is relevant, but it does exist and will not close entirely in the foreseeable future.

Having got our priorities straight, I fully agree that the Corps can do an enormous amount of good, at home and overseas, in the field of Military Aid to the Civil Community. The Field Squadron, in combination with the appropriate Specialist Team Royal Engineers (including STRE Airfields?), is the ideal unit for this purpose.

We should not be in any great rush to change our name. Let the Infantry keep their Assault Pioneers—the more there are and the better they are trained, the happier I shall be.—Yours faithfully, J. N. Cormack.

Lieut-Colonel M. G. L. Roberts, MBE, RE,
Office of the Deputy Supreme Allied Commander Europe
Shape, BFPO 26.
27 June 1968

'"WITHER" THE CORPS?'

Sir,—I was so delighted to read Captain C. G. B. Brodley's letter '"Wither" the Corps?' in the June 1968 *Journal* that I felt I must put pen to paper to back him up. There was a time, I am ashamed to say, when I thought of Works Services, and indeed of any form of "real" engineering, as being somewhat beneath the Sapper officer, whose proper function I regarded as providing combat engineer support for the other Arms. That many others in the Corps were of the same opinion was borne out by some of the correspondence following the publication of Brigadier J. B. Brown's article, 'Whither the Corps'. The termination of the Corps's responsibility for Works Services has, to some extent, healed the breach which previously yawned in our midst between the combat engineer and the civil engineer. But unfortunately this has brought the danger that we will degenerate from military engineers into assault pioneers. We simply cannot afford to forget that, whereas our military qualities give us our status as soldiers, it is our ability as engineers which differentiates us from the other Arms and without it there is no justification for our existence as a separate Corps.

But does the Army really need engineers, as opposed to assault pioneers? This question would never be asked if it were not that during training in peacetime it is rarely, if ever, possible to simulate the destruction of war. All of our past history tells us that warfare, in whatever theatre it may occur, will be such as to call for engineers' effort of every kind. Our problem, therefore, is to persuade our masters that this is true, so that they will let us have the funds and the opportunity to carry out the necessary training. We will be greatly helped in this if we can show them that what we propose to do, as training is intrinsically useful in itself.

Three years ago I was sent out to Thailand, where I was lucky enough to have been given command of 59 Squadron, engaged on the Crown, and subsequently on the Post Crown, Project. My background experience for this type of work was two and a half tours in field squadrons in BAOR and one tour instructing in equipment bridging at the RSME! My situation would have been hopeless without the expert knowledge provided by the Project Officer, a trained civil engineer, and his Clerks of Works. Contrary to all my earlier prejudices, I found the work fascinating and, above all, rewarding, because it was creative. It was creative not merely in the sense that we were building something which would endure, but also in that we were helping to bring stability and prosperity to a primitive and economically depressed people who were threatened with subversion and terrorism. In this way we were carrying out the highest function of the soldier, that of safeguarding peace.

The value of the work done by the Corps in Thailand has been well recognized and has been the subject of Memoranda from both the Prime Minister and the Secretary of State for Defence. None the less, with the withdrawal from East of Suez, the Corps clearly will have an uphill battle, as Captain Brodley so rightly points out, to obtain more work of this sort. We will not have much hope of winning this battle if we ourselves are not sure where we are going. To my mind there has never been any doubt. We must be, as we have always had to be, both capable engineers and good soldiers. That this presents training problems (so admirably illustrated by the playlet "The BM's Nightmare" published in the June *Journal*) only makes it clearer than ever that this is a challenge which can only be met by officers and men of high calibre. And unless we can offer such a challenge, we will not get them.—Yours faithfully, M. G. L. Roberts.

Ordnance Survey,
Leatherhead Road, Chessington, Surrey.
23 April 1968

HISTORY OF THE ORDNANCE SURVEY

Sir,—An Official History of the Ordnance Survey, from its establishment as the national mapping department in 1791 to the present year, is in preparation for eventual publication by H.M. Stationery Office. The authors would be grateful for reports of unpublished or out-of-the-way information relating to the activities of the Survey. This may include personal papers, including diaries and letters; recollections (written or unwritten) of persons directly or indirectly connected with the Survey; newspaper reports; articles in local or specialist journals; references in biographical and other published works.

Anyone who possesses, or is aware of, such materials is asked to communicate with the Editor, Ordnance Survey History, Library, Ordnance Survey, Leatherhead Road, Chessington, Surrey.—Yours faithfully, R. A. Skelton, Editor, Ordnance Survey History.

Imperial War Museum,
Lambeth Road, London, S.E.1.
20 May 1968

HISTORICAL RECORDS

Sir,—I am undertaking, on behalf of the Imperial War Museum, an intensive drive to secure the many still outstanding collections of private military, naval and air papers which form such an important part of the historical records of this century. The dispersal of these records has resulted in their deposit at a wide variety of institutions. These include university and college archives, national and local museums, local record offices, and so on. Many of these institutions are admirably suited for the preservation of such papers, and do a first-class job in making them available to students of the many aspects of war.

This museum is concerned, however, with the records of senior officers, and other public servants, who have yet to make arrangements for the deposit of their papers at a centre where they will eventually be subject to serious historical research. We are concerned with the large number of officers who have probably never even considered that their records could valuably be subject to such investigation, and consequently have never brought them together in any coherent manner. We are concerned also with the many cases where collections, as such, do not exist, but where single documents still remain as valuable historical evidence.

The military archive of the Imperial War Museum is the only national institution in this country, established by Act of Parliament, for the collection and preservation of the records of all three services. It provides a place of deposit for the records of the nation, where the history of war in the twentieth century may be studied from every aspect, service and civilian, and where documentary records are valuably complemented by the foremost collections of photographic and film records in this field.

I would greatly appreciate the opportunity to appeal, through your journal, to the many officers whose personal papers will help to throw light on the events and decisions in which they have played a part. It is vital that their records be preserved, and desirable that valuable collections are centrally held by a public institution actively engaged and professionally competent in this field. The Imperial War Museum is one such centre. I would welcome contacts from senior officers who might be prepared to consider adding their papers to the national collection which we already hold.—Yours faithfully, D. G. Lance, Keeper of Libraries and Archives.

Colonel L. J. Cardew Wood, BSc, FCGI, MICE, FIMechE, AFRAES,
Tile House,
Hampden Close,
Stoke Poges,
Bucks.

14 June 1968

THE SAPPERS' CLUB, JOHANNESBURG

Sir,—I have just returned from South Africa. While there I visited the Sappers' Club, near Johannesburg.

If the Club has not already been mentioned in our *Journal*, the following extract from my diary may be of interest:

"*21st April 1968.* We drove out to the Sappers' Club, above Hartbeespoort Dam, about forty-five miles from Johannesburg. Cold air and the sun blazing from a deep blue sky.

"The dam is a great lake, dotted with yachts and surrounded by a number of country houses and small hotels. The Club is a large and delightful place, run by the S.A. Engineer Corps. The sub is only £3 p.a. or 30*s* for country members and any visiting Sapper is a free member for a day.

"There is tennis, bowls, a swimming pool and every kind of amusement for children, and one can rent a rondaarvil for 7*s* 6*d* a night and eat in the restaurant.

"Above the Club, which is on a hillside, is a Garden of Remembrance, full of roses, other flowers, shrubs and trees. At the top of the hill there is a tiny Chapel to the memory of all S.A. Sappers who gave their lives in the last war.

"The shrine nestles under an escarpment of the Magaliesberg mountains and the view is magnificent.

"Notices in the Garden of Remembrance ask people to 'respect it as a place of peace and quiet', which indeed it is, and the continuous coo of doves made one think of Longfellow's '. . . Come back with a Sabbath sound, as of doves in quiet neighbourhoods' "—Yours faithfully, L. J. Cardew Wood.

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Memoirs

MAJOR-GENERAL R. W. URQUHART, CB, DSO, DL

Colonel Commandant Royal Engineers

RONALD WALTON (TIGER) URQUHART, who died on 19 April 1968, was born on 26 March 1906, the third son of W. L. A. W. Urquhart, Esq, of Montevideo, Uruguay. He was educated at Bedford School and the Royal Military Academy, Woolwich, where he became the Senior Under Officer and was awarded the Sword of Honour.

After completing his Young Officer Courses at Chatham and at Cambridge University (Pembroke College), he became a troop leader in the 1st Field Squadron, RE of the 1st Cavalry Brigade at Aldershot, where he remained for three years. In 1931 he was loaned to the Colonial Office and employed on survey work in Tanganyika and Northern Rhodesia. In 1934 he became an Instructor at the RMA Woolwich and in 1938 he was posted to the 54th Field Company RE, then at Bulford, and he accompanied the unit when it was moved soon after to Palestine and later to Egypt.

Shortly after the outbreak of war in 1939 he was sent home to attend a Short Staff Course at Camberley. He took part in the campaign in Norway during the summer of 1940 as Brigade Major to the Independent Companies, later converted into Commandos, and was mentioned in despatches.

Back in England he was successively Brigade Major 145 Infantry Brigade in 48th Division, Instructor at the Staff College, Camberley, and GSO 1 to the Chief Engineer GHQ Home Forces (Major-Generals B. K. Young and J. D. Inglis). In this latter appointment he was concerned with the initial engineer appreciations of the problem of the invasion of the continent of Europe and the resources required, including the organization necessary for the provision of airfields, a commitment which was at that time finally and firmly placed on the Corps.

He was appointed CRE 3rd Division at the end of 1942. This Division was the special strategic Reserve Division which, during 1943–4, was trained not only for the normal functions but also for desert, arctic and, very specially amphibious operations. Its staff was also involved in the planning of a number of stillborn operations and its Sappers carried out the detailed engineer planning of the UK-based division for the invasion of Sicily carried out at short notice by the 1st Canadian Division. He was with the Division during the Normandy landings in June 1944 and in subsequent operations in France and Belgium. For his services with the Division he was awarded the DSO and the Order of Leopold and the Croix de Guerre and he was twice mentioned in despatches. In November 1944, in Holland, he became GSO 1 43rd Division, having in July declined the same appointment in the 3rd Division on the score that he was, at the time, more essentially involved as CRE.

He returned to England at the end of 1945 to become GSO1 at the SME, then at Ripon, for a year after which he was appointed AA and QMG 46th Division in Austria and later Commander Graz Garrison, which was responsible for the Province of Styria.

In 1947 he was appointed Director of Combined Operations (Military) in the rank of Brigadier. In July 1950 he became Brigadier General Staff in the Military Training Directorate of the War Office, and in 1953 he was given command of 35th Infantry Brigade in Hong Kong.

Major General RW Urquhart CB DSO DL
Colonel Commandant RE

He was selected for the Imperial Defence College in 1955 and on graduating from there he was made Chief of Staff Western Command with the rank of Major-General. From November 1956, until his retirement in February 1960, he was Commandant the RMA Sandhurst. He was created CB in 1957.

General Sir Charles Jones, Chief Royal Engineer, writes:

"Tiger" Urquhart and I joined the "Shop" on the same day; we were commissioned with the Sappers in the same batch; we shared rooms at Pembroke College, Cambridge; he was my best man and the closest of friends.

From the start he inspired me and all around him. He set a standard in work and play, with a gay, devil-may-care flourish, which roused us and forced us to try to follow suit. He was a leader born; we loved and followed him.

Naturally and properly he became Senior Under Officer of our term at the Shop, winning the Sword of Honour; after being commissioned he was picked for the plum job—a vacancy in the 1st Field Squadron at Aldershot; and was later appointed instructor at the "Shop". He was the gay, efficient, dashing mounted sapper in those years between the wars; he filled the part to perfection and enjoyed it to the full.

The highlight of his 1939–45 war was his tour of duty as CRE of the 3rd Division under the Command of General "Bolo" Whistler. He trained his sappers to a peak of efficiency in the months before D-Day and then led them—and literally led them—with selfless gallantry in the assault on the Normandy beaches on that memorable 6th of June 1944. He continued to lead them in the hard fighting which followed and was badly shaken, suffering lasting damage to his back, when his scout car was blown up on a mine. This didn't keep him out of the battle; he was in it to the end, spending the last months of the war as GSO1 of 43rd (Wessex) Division, which was always in the thick of the fighting.

In 1942 he made the most important and wisest decision of his life. After a hurricane courtship he won and married Jean Moir and there couldn't have been a better match—in quality, in gaiety, in joy of life. Children arrived and Tiger, turning his thoughts to the future, invested—after careful study of the problem—in the home and fruit farm in Gloucestershire which became the main interest of his life in later years.

He soldiered on after the war, doing much good in a variety of appointments, including Chief of Staff to General Bolo Whistler in Western Command and Commander of 35th Infantry Brigade in Hong Kong in the mid-1950s, but the climax of his military career came in 1957 when he was appointed Commandant of the Royal Military Academy, Sandhurst—the first Sapper to hold the appointment. This was a task after his own heart, giving full scope to his great qualities of sturdy independent uprightness, gaiety, efficiency and powers of inspiration. He was greatly admired and loved by the Staff, Military and Civilian, and by the Cadets. None will forget him.

After a most distinguished three years at Sandhurst, he retired in 1960 to his beloved "Meredith" in the village of Tibberton, where he farmed his fruit trees with success, made a wonderful home for his family, did endless and important work for the Church in Gloucestershire, supported the Army, Regular and Volunteer, and took a great and valuable interest in local and county affairs, becoming a Deputy Lieutenant for Gloucestershire in 1965.

He became a Colonel Commandant of the Royal Engineers in 1964 and was Representative Colonel Commandant of the Corps in 1965.

Tiger did much good in his all too short life and left the world a richer and a gayer place. He will be desperately missed by his widow; by his eldest son John, a Captain in the Gordon Highlanders and at present seconded to the Gurkhas in the Far East; by Peter, a subaltern in the Sappers; by Jane, a painter of great promise; by David, still at Sherborne.

The Army and the Corps of Royal Engineers mourn his death. They will never again feel quite the same without him.

C.A.S. writes:

Tiger Urquhart entered the Shop from Bedford in January 1924. His attractive personality and all-round ability made him a natural leader of his term. Success on the Rugby field, in the boxing ring and in the saddle were preliminaries to the award of the Sword of Honour as Senior Under Officer.

He joined the SME in February 1926 as one of 14 YO (C. P. Jones's) Batch. His many activities included rugger, rowing in a successful batch four, and in the last inter-war Sapper Eight at Henley, and playing the bagpipes in his quarters—a deafening performance!

At Cambridge he was paired with Splosh Jones at Pembroke. And this talented combination were the leading spirits in a batch which later produced four generals amongst the dozen who survived VE Day. 14 YO's last joint exercise was a riding course at the RE Mounted Depot, Aldershot. Tiger was then posted to the 1st Field Squadron at Aldershot, the only fully mounted first-line unit in the Corps.

For the next three years he was one of that bevy of able horsemen who, in the show-jumping ring and driving the Regimental Coach during the summer and in the hunting field and on point-to-point courses in the winter, contributed to the hey-day of Sapper equitation. Batten, Coxwell-Rogers, Cleeve, Vachell, Foster, Lacey, Claussen and Myers were all distinguished performers during this final flowering before mechanization and war so drastically curtailed the opportunities for riding available to the average Sapper officer. Tiger used to drive the Coach as one of Vachell's assistants and he was a good man to hounds and between the flags of a point-to-point course.

For the invasion of Normandy Tiger had been selected as CRE 3 Division, one of the two British spearheads. Attached to him for the landing was 629 (formerly 9th) Field Squadron, a wartime unit composed nearly entirely of hostilities-only soldiers which had fought the Afrika Korps from El Alamein to Tunis. 629 Squadron had been specially trained to remove underwater obstacles to enable landing craft to reach the beaches.

On approaching the beaches, 629 Squadron's landing craft came under heavy fire from an emplaced 88-mm gun, and suffered heavy casualties. Tiger Urquhart and Major Carson (OC Squadron) led the Sappers of 3 Troop into shoulder-deep water to start hours of arduous and dangerous work under most unpleasant conditions. 629 (9th) Field Squadron, who continue to gather annually, still recall Tiger with great respect and affection.

M.C.A.H. writes:

The Staff at the "Shop" cannot have had much difficulty at the end of the summer of 1925 in choosing the Senior Under Officer for the next term; for Tiger was the obvious choice. Looking now at the old photographs brings back something of those days gone by.

A boy was not made SUO for his promise of future distinction—though with Tiger it was, in fact, fulfilled. They made him SUO because they believed he had in him, there and then, the qualities he would need from the day of his appointment. Tiger certainly had the right qualities. In today's idiom "He had what it takes". In a term to which the most charitable epithet that could be applied was "unruly", no SUO could succeed unless he commanded universal respect. And respect was what we all accorded Tiger.

Why did he command respect? He was not the foremost games player, which is (or was) important amongst boys. He was above average only. He was not in the Saddle Ride, which was the ambition of us all. He was not the star academic, for I see from *The Times* cutting of 24 December 1923 that he only passed into the "Shop" eleventh. Nor was he a blue-eyed boy who never got into trouble, for he was in the thick of many escapades. Yet, looking at the photographs, I see developing in him an unmistakable presence, a presence that sets him above the rest of us, and which went with him all the days of his life.

Presence is a great gift, but he had a greater—Integrity. It positively shone in his genial face. It was instinctive in his every act. Integrity is a gift without which all others are illusory; it acts like a catylist and makes the others work. If you find it in the cadet you will find it in the grown man. They saw it in Tiger. It was the secret of his influence on everyone he met. Total and complete integrity was the hallmark of his nature.

After our YO Course our ways parted. The next time we met he was driving the RE Coach to Ascot. The horses were restive and a policeman, not knowing the form, held us up at a cross-roads.

"Put your hand down, officer," ordered Tiger. "We are going on".

It was a subaltern speaking, but the policeman obeyed as though it were the Chief Constable. I overheard one of the girls on the coach remark: "This chap seems to know what to do." How right she was! Tiger had presence of mind, too, which is a useful gift for a soldier.

The next time we met was in Holland in 1944, when he came to 43rd Division as GSO1. He came from being the almost legendary CRE of the famous 3rd Division. What would he think of us? Would he always be standing in my place, telling the General what I, as CRE, should do? Would I find him always proffering engineer opinions without consulting me, a councillor without responsibility? The temptation must have been considerable, for we had many shortcomings; but he never succumbed. He was the best GSO1 I've ever known. His loyalty to his Commander and to the troops, and his common sense were an example to all the staff.

He was immensely calm. I remember a conference—"Morning Prayers" at Divisional HQ—at which Tiger presided. It was in a schoolroom in Holland or Belgium. You could see the snow glistening in the sunshine on the roofs near by. The Luftwaffe was having a last fling. There was a sudden, deafening roar of aircraft flying low, rent by the bark of guns. A flaming trace of cannon shells cut past the schoolroom window. There was a general, but futile, dive for cover. Tiger never moved. Everyone looked rather sheepish as they emerged from beneath the desks. What would Tiger say? Would he be scornful, or reproachful, or would he be shaken himself? He was none of these things. He never even altered the tone of his voice. God knows what he thought!

The scene changes to the last day of hostilities in Europe. A low-lying stretch of marsh land with low hills beyond. The enemy is in those hills. Everyone knows that the Cease Fire has sounded, but nobody fancies actually walking forward, without fire support, to see what will happen. In the end three lieutenant-colonels led the way, 200 yards ahead of the leading troops; and it is Tiger who leads the three. Quite simple in the after light; but impossible without Tiger at the time.

Then came Demobilization in Europe. Literally dozens of Sappers of Tiger's old 3 Division RE came over to our HQ in Celle to say good-bye to him before they returned to civil life. Few officers are privileged to be so loved and respected as he was.

A last scene. We are both retired. My wife and I called unexpectedly at his home on our way through Gloucester. Tiger is loading baskets of apples into an old motor car to take them to market. The hour is late, and as we trundle into Gloucester he tells me that the place will probably be closed and the Supervisor gone. As we arrived that worthy had just locked the last padlock on the sliding doors.

"Oh Hell!" exclaimed Tiger. "We've missed it."

"No you haven't, General" replied the Supervisor. "I can easily open up again for you." . . . But I have a strong feeling that that wouldn't have happened for everyone.

Everyone saw in Tiger the figure of a Man; a man who was great in heart. A man who would never forsake a friend; who would never be petty; who would never nurse a grievance. One's sympathy goes out to his courageous wife and to his children.

Let us pray that the Almighty, in whom Tiger put his absolute trust, will help to sustain them in their loss.

It will not be easy for those of us who remain to carry on the torch.

A Memorial Service was held in Gloucester Cathedral on 20 May 1968. The service was conducted by the Dean of Gloucester. The blessing was pronounced by the Bishop of Gloucester and an address was given by the Bishop of Sherborne, the Rt Rev. V. J. Pike, formerly Chaplain-General to the Forces and the last Chaplain of the Royal Military Academy, Woolwich. General Sir Charles Jones, Chief Royal Engineer, read the Lesson. Among those present were:

Mrs R. W. Urquhart (widow), David Urquhart (son), Jane Urquhart (daughter), Mrs. D. Moir (mother-in-law).

Sir Tom Hood (representing the Lord Lieutenant of Gloucester) and Lady Hood, the Duchess of Beaufort, General Lord and Lady Robertson of Oakridge, the Bishop of Tewkesbury and Mrs Horan, Brigadier Sir Mark Henniker, Lieut-General Sir Francis Nosworthy, General Sir Charles Richardson, Major-General T. H. F. Foulkes, President of the Institution of Royal Engineers, General Sir Hugh Stockwell, Admiral Sir William and Lady Elizabeth Davis, Sir Alexander Grantham, Mrs Victor Pike, Mrs B. T. Guy, Major-General J. C. Walkey, Major-General and Mrs G. N. Tuck, Major-General A. J. H. Dove, Major-General J. R. C. Hamilton, Major-General St Clair Ford, Major-General and Mrs G. A. Rickards, Brigadier W. M. Inglis, Brigadier R. W. C. Smales, Brigadier C. Scott-Bowden, Brigadier and Mrs E. C. W. Myers, Major Peter Birchall (chairman, Gloucester County Council), Lieut-Colonel C. A. Swettenham, Lieut-Colonel J. C. Smith, Mrs. H. Chesshyre, representatives of the Corps of Royal Engineers, the Royal Military Academy, Sandhurst, the British Legion, the Royal Engineers Association, the Royal Engineers' Benevolent Fund, S.S.A.F.A., and the deanery lay council.

BRIGADIER L. F. S. DAWES, MBE, TD

LESLIE FRASER SPEARMAN DAWES was born on 14 February 1897. He was educated at Bedford School and passed into the RMA Woolwich as a Prize Cadet in 1915. He was commissioned into the Corps on 27 October 1915 (Keane's Batch). He served mostly in France during the 1914–18 War and was gassed. He used to boast of having been up at Oxford, at Somerville—the Women's College near Radcliffe Hospital—then in use as an annexe for gas casualties.

From 1919 to 1921 he served in Mesopotamia with No 2 Bridging Train, 1st KGO Bengal Sappers and Miners, and was involved in the "Arab Rebellion". A bridge over the Euphrates, much in use during the campaign, was commonly known as "Dawes" Bridge. He was awarded the MBE for his services during the campaign. Then followed a Supplementary Course at Chatham and a year at Selwyn College, Cambridge University. Cambridge was fun for Young Officers back from foreign service, and not much work was done by the majority. It was here, at an RE Dance, that Dawes met his future wife.

Now married, he and his wife spent the next seven years abroad, first in Indian Railways, an interesting period which included a survey for a link line through Bihar, and the management for a year of the Aden Railway. After a period in Military Works in Quetta he passed into the Staff College there and duly received his *psc*. Then followed home service, including staff appointments in the War Office.

In 1935 he was faced with another tour of foreign service. At the same time it was confirmed that his wife had multiple sclerosis. He therefore retired (as a Major) and became Secretary to the Southern Railway. He maintained his connexions with

the Corps, however, by joining the Territorial Army and, on mobilization at the outbreak of war, he was in command of an Anti-Aircraft Battalion RE (TA) composed mainly of men from the Southern Railway. He was almost at once grasped by the War Office and sent, as a brigadier, to the British Supply Mission in Washington, DC, where he was responsible for the procurement of engineer equipments and stores. On returning home in the closing stages of the war he organized a great fly-in of blankets and other necessities of life to the destitute population of the Netherlands, for which he was awarded his most prized decoration, that of the Order of Orange—Nassau.

He returned to his post of Secretary to the Southern Railway when hostilities were over, but this appointment came to an end when the railways were nationalized in 1949. He was then asked by Courtaulds and Shell to set up the Engineer Equipment Users Association and he acted as Director and Secretary of the Association. The purpose of EEUA was to standardize and simplify the requirements of user industries when ordering equipment or work from manufacturers or contractors. This involved preparing and publishing specifications in accordance with the recommendations of technical experts from the various industries.

In 1959 he suffered a serious heart attack, which led him to retire from the EEUA to a charming home he had built for himself and his now almost completely paralysed wife in Kemerton, near Tewkesbury. He did not, however, give up his various side-lines until the end. He was one of the British Directors on the Board of STAB (Swedish Matches), and travelled frequently in Europe on their behalf. *MATCHCO News* of April 1967 carries a very moving tribute to his character and personality.

He and his wife were old friends of Kurt Hahn and took a great and active intest in Gordonstoun School, where they often stayed. Indeed, Leslie was a member of the Schools Council for thirty years.

For twenty-five years he was a valuable member of the Council of the RE Officers' Widows Society, especially on account of his knowledge of Stock Exchange investments, gained while with the Southern Railway. For sixteen years he was a member of the Committee of Management of the RE Benevolent Fund, which equally profited from his special talents.

A "retirement" like this involved a great deal of travelling. On his journeys, if it was possible to find a trained nurse to go too, he took his wife, who was by this time completely confined to a wheeled chair, but still took a lively interest in the world around. Their furthest-afield visit was to New England. His own death on 16 September 1967 of a second heart attack followed his wife's by a few months only.

He was a very keen fisherman, was a member of a local rough shoot and played golf sporadically.

Lieut-General Sir Alexander Cameron writes: "I think my outstanding impression of Leslie Dawes was his unfailing cheerfulness. He had his full share of troubles, but he never inflicted them on other people. To the world he was always cheerful and gay. He was the most uninhibited person I have met, and you knew just where you were with him."

He was indeed a very good companion, a true friend, a great and courageous personality with a genius for dealing happily with difficult situations.

He leaves two sons, one of them Vicar of Overbury within a mile or so of his parents' home.

Brigadier LFS Dawes MBE TD

COLONEL A. H. C. TRENCH, CIE

ARTHUR HENRY CHENEVIX TRENCH was born on 28 April 1884, the eldest son of the Rev H. F. C. Trench, and grandson of Archbishop Trench of Dublin. After school at Summerfields and a scholarship to Charterhouse he passed into the "Shop", and was commissioned in the Royal Engineers in March 1903.

His work at the "Shop" had clearly demonstrated his electrical ability and so from his YO Course at Chatham he joined the Submarine Mining Service at Pembroke Dock. After a civil works attachment he was posted to India in 1907, spending four years with the Indian Submarine Mining Corps in Bombay and Karachi. In 1911 he was selected to be the Assistant Electrical Engineer for the Coronation Durbar in Delhi which involved the planning and execution of the electrical work necessary for the setting up of a large number of camps to accommodate the Royal party and several thousand troops.

After attending one of the first E & M Courses at Chatham and with electrical manufacturers (Siemens and BTH), he returned to India in 1914, where he was appointed DADG Military Works (India), and employed on E & M work in connexion with the expansion of the Indian Army during the first years of war. In 1917 he became ADW (E & M) to the Mesopotamian Expeditionary Force and was in charge of the electrical work for installations and hospitals in Basrah and Baghdad.

After being appointed DD Works and temporary Colonel in May 1919, he became ill with malaria and was invalided home, returning to Bombay in 1920. For his work in Mesopotamia he was mentioned three times in despatches and awarded the CIE.

After four years in India as ADW Army Headquarters and Deputy Chief Engineer Military Land Scheme, Bombay, he returned home and in 1925 he was posted to the Chief Engineer's office, Aldershot Command, as Staff Officer (E & M). He found this a most congenial job, which included responsibility for the administration of the Central Electrical Power Station (steam, capacity about 8,000 kW), and for power supply to practically all barracks and military establishments in the Command. A fifteen-mile extension of the 6,600-volt feeders through Bordon to Longmoor, carried out under his supervision, enabled the two small local power stations there to be closed. He was also instrumental in negotiating terms with the Borough of Aldershot for a bulk supply to the town from the Central Power Station as a result of which the Council's own generating station was closed.

On his retirement from the active list, in September 1927, he joined the Railway Inspectorate at the Ministry of Transport. Unlike the other Inspecting Officers he had at that time no specialized railway background, but he soon acquired the expertise needed to deal with accident enquiries, and with the inspections of railway alterations and new works. His extensive electrical experience was, however, most valuable, and he acted as Secretary of the Committee, under the chairmanship of Lord Weir, appointed to examine the possibilities and economics of large-scale railway electrification, with particular reference to the East Coast main line between King's Cross and York or Newcastle. Later he dealt successfully with matters connected with the electrification by the LMS Railway of the Manchester, South Junction and Altrincham line, and of the Wirral Railway, and later with the preliminary stages of the LNER Liverpool Street–Southend electrification.

From 1927 onwards he was much associated with measures to deal with a hazard arising from the widespread replacement of electric trams by trolley-buses. Insulated from earth by its tyres, the trolley-bus could become "live" through some wiring defect, with consequent risk of shock to passengers boarding or alighting. He was associated with attempts by the operators to devise a continuously reading leakage indicator and alarm, to be fixed in the driver's cab, but these were not successful in the absence of a reliable "earth"; ultimately the problem was solved by the use of a semi-conducting rubber for the tyres.

From 1939 onwards, throughout World War II, he was actively engaged on matters connected with air-raid precautions on the railways, serving as a member of the Railway Technical Committee on ARP and on the Committee of Inquiry into Railway Emergency Lighting. He dealt with such complex matters as shelter accommodation for railway staff; protection of administrative centres and of railway and trolley-bus power supplies; with the provision of emergency telephone connexions, and with railway lighting restrictions, the last-named being a matter beset with technical complications. Each case had to be considered on its merits with the Home Defence authorities, usually resulting in a reasonable compromise regarding permissible intensity of lighting, and its control during raids.

His interests were technical rather than sporting and he was keenly interested in the development of motor transport. As a YO at Chatham he owned a Quadrant motor cycle and subsequently a single cylinder de Dion motor car. He was also a keen sailor both before and after the 1914–18 war in Bombay and Karachi and was responsible, with two other officers of the Corps, B. L. Eddis and E. K. Squires, for founding the Karachi Yacht Club.

In 1960 he developed a serious muscular illness which confined him to bed; he died peacefully, in his sleep, on 12 January 1968, in his eighty-fourth year. His wife, Dorothy Pauline, daughter of A. G. Steel, QC, whom he married in 1913, died before him, in 1950.

COLONEL I. C. C. MACKENZIE

IAN CHRISTOPHER CLUTHA MACKENZIE, son of Sir Clutha and Lady Doris Mackenzie and grandson of a former Prime Minister of New Zealand, died suddenly at his home in Bookham, Surrey, on 19 May 1968, aged 47 years.

Ian Mackenzie was born on 30 July 1920 in Auckland, New Zealand. Educated in Auckland, he came to the United Kingdom immediately prior to the Second World War and was commissioned in the Royal Engineers on 16 December 1939. After service in Gibraltar between July 1941 and November 1942, he was posted to the 3rd Division in the United Kingdom. In early 1944 he joined the Depot of the Combined Operations Pilotage Parties (COPP) on Hayling Island, to begin a type of service which reflected his adventurous spirit. On D-Day he was the sapper officer of COPP 6, whose duty it was to lead in two squadrons of tanks of the 13/18 Hussars and the AVREs of 77 and 79 Assault Squadron RE to "Queen" Beach near Ouistreham. An account of this operation, in which he is mentioned, is given in *The Secret Invaders* by Strutton and Pearson. The same book also records the story of another operation carried out in April 1945 by COPP 3 on Pukct Island, off the peninsula joining Thailand to Malaya, which at that time was held by a mixed force of Japanese and Thais. COPP 3, with Mackenzie in command, landed on the island to reconnoitre possible airfields for the coming Allied invasion. His mission was completed, but the arrangements for evacuation went astray, and there followed many days of privation during which the party was hunted by the enemy until eventually he, with two other starved and exhausted survivors, was captured by the Thais. They were fortunate in their captors; the Thais hid them from the Japanese and eventually imprisoned them in Bangkok, where they remained until they were released in August 1945.

Ian Mackenzie joined the School of Military Survey in 1949 as a student on the Long Survey Course. For his first two years as a surveyor he was seconded to the then Directorate of Colonial Surveys and was employed in East Africa. He returned to the United Kingdom and from February 1953 until December 1955 he was Officer in Charge of Triangulation and Levelling in the Ordnance Survey. During his tenure of this post work continued on the Third Geodetic Levelling of England and Wales under his personal direction. The planning for the subsequent lower-order

Colonel I C C Mackenzie

levelling to be based on the geodetic levelling was done by him and the system he devised is essentially the same as that now in use. He directed the experimental measurements made with the geodimeter on the Ridgeway and Caithness bases and subsequently reported the results of his work in an Ordnance Survey Professional Paper.

His next appointment took him to Cyprus, where he was Second-in-Command of 42 Survey Engineer Regiment; then back to Nairobi, where he was DAD Survey in East Africa Command. In 1959 he became AD Survey FARELF and this was a very happy period for him, with a great deal of independence of action and plenty of opportunity to travel. More than this, it gave him the chance of renewing his acquaintance with the Thais, to whom he had owed his life. His affection for these people probably lay at the root of his own personal dedication to the cause of SEATO, in which he was a whole-hearted and firm believer.

In February 1962 he took over as Commandant of the School of Military Survey at Hermitage, near Newbury. He had always been a keen shot and of course as Commandant he needed to know the local landowners well; these two things fitted together very neatly for him. It was his idea, too, to institute regular visits between the School staff and members of the US Engineer Topographic Center at Schwetzingen, near Heidelberg, making use of convenient USAF transport facilities stationed near by. This practice still continues and has generated much goodwill and many friendships between the Corps of Engineers and the Royal Engineers.

His last full tour was as Chief Survey, Northern Army Group in Germany. He was well suited to this international appointment, where his geniality and professional ability increased his already wide circle of friends and made many new ones for him among the NATO armies. It was one month after he had left this post and taken up a new appointment as Colonel (Survey) in the Ministry of Defence that his sudden and tragic death occurred. His loss has left the surveying community much the poorer, and he is sadly missed by many friends in many countries.

Ian Mackenzie was married in January 1946 in Auckland, New Zealand, to Pamela Anne Thorburn, who survives him. He leaves two daughters, Elspeth (age 13) and Kirsty (aged 6).

Technical Notes

CIVIL ENGINEERING

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

FOULNESS: SOME GEOLOGICAL IMPLICATIONS. J. T. Greensmith, BSc, PhD, FGS, and E. V. Tucker, BSc, PhD, FGS, both of the Department of Geology of Queen Mary College, London, suggest that the reclamation of Maplin Sands off Foulness Island to provide a site for London's third airport has been proposed with little regard to the geology of the area. Their article discusses the geological implications of the scheme and the consequences of mass dredging to provide material for the reclaimed area.

The authors conclude that the geological problems can be overcome, but emphasize that the structure of the area is by no means as straight-forward as it appears. They conclude that adequate model research is essential if the value of the Thames and adjacent seaways are not to be damaged by incautious alteration of the sedimentalogical conditions.

SETTLEMENTS UNDER FOUNDATIONS. This article by J. Kerisel, Docteur des Sciences Paris, Professor at l'Ecole National des Ponts et Chaussees, and M. Quatre, Ing. Ecole Polytechnique, Paris, Ingenieur des Ponts et Chaussees, proposes that the aerial deformation of a sample under conditions of controlled lateral stress provides a more realistic model

analysis from which foundation settlements can be forecast than does the commonly used sedometer test. The authors propose the use of the triaxial compression test apparatus for this investigation.

Part I of their article appears in this issue; it introduces their new method and the calculation of lateral stress under various loading systems.

BRITISH RAIL CONTAINER FACILITIES AT PARKESTON QUAY, HARWICH. A most interesting article by R. W. Bale, BSc, MICE, describes the works undertaken for British Rail at Parkeston Quay. These consist of the strengthening and part reconstruction in sheet piling of the 800-ft existing quay to carry two high-capacity transporter cranes, stacked freight containers and road and rail vehicles. Also described is a new 1,200 ft long freightliner terminal building. The contract includes the construction of a control building, road system, permanent way, works and the associated services and drainage.

Of particular interest are the construction sequence for the quay works, the description of the piling process and the installation of the bars and anchors.

STABILITY OF MEMBERS IN DOME STRUCTURES. This paper by P. M. Lovie, BSc, MAM, AMASCE, CEng, was based on a paper presented as part of the author's work for the degree of Master of Applied Mechanics at the University of Virginia. This is fair commentary upon the level of approach of the article.

The article is concerned with the inward collapse of the members of dome structures where the dome is constructed by the use of large numbers of similar or nearly similar members, e.g. the geodesic, lamellar and lattice domes.

Where joints are fixed the author concludes that failure will occur due to the development of plastic hinges accompanied by gross distortion. In the case of pinned joints two modes of failure may occur; either the members may buckle or complete sections of the lattice (normally hexagonal arrangements) may "snap" through. The mode of failure is dependent upon the angle of inclination of the members and upon their slenderness ratio. The load at failure is independent of the yield stress of the material.

Fixed joints provide, as would be expected, a high load capacity.

COMMON TRENCHING ON BUILDING SITES. Mr R. M. Hutson, MBE, BA, BAI, AMICE, AMIMUNE, is Senior Engineer in the Directorate of Development of MPBW. He is Technical Secretary of the Committee for the Co-ordination of Underground Service on Building Sites, a body set up by the Ministry to investigate the problems which arise due to the lack of space available for the installation of an increasing number of underground services.

In this article he discusses the problems and some of the recent findings of the Committee. One of the most important of these is their proposal that all services should be laid in a common trench or duct.

J.D.W.

THE MILITARY ENGINEER

MARCH–APRIL 1968

This issue contains articles of special interest covering the following subjects:

Water for Vietnam. The geological patterns, rainfall distribution and drilling operations are concisely covered.

Runway Roughness. An interesting description of the causes and effects of surface irregularities found in flexible pavements in use and the means of removing them.

Bridging in Vietnam. An article describing the erection of a 120-ft triple/double Bailey bridge over a damaged one in Saigon.

Platean Soils of South Vietnam. A worthwhile article for any engineer in South Asia.

MAY–JUNE 1968

This issue contains a most valuable article on new devices in guerrilla warfare—such devices as free-fall water containers, fabric boats, helipads and runway lighting and marking kits are well described.

Other articles of particular interest are ones describing the general construction programme in Vietnam, research into protective revetments and the construction of prestressed concrete bridges in Thailand.

Book Reviews

ALKALI METAL HANDLING AND SYSTEMS OPERATING TECHNIQUES

MAUSTELLER, TEPPER AND RODGER; (MSA Research Corporation)

(Published by Gordon and Breach, New York. Price 75*s*)

This book is produced through the combined efforts of the American Nuclear Society and the US Atomic Commission, and is part of a series intended to cover specific areas of nuclear science and technology, as an aid to both the student and the practising engineer.

The book deals with operational information in the field of alkali liquid metals. Much of the detail given is related to sodium and sodium/potassium alloy, NaK. However, methods of handling, system operation and safety are very similar for other alkali metals such as potassium, rubidium, cesium and lithium.

The technology dates back to the late forties, when the main interest was in the design of the sodium-cooled submarine nuclear reactor, and developed in later years with a number of other Na and NaK reactors in the U.S. At the same time, lithium coolant was being developed for aircraft propulsion units and areospace power units.

Cesium on the other hand, because of its low ionization potential, has an obvious use in ion propulsion, thermionic converters and MHD plants.

The operating temperature of these plants has increased now to 2,000°F, and this increased temperature calls for higher purity and improved analysis techniques if problems such as corrosion and embrittlement are to be overcome.

Consequently the opening chapters of the book deal with contaminants found in alkali metals, and methods of purification. In addition, the purified metal must be protected against atmospheric reaction, and involves containment in an inert-gas blanket of helium, argon or nitrogen. Having achieved the desired purity, methods of analysis must be perfected in order to establish that this purification quality has indeed been achieved. Detection sensitivity of 1 part per million is called for, and with recommended sample sizes of 1 gramme this means an impurity level of as little as 1 microgramme.

Methods of taking the sample in a way that preserves its purity and the analysis of it are discussed in very considerable detail.

Associated with the problem of contamination, is precleaning of the system before introduction of the working fluid. This is dealt with adequately in Chapter 6.

System operation is dealt with in Chapter 7, and covers such aspects as the loading of the alkali metal, control and measurement of its level, flow and pressure, and degree of wetting. This chapter also discusses pumps, in particular electromagnetic pumps, their choice and maintenance. Leakage from pumps and pipework is serious in view of the fire hazard, and much of this chapter is devoted to this problem.

Chapter 8 deals with the cleaning of the liquid metal loop after draining, but it is made clear that the degree of cleaning necessary depends entirely upon the mechanical design of the plant.

The fire hazard is covered very adequately in Chapter 9, and discusses shipping and storage, protective clothing and first-aid, firefighting and disposal of the residue.

This book must be unique, and deals with a very special subject in a very lucid manner. Interest for most engineers would be academic only, but with the attraction to liquid metal cooled reactors in U.S. military and aerospace programmes, and the UKAEA developments at Dounreay, it is very possible that in the not too distant future the sphere of interest in this book may extend considerably.

D.R.T.

PYROMETALLURGICAL PROCESSES IN NON-FERROUS METALLURGY

Edited by J. N. ANDERSON and P. E. QUENCAN

Noranda Mines Ltd and International Nickel Co of Canada Ltd

(Published by Gordon & Breach, Science Publishers of 150 Fifth Ave, NY, 10011, London and Paris. Price $31.50)

This December 1967 publication contains the text of twenty-six professional papers presented at a Symposium held in Pittsburgh, Pennsylvania, during 29 November–1 December 1965, sponsored by the Extractive Metallurgical Division of the Metallurgical Society, American Institute of Mining, Metallurgical and Petroleum Engineers. It is Volume 39 of the Society's conference proceedings.

The authors, all practical metallurgical engineers with commercial firms in the USA, Canada, Japan, Australia, France, Sweden, Congo, Zambia and Peru, have based the content of their papers on experiments and normal processing work done with their firm's plant, and most contain detailed descriptions of the equipment used.

The papers are grouped under five section headings: Roasting: Copper and Zinc; Smelting: Copper, Lead and Nickel; Use of Oxygen; Recovery of By-Product Iron; General. The number of papers in each section varies from four to eight. Typical papers of each section are:

ROASTING	Development of a Fluid Bed Roaster for Zinc Concentrates. Operation of a 350-ton per day Suspension Roaster at Trail, British Columbia.
SMELTING	Low Shaft Furnace for Nickel Ore Treatment in New Caledonia. Copper Blast-furnace Practice at Union Miniere Katanga. Lead Smelting Improvements at La Oroya, Peru.
USE OF OXYGEN	Oxygen in the Secondary Lead Industry. Economics of Oxygen Production for Non-Ferrous Metallurgy.
RECOVERY OF BY-PRODUCT IRON	The Production of By-Product Iron Ore at Falconbridge. Iron Ore Agglomeration at Copper Cliff.
GENERAL	Copper Smelter Process Computer. Continuous Casting and Rolling of Copper by the Properzi Method.

The text, 517 pages, is well illustrated with photoprints, diagrams and tables.

F.T.S.

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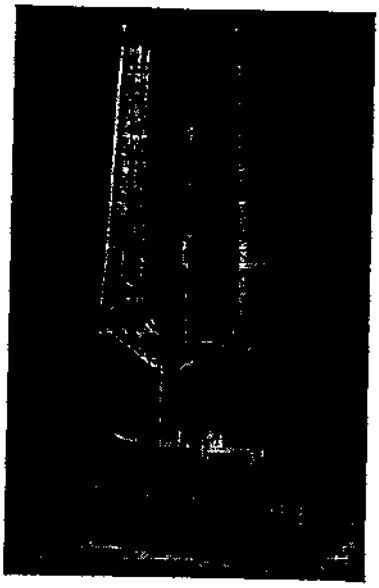

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