THE ROYAL ENGINEERS JOURNAL

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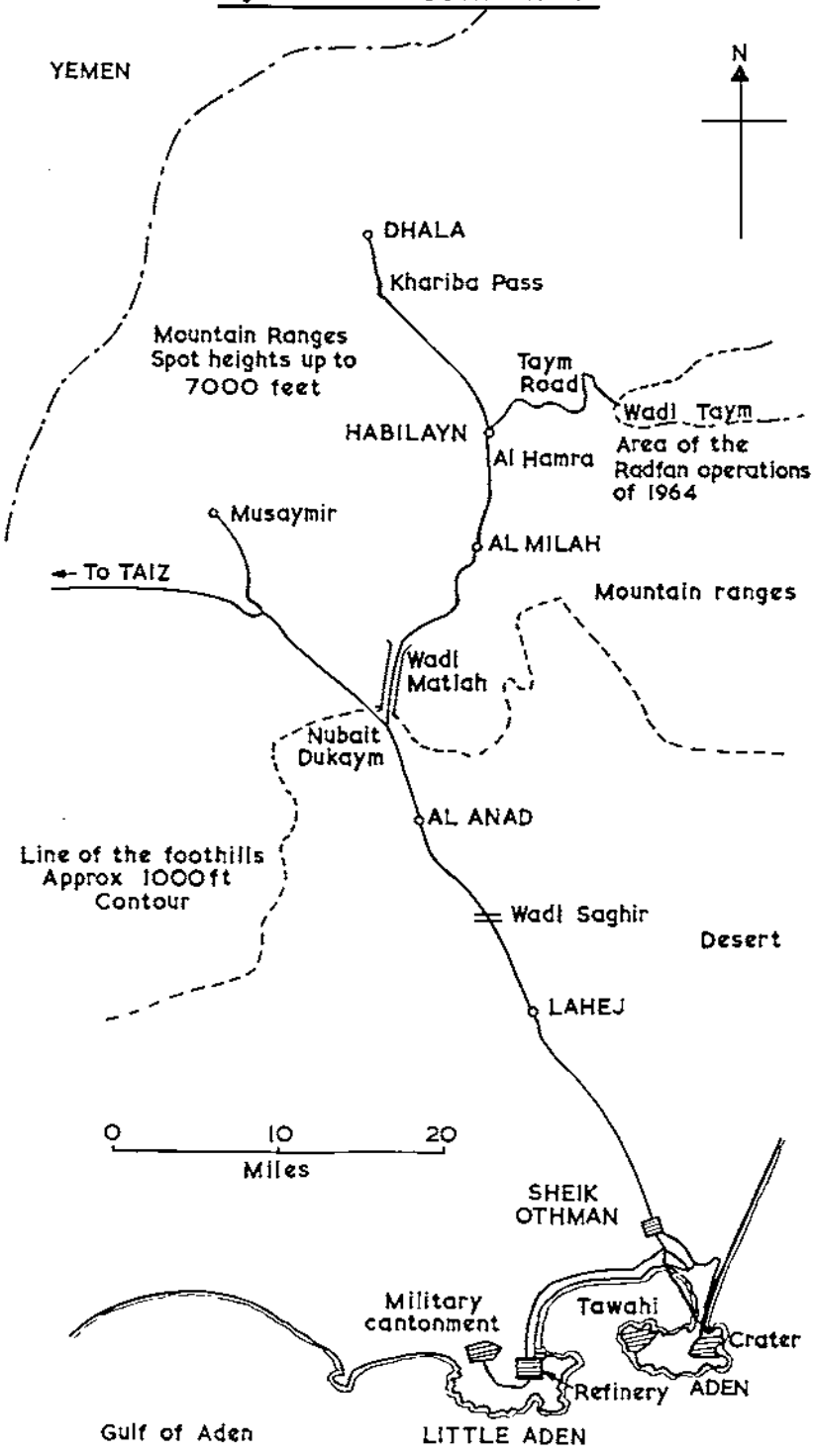
Figure 1 — SOUTH ARABIA



The Dhala Road

BRIGADIER P. C. SHAPLAND, MBE

INTRODUCTION

MOST of the Corps must have heard or read of the Dhala Road. It has been mentioned in the Press; at least one article about it has appeared in *Soldier Magazine*; numerous items of unit news in the *Sapper* recall effort put into the road; and even a tie has been produced to commemorate its construction.

It is now some eighteen months since British Forces left Aden and over two years since the road was completed. It is, therefore, about time to look back and not only report on its construction but also to draw attention to the many lessons that were learned in the process. But before I do so, I should perhaps explain my association with this road. I first made its acquaintance in 1962. I was then serving in the War Office (E1—now ASD 7) and paid a visit to Aden with Major-General Foulkes—then Engineer-in-Chief. In the course of our visit we flew to Dhala—then the only way of making a visit to upcountry stations and returning the same day. During this visit the lack of any good roads in the Federation of South Arabia became only too apparent to us. Later, while in the same branch of the War Office, I was on the touchline of discussions between Middle East Command and the War Office on the possibilities of building a black-top road to Dhala. From the War Office I was posted to 3rd Divisional Engineers as Second-in-Command. During my tour the Radfan Operations of 1964 took place, to which we sent the 3rd Independent Field Squadron. It was as a direct result of the Radfan campaign that the decision was taken to build the first section of the Dhala Road, and the first units sent out to deal with this problem were HQ 3rd Divisional Engineers and 6 Field Park Squadron from the Division. I was, therefore, concerned not a little with such planning as then took place on the construction of the Dhala Road.

In May 1965 I was posted as CRE (Operations) MELF, a title about which I shall say no more in this article. In this appointment, one of my tasks was the construction of the road.

When I left this appointment in May 1967 I could therefore look back on five years during which I had been connected in lesser or greater degree with the Dhala Road—and this, I think, is some small qualification for writing about it.

AIM

I have always been taught that any military paper should have an aim. I consider this article should be no exception, particularly as on many occasions the aim of building the road was often questioned.

I have set as my aim to tell the story of the Dhala Road as I have known it from the broadest military viewpoint and not purely from technical considerations of road construction.

GEOGRAPHICAL AND HISTORICAL

Some detail of the geography and history of South Arabia is necessary to understand the full story of the Dhala Road.

Although there are many members of the Corps who now know this part of the world fairly well, there must be many others who have seen it only from the decks of a troopship or liner passing through Aden and whose only close acquaintance with the country has been with the tax-free shops at Steamer Point. Indeed, in these days of air travel there may be many who have not visited Aden at all.

To the sea traveller, Aden is probably remembered as two groups of mountainous

rocks—the remains of two old volcanoes. One forms the peninsula alongside which the harbour is situated, and the other is some ten miles away at Little Aden where the British Petroleum refinery is situated. Inland appears as a very flat, very arid desert. This same view inland was seen for most of the year by those who lived in Aden. But occasionally, early in the cool clear mornings of the winter months, the horizon was clear and abounded with row upon row of rugged mountain peaks which formed the majority of the hinterland of South Arabia.

As the map in Figure 1 shows, the desert stretched some forty miles in from Aden Colony before reaching the rocky mountainous area which as so many senior officers, visiting the area, pointed out was so like the North West Frontier of India.

An examination of the coastline of South Arabia and the Horn of Africa also shows that Aden is the only natural harbour for many hundreds of miles. It is undoubtedly this fact that has given Aden its importance over the ages. History tells that it was one of the ports to which the spices of India and the East were brought and from which caravans of camels carried them into the Arab world along the famous "spice routes". It is almost certain that one of these routes ran due north from Aden and passed through Dhala on its way into the land where the Queen of Sheba ruled. This is the route of the Dhala Road.

Much later, at the end of the nineteenth century, when the Turks invaded the area, they followed the route of the Dhala Road in their advance to Sheik Othman—some ten miles from Steamer Point.

South Arabia is a part of the world where the tribe is of paramount importance. The history of the area is one of continuing tribal feuds and even the grant of independence to Aden does not appear to have changed this. The Emirate of Dhala contained more than its fair share of troublesome tribes and it was these tribes that were directly responsible for the construction of the Dhala Road.

The first recorded incident occurred in 1928/9. The story is as told to me by Colonel H. A. Urquhart, now retired, who was then serving in Aden as a junior officer. Purely for financial reasons, Aden had become an RAF Command. The Government of the day had been persuaded that a relatively small number of aircraft could exercise control over a country of warring tribes more cheaply and effectively than a Division's worth of soldiers which was what the Army considered was required.

Tribes in the Dhala area had become restive and were following their usual pastime of raiding their more peaceful neighbours. It was decided that to pacify them part of the air effort must operate from Dhala and a rough airstrip was constructed. Whether it was the condition of the airstrip, or the weather conditions, or the unsuitability of the aircraft—or a combination of all three—very soon far too high a proportion of the total air effort was standing damaged on the Dhala airstrip. It became of paramount importance to get vehicles by road to Dhala and Colonel Urquhart was asked to construct a road up the Khariba escarpment. This he did, using local labour. For the princely sum of £204, he not only built the pass road but also included, in the bargain, four miles of road to Dhala town at the top of the pass. His road stands to this day—the well-known Khariba Pass. Very deservedly, he has now become the senior member of the Dhala Road Tie Club.

But it was the 1964 revolt of the Radfan tribesmen which led directly to the construction of the Dhala Road as we now know it. From time immemorial the Radfani's have been given to raiding and exacting tolls from the caravans which passed through their tribal areas to Dhala and the north. This came to a head in 1964. Backed and armed with more sophisticated weapons, provided by the Egyptian Intelligence Service in the Yemen, they started raiding military convoys and disrupting the peace to a degree greater than ever before. Such was the degree of revolt that punitive action was considered necessary. The result was the Radfan Campaign of 1964, of which much has been written elsewhere. The engineer aspects were covered by Lieut-Colonel John Groom in his excellent article in the *RE Journal* of September 1965.

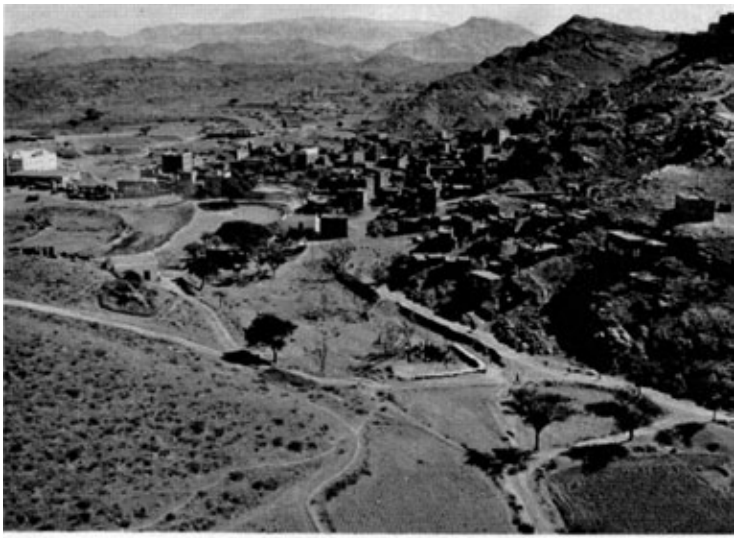


Fig 2. Dhala—the Goal of the Road.

Fig 3. The Khariba Pass—constructed by Colonel H. A. Urquhart in 1928/29.

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It was during these operations that a new menace appeared—the menace of indiscriminate mining, not only of the tracks in the operational area but also of the main supply routes along which military convoys regularly ran. The toll of vehicles—and lives—rose. By the end of 1964 forty-nine vehicles including ten civilian lorries had been destroyed on mines and a further forty-seven mines located before they could do any damage. Twelve lives had been lost—five soldiers and seven civilians—and a further fifty-eight persons had been wounded. It was decided that to safeguard convoys from the mine threat the road to Habilayn must be provided with a "black top" which it was hoped would be resistant to mining. The Federal PWD undertook the first six miles of this road from where the tarmac ended in Lahej town to the crossing of the Wadi Saghir. The Royal Engineers undertook the remaining thirty-four miles to Habilayn.

THE REQUIREMENT

The requirement was clear—to produce, as quickly as possible, a road from Lahej to Habilayn with a "black-top" surface which would be difficult if not impossible to mine. After a certain amount of dalliance in Whitehall over the provision of units, of equipment and of money, the order to proceed was finally given by HQ Middle East Command on 6 July 1964. It is interesting to quote one sentence from this order: "It is a purely military requirement and the work will be done to a very simple specification."

SPECIFICATIONS

The initial specifications were simplicity themselves, so much so that they do not warrant an Annex to this article. They were:

Specification for Lahej—Thumair Road

1. The road is to be gravel based with a bitumen and chipping surface dressing.
2. Width 24 foot base, 15 foot surface dressing.
3. Drainage ditch required throughout most of length on one side only.
4. Small Armco, steel or concrete culverts will be required at intervals.
5. Concrete Irish bridges will be required at wadi crossings.

These were later expanded to more detailed specifications shown in Annex A. With the exception of the "sight distance" requirement, which could not be met in one or two places without massive rock movement which was considered unjustified, these specifications were followed throughout construction.

PROGRESS

Before examining some of the construction problems, let us look at the progress of the project as a whole. Geographically, the road divided itself into three sections:

(*a*) The Southern Sector—from the Wadi Saghir crossing to Nubait Dukaym, the road junction where the road to Taiz, the southern capital of the Yemen, branches off to the west. This section was thirteen miles in length.

(*b*) The seven-mile section of the Wadi Matlah where the road follows the line of the wadi throughout.

(*c*) The Northern Sector—from the north end of the Wadi Matlah to Habilayn, fourteen miles in length.

Initial plans covered only the Southern and Northern Sectors. It was not until June 1965 that any serious thought was given to construction of the road through the Wadi Matlah.

The Southern Sector

Work on the Southern Sector was started by 6 Field Park Squadron, who moved from UK to Aden on a nine-month emergency tour in July 1964. Their first task was

to establish a construction camp at Al Anad, roughly in the middle of the Southern Sector and fourteen miles north of Lahej. Because no specialist team or project officer was available, they were responsible for survey and planning of the task as well as execution. They also had all the administrative problems of a squadron in a new command under semi-active service conditions—not the ideal way to start a major road-construction project.

It was originally thought that the squadron would be able to complete both the Southern and Northern Sectors of the road in their nine-month tour—a wildly optimistic guess, as events were to prove.

Fig 4. The southern sector—the completed road looking north near Al Anad.

By November 1964 it was clear that, though now reinforced by a troop from one of the field squadrons in the command, 6 Field Park Squadron would not even complete the Southern Sector before their tour expired in April 1965. To complete the task, Squadron HQ and the Park Troop of 9 Independent Parachute Squadron were therefore nominated to replace them.

On the face of it, this may appear an unusual selection of sub-units for a task such as this. In the event it proved more than adequate. Squadron HQ contained all the administrative elements so essential to a task such as this, and the Park Troop, when strengthened by individual tradesmen from other field squadrons and 63 (MELF) Park Squadron, provided the ideal working element. With this task force the Southern Sector was completed on 5 July 1965. Maintenance of this sector remained my responsibility until 20 July 1966, when it was formally handed over to the Federal PWD. It says much for the standard of construction that during the year, very little repair work was necessary.

The Northern Sector

For the Northern Sector, a new task force was established in February 1965 at Al Milah, some eight miles south of Habilayn. The basic unit of this force was a field squadron, initially 24 Squadron, who, until its move to Al Milah, had been employed on construction of the redeployment camps at Little Aden. One of its field troops had to remain in Little Aden to finish this work and it was therefore given a troop of 50, my other field squadron, to assist it. Along with a section of Pioneers, who took on many tasks, including operation of all the road rollers, the move to Al Milah also saw the advent of the RASC platoon responsible for control and operation of 10-ton tippers. Until their arrival, these vehicles had been driven by local Arab drivers and many is the sorry tale of unserviceability that resulted. Perhaps the sorriest concerns the two tippers, one running, the other unable to start because of battery trouble, both minus their front bumpers, pulled off in attempts at tow starting, who decided to push start front end to front end—and succeeded in pushing the ends of the chassis members to which the bumpers had been attached into each other's radiators! The arrival of the RASC platoon made all the difference in the world to the serviceability and operation of tippers. As plant was released from the Southern Sector, so it moved with its operators to the Northern Sector. Another most important element in this task force was a forward repair team from 22 Engineer Equipment Workshop REME.

An examination of the map at Figure 1 will show that the Northern Sector passes through much more rugged and difficult country than the Southern Sector. No less than fourteen Irish bridges and sixty-four culverts had to be constructed before any major effort could be put into formation work. It was estimated that work on this sector would be completed by the end of 1965. In July 1965, 24 Field Squadron were relieved by 73 Field Squadron in the Northern Sector task force. Shortly after this plant serviceability began to drop very rapidly. This can be traced to too much being expected of too little plant in the harsh conditions of work in South Arabia and also to the failure to set up, right at the start, a thorough system of inspection, maintenance and repair of machines adequate for a project of this size. For example, 63 (MELF) Park Squadron, which did not begin to form until after the project had started, held over 200 machines or pieces of plant in its plant troop—and this troop consisted of one officer and thirty-two other ranks, including eighteen operators and eight plant fitters. More of this later! The effect of this loss of plant effort was to delay completion of work on the Northern Sector—the "black top" was not, in fact, finished until 9 February 1966.

The Wadi Matlah

The Wadi Matlah was a problem all of its own. Dry for the majority of the year, this wadi was liable to sudden and severe flooding during the heavy rains, generally thought to fall in August and September each year. The existing track ran along the wadi bed. Flooding removed all traces of it. After floods, the first vehicles to travel through picked their way as best they could along the wadi bed until a new track was formed. Unfortunately, in 1964 and 1965 there were no heavy rains and no appreciable degree of flooding. Nor was there any reliable evidence that could be found of the size or frequency of the floods. From the Department of Agriculture and Irrigation of the Federal Government we obtained their empirical formula for calculating maximum flood discharge through a wadi.

$$Q = 645\sqrt{A}$$

where Q, the maximum flood discharge, is given in cusecs and A is the area in square miles of the catchment area.

Applying this to such maps and air photographs as were available, we discovered that a flow of something like 9,000 cusecs was possible. This meant that in places where the wadi was 100 ft wide we could expect water to the depth of 5 ft flowing at

Fig 5. The northern sector—three miles south of Al Milah—culverts completed and formation under construction.

Fig 6. The northern sector—completed road at "Spreader's Gap"—four miles north of Al Milah—(despite massive rock blasting it was not possible to achieve the sight distance at this gap named after S/Sgt Hurst, 50 Field Squadron).

The Dhala Road 5 & 6

10½ knots—and in places the wadi wasn't even 100 ft wide! To plan a road to cope with such floods seemed nigh impossible.

Obviously the same problem had concerned the Turks when they had invaded Aden from the north in the early part of the twentieth century. They had built a road in this area and had kept it to the west of the wadi as far as was practicable. They could only do this in the southern four miles of the wadi, where their route lay along the top of an escarpment some 30 to 40 ft above the wadi bed. Clearly this alignment was floodproof.

The first plan for construction of a road through the Matlah was based on what was left of this old Turkish road. Because it was designed for horses and mule-drawn traffic, its bends were sharp and some of its gradients steep. A considerable amount of earthwork would have been required and the first estimate of cost for materials and local labour was £30,000. We also calculated that it would take some nine months to build. We were told that the Federal PWD could only provide £20,000.

This fact and the need to construct a mineproof road through the wadi as quickly as possible brought forth the advocates of simply putting tarmac on the existing wadi track. This would certainly have been a quick method of producing a mine-proof track, but very little of it would have survived a flood. Nor were the Federal PWD prepared to see their money put into a project of such doubtful durability. Eventually a compromise was accepted—the general line of the wadi was to be followed, but the road was to be built on the flood banks on either side of the wadi wherever possible. This precluded using the Turkish road alignment. 73 Field Squadron produced a detailed plan for the task and a survey which attempted to forecast which sections of the road were liable to wash out in severe flooding. The task was expected to take six months. The survey showed that 3,260 yards of road were liable to wash-out—a forecast which was to be of great interest some eight months later.

Work on the Matlah sector was started by 73 Field Squadron in February 1966. Specifications for the road were reduced to an 18 ft wide formation with the centre 12 ft "black topped". No passing places were provided, as it was well known that the Arab driver would pass a vehicle coming in the opposite direction wherever he met it. It was also decided that because of the desire for a "black-top" road as quickly as possible, no elaborate work would be done where the road crossed the wadi. The wadi bed would merely be stabilized and compacted and "black top" laid on this. Such crossings would need replacement after floods.

As I said at the start of this article, the object of the "black top" was to make the road mineproof. In March 1966 an incident occurred which made us wonder if this was going to be the case. A civilian lorry travelling south early in the morning had its nearside front wheel blown off by a mine when about four miles south of Habilayn. The mine had been placed in the road about 2 ft from the edge of the "black top", a section of which had been very carefully cut out and replaced after the mine had been laid. As we learned from questioning the Arab driver, the whole area had then been sprinkled with oil and it looked to him just another one of those places where an Arab vehicle had had an involuntary oil change. Luckily, this was the only occasion when a mine was laid in the "black top".

April 1966 saw yet another squadron change at Al Milah when 48 Field Squadron from UK relieved 73 Field Squadron. As was inevitable when one field squadron relieved another in an up country station under active service conditions, but under full conditions of peacetime accounting, April was a non-productive month on the project. Allowing for this, and provided all went well, we hoped to complete the Wadi Matlah Sector on 31 August 1966.

Because of the enclosed area in which the road was being constructed, all working parties were protected by infantry piquets either from the British battalions or from the Federal Regular Army or Federal Guard in the area. At night, plant was guarded by locally employed chowkidars. The system seemed to be working well until April

Fig 7. Wadi Matlah—before any construction work had started—the alignment finally selected is shown by dotted line.

Fig 8. Wadi Matlah—an example of the amount of rock blasting necessary to keep the alignment out of the Wadi Bed—(named "Fitz Polly" by 48 Field Squadron as a token of respect for their OC).

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1966, when gangs of dissidents started attacking the plant at night. In the first attack, on 24 April, shots were fired at a plant park, damaging three machines. In the second attack, on 27 April, explosive charges damaged an RB19 excavator and a road roller to such an extent that they were both a write-off. This attack called for a reappraisal of defence plans. I decided that at night all plant must now be protected in night leaguers which were to be guarded by regular infantry units—no further reliance could be placed on the chowkidar system. It meant that work had to finish earlier each day to allow machines to track back into the leaguers. The project could no longer be executed in accordance with an ideal engineer plan. Working sites were now dictated by the position of the night-plant leaguers and the economic distance that machines could move from these by day. Until sufficient infantry could be provided to guard two such leaguers, work was very restricted. Enough, however, to report that no more plant was damaged by dissident attack. This restriction on work put a further delay on the completion date, which was now set at 15 September 1966.

All was going well when on 16 August the first of a series of violent rainstorms struck the area. This produced a sayl—the local name for a bore—about 3 ft high which ran for some three miles down from the north end of the wadi before it dispersed. Surprisingly, very little damage was done to the road. It was limited to cutting away of the wadi bed on the downstream side of those crossings which had been completed. But this first storm was quickly followed by much more severe storms on 5, 8 and 14 September and on 10 October. At the peak of one of these, the wadi was flowing 8 ft deep at some 5 knots. Obviously, we were very near the maximum flood which the Department of Irrigation's formula had told us we might expect. Some idea of the force of the water can be gathered from two incidents which occurred. Half-way along the wadi, two 6/8 ton road rollers were parked for the night on an island, some 4 ft above the wadi bed. The following morning, when I flew up in one of my Sioux helicopters to inspect the damage caused by the flood, I found that both the island and the road rollers had disappeared. I spotted them from the air about 15 yards from where they had been parked, one buried on its side and the other buried upside down with only nine inches of its rear wheels showing. When we managed to dig them out we found that both were extensively damaged beyond repair. We never did find the cabs of either machine. The other incident occurred at the crossing at the south end of the wadi. This was an 80 ft long Irish drift consisting of reinforced concrete slabs 12 ft wide and 6 in thick which were tied into longitudinal beams 2 ft deep with similar cross beams at 10 ft intervals. This was washed out completely, the nearest piece to be found being one section of a 6 in slab which was 100 yds downstream from its original position.

Gloom might well have set in, had not I remembered the survey plan produced earlier by 73 Squadron. This was re-examined and (to our delight) we saw that although the road had suffered a considerable amount of damage, less than half of that marked as liable to loss in severe flooding had, in fact, been lost—only some 1,550 yds.

With renewed rigour, we re-examined what remained to be done. As a result of the floods, there was still three months' work required to finish the Matlah. But the Matlah was not the only sector affected. Damage of varying degrees had occurred all along the fourteen-mile stretch from the north end of the Matlah to Habilayn, and amongst the various repair tasks one new culvert was required at Al Milah and a new Irish drift at Al Hamra.

But other factors were to affect the problem. During 1966 dissident attacks had increased on all British garrisons and Al Milah had had more than its share. Far from being a purely sapper construction camp, it had grown into a garrison of its own. As well as the construction force, the camp housed an infantry company, a troop of armoured cars, up to four infantry mortar sections, from time to time a section of 105 mm guns and occasionally a squadron of SAS. The Field Squadron Commander was also the Garrison Commander. At about this time there was a marked increase in terrorist activity in Aden State which called for more British

Fig 9. Hazards—a wadi in spate—at this moment the water was 6 ft deep and travelling at about 8 to 10 knots.

troops for IS duties. Some saving in those troops deployed in upcountry garrisons was necessary and HQ Middle East Command decided that all troops in this part of the Federation must be concentrated in Habilayn garrison. Al Milah was to close by the end of October.

I took advantage of this move to make a further change in the troops in the construction force. It was now clear to me that six months was about as long as a field squadron should spend on this project without being relieved. Although it meant a break in continuity of work, efficiency of squadrons began to drop off after six months upcountry. (Infantry battalions generally spent only six weeks upcountry at a time.) By October, 48 Squadron had completed a gruelling six months during the hottest part of the year. The heat was such in the Wadi Matlah that at midday it was possible to fry an egg on the bonnet of a Land-Rover! 48 Squadron had also had more than their fair share of attacks and had also suffered all the severe storms. It had also been agreed that construction of the Wadi Taym road, which started from Habilayn, should go ahead. In October 1966 I moved 30 Field Squadron, who had arrived in the Command from BAOR on a six-month tour, to Habilayn. Their main task was the construction of the Wadi Taym road. To complete the Wadi Matlah sector and repairs to the north of it, I moved a reinforced troop of 48 Squadron from Al Milah to Habilayn to live with 30 Squadron, and withdrew the rest of the Squadron to Little Aden. Work on the Matlah sector went ahead steadily and the first layer of "black top" was completed through the Wadi Matlah on 29 December 1966.

But the repair work was not without incident. On 20 January 1967, when motoring out to working sites, 48 Squadron's troop commander found two culverts had been severely damaged by explosive during the night. Why should the dissidents wait until the road was almost complete before starting to destroy it? What was behind this new form of attack? Various views were put forward. A likely one was that the Haushabi tribesmen, who had supplied the labour force for that sector of road in their tribal area, and who were now unemployed, had blown up the road

with a view to further employment while repairing it! The finally accepted view was that the damage was the direct result of the serious illness or death of Mohammed Ubaid Umar, dominant leader of the principal Haushabi gang of dissidents. While in control of dissident activity in the area, he was far-sighted enough to realize that although his orders from the Egyptian Intelligence Service (EIS) were to attack everything British, there was little point in destroying a road which would be of direct value to his tribe when the British left Aden. While he was in control of the dissidents in this area the road was safe. Unfortunately for the sappers, he suffered a severe stroke in late 1966 and, as the EIS well knew, his successors were prepared to do anything for money—and so culverts came in for attack. In all, eight were blown up by mid-February. The problem was what was to be done about repairing them. It had already been decided that the Federal PWD would assume responsibility for the remainder of the road on 1 April 1967. Until then the British military aim was to maintain a mineproof surface to Habilayn. So the damaged culverts were not repaired. The holes were filled in with road metal and the surface repaired with a carpet of premix from a spot mix machine. The local tribes were told that the culverts were not being repaired and that the blame for the subsequent failure of the road was theirs—most of the local dissidents came from these tribes. By early March 1967 such repair work as was required was finished and final sectors of the road were ready for handover to the Federal PWD on 2 April 1967.

Thus what had started as a nine-month project for one field park squadron had taken thirty-one months to complete—and all or part of five more field squadrons, supported by a large theatre park squadron, had been employed on it. I hope that some of the reasons for this have become apparent from the story of the building of the road. But before I endeavour to draw conclusions, a word or two about some of the technical problems which were encountered.

TECHNICAL POINTS

It would easily be possible to write a complete article about the technical problems which faced us during the construction of the Dahla Road. But in this article, I intend to touch on only a few of them.

Bitumen

Bitumen is probably one of the commonest of road-construction materials—and yet far too few members of the Corps have experience of working with it. As a result, I believe that it has gained a quite unwarranted mystique.

As the specification for the road shows, a bitumen and chipping surface dressing provided the wearing and protective cover for the stabilized base on which the road depended for its strength. Strict control of the laying of this surface dressing was therefore essential.

The majority of the work was done using the High Spread Road Surfacing Unit (HSRSU) which had been developed by MEXE several years earlier. A brief description of this machine and a report on its use is contained in RE Training Notes No 10 issued in March 1968. Apart from the odd occasions when it had been loaned by MEXE to the Hampshire County Council, it had never before been used in anger—and certainly not by field squadron sappers. Of the two machines which were constructed by MEXE only one was sent out to Aden, the other being retained in England to provide a stock of spare parts.

In retrospect, it seems remarkable that we relied on one, and one machine only, for all the surfacing work required. At the back of people's minds was always the thought that we could, in an emergency, use the 1,000 gallon trailer bitumen distributors which were held by my park squadron. It was not until 10 Field Squadron (Airfields) tried to use one of these when extending Beihan airstrip that we discovered the inability of these antiquated pieces of equipment to spray bitumen. And it was not until October 1966 that two new lorry-mounted Phoenix distributors were sent out as a reserve for the HSRSU. Certainly, the HSRSU was given VIP treatment.

When parked at night upcountry it was always surrounded by 10 ton tippers to act as stop butts for any dissident rockets or bullets that were flying around.

As the specification for the road shows, the bitumen used on the project was Shell S125 (80/100). In the very hot weather, when some sections of the road began to bleed, it was suggested that we should have used a more viscous bitumen. I am sure that bleeding only occurred because too much bitumen had been put down in the first place. Where less was used the road surface stood up well to all weathers. All the bitumen for the project was ordered at the start and it arrived in Aden in 30 gallon drums—over 5,000 of them. No storage space was available for it in Aden and it was pointless hauling it the thirty miles to Little Aden only to have to take it back through Aden again when it was wanted upcountry. It was therefore dumped in the desert some four miles south of Lahej. Two civilian chowkidars were engaged to look after it, and although the dump was not finally cleared for nearly two years there was no pilfering and very little was lost from seepage from the drums.

Bitumen for the HSRSU was heated in a 2,500 gallon storage and heating plant. This was located alongside the construction camp. Loading the tank was a dirty job. One end of a bitumen drum was removed using cold chisels and the drum was then hoisted by crane on a special cradle on to the top of the heating tank, where the bitumen was tipped in. This task was shared by sappers and local labourers and, thankless though it was, a great team spirit soon built up in the mixed gangs. In only one of the squadrons engaged on the task was there any large number of cases of industrial dermatitis from handling the bitumen. This upset the squadron's deployment plan and some of the sappers who had been trained, while in the UK, to work the bitumen plant had to be moved to other jobs. Heated bitumen from the storage tank was transferred to the HSRSU by road tankers fitted with their own heated elements. Even so, when working eight miles from the storage tank there was a heat loss of some 45–50°F. This meant that in the winter months it was necessary to heat the bitumen in the storage tank to 400°F before starting operation.

At Al Milah, the storage tank was sited alongside the stone-crushing machines in a wired-in compound some 500 yards from the main construction camp. The site was guarded by chowkidars at night and suffered no attacks or damage to plant for nineteen months. Then, on 12 September 1966, less than four weeks before Al Milah was due to close, a gang of dissidents succeeded in getting into the site and overpowering the guards. Knowing the importance to us of the heating plant, they packed a large explosive charge on the bitumen pump at the end of the tank. The resulting explosion not only blew the pump about 100 yards away but also set fire to the bitumen in the tank and burnt it out. As a result, we were without a heating and storage tank for six weeks until a new one arrived from the UK. Needless to say, this was sited well inside the perimeter of the new construction camp at Habilayn.

Operating the HSRSU required a very precise set of drills. Before work started each day a number of checks had to be carried out. As with the pre-flight checks of an aircraft, failure of any one of the daily checks meant that the machine could not operate until the fault had been rectified. As the HSRSU took more and more wear, we also found it better to allow a day's maintenance after each day's operation.

Well might the reader ask was all this worth it?—and what would have happened if the HSRSU had been blown up? As I have already said, we took considerable precautions to see that the latter emergency did not arise. The machine was protected at night—it was never allowed to run on tracks which we were not absolutely sure were free from mines, and when there were long gaps in the surfacing programme it was brought down to Aden for safety.

We did practice surfacing using the lorry-mounted distributors and 3 ton tippers fitted with Hornsey gritters. In this process, after the bitumen has been sprayed from the distributors, stone is spread from a tipper backing along the road. Our experiments soon showed us how much more difficult it was to control these operations. Backing a tipper at constant speeds round bends and up and down grades is a very different matter from driving a vehicle from which the spread of bitumen and

stone on the road is constant no matter what the speed of the vehicle. I was very soon convinced that with a constant change of squadrons a constant standard of surfacing would only be achieved with the HSRSU.

There is no doubt that work on the Dhala Road provided for many members of the Corps their first experience of working with bitumen. I hope that the experience gained and lessons learnt will not be forgotten.

Concrete

If there is a mystique about bitumen, the very reverse is the case with concrete. Everyone thinks he knows all there is to know about the subject. In the construction of the Dhala Road, this led, in some cases, to some very bad concrete work. The principal concrete works were the Irish drifts, some twenty being constructed. The longest was 160 ft in length. Concrete was also used for the head and wing walls of all the culverts in the Southern Sector (most of those in the Wadi Matlah and Northern Sector had masonry walls—because the road passed through areas where the local tribes had plenty of good masons). Concrete was also used in the construction of shallow side drains in those rocky areas where it was impossible to construct deep side drains. Good aggregate for the concrete was always difficult to obtain—in fact, strange though it is to relate, it was impossible to obtain sand in certain parts of the Federation. On occasions, insufficient care was taken in selection of the aggregate with disastrous results in the concrete that was produced. Once squadrons got into the habit of using the technicians from the Construction Laboratory to test aggregates, good results were achieved. Shuttering also presented its problems. Steel shuttering was unpopular because in the summer months it became too hot to handle. When timber shuttering was used there were occasions when the strutting was not strong enough or insecurely anchored. It was also not always appreciated that reinforcing bars or mesh must be fixed firmly in position to prevent them floating about when the concrete was vibrated.

But don't let me give the impression that these faults occurred in every concreting job that was done—far from the case. I have mentioned them to demonstrate faults which can occur, by those who think they know all about the subject. Some very good concrete works were constructed which showed no signs of wear after being in use for over a year.

In Al Milah Camp, a reinforced concrete tower was constructed to give the infantry company commander a bulletproof command post, above the level of the tents, from which he could control the defensive fire and counter-attack against the many bands of dissidents which attacked this camp at night.

Mass concrete works require the continual use of concrete mixers of all sizes—and, as every squadron learnt, these sturdy machines will give long service provided they are properly maintained. Generally the standard of maintenance was very good, and I recall only one disciplinary case arising from failure to clean out the drum of a mixer at the end of the day's work.

In the hands of a field squadron, cement is a most useful asset. It could be used in a variety of ways to improve the standard of living in the upcountry camps in which the various units lived. If some of the cement destined for the road was misused to the benefit of the local infantry battalion or commando, it did much to cement the friendship and close cooperation which was so essential to the manner in which we lived and worked.

River Training

In the Wadi Matlah alone, the road crossed the wadi bed a dozen times. The road also crossed three other major wadis. If the water, when it came, was to flow across the centre of the Irish drift or the point where we wished it to flow, it had to be directed by some form of upstream bank—the flow of the river had to be trained. At the start we had no indication of how much water was going to flow. Some of our first efforts at river training were therefore not very successful. Some of the protective banks were set at too great an angle to the direction of flow and were washed away.

But we soon learnt from these errors and eventually succeeded in quite a measure of control of the stream.

We learned that many protective walls had to be considerably longer than we had bargained for. We also learned how much easier it is to plan the position of protective banks from the air than from the ground. With the advent of our own troop of helicopters, alas far too late and for only a short period, it was only too easy to see the direction of flow and where the protective banks were needed.

Various types of protection were tried—from earth banks pushed up by dozers to massive stone-filled wire gabions, each stone placed by hand. The latter were expensive in time and manpower, but, if properly sited, were certainly the most durable. We found we could strengthen earth banks very cheaply and effectively with empty bitumen barrels of which we had many hundreds. These, when filled with rocks and wired together, provided a sound foundation for the earth banks.

River training is an art which we are rarely called on to practise, simply because it is only in remote parts of the world such as South Arabia that one is faced with the problem of dry wadis which become raging torrents in a matter of a few hours. But once the elementary lessons were learned, very adequate control was achieved of some of the later floods we had to encounter.

Plant

No article on the Dhala Road would be complete without mention of construction plant. Plant of all types, all shapes and all sizes. From vibrating screed boards to two-stage rock crushers; from mechanical road-sweeping brushes to Parker Spotmix batching machines; from agricultural tractors, so useful for towing a servicing trailer round a large plant park, to the heavy wheeled tractors on trial, for which the cost of one tyre was about £900. All these and many more besides were used in the construction of the road. And yet, despite the large number of machines held, far too often in the early stages work was held up or delayed because of mechanical breakdown. It was not until the closing stages of construction of the Dhala Road that the problem of maintenance, repair and spares backing was really solved—and by this I mean that there were always fit machines in reserve and we were able to withdraw machines for overhaul, not because they had broken down but because we considered that they were due for overhaul. The full story of how we solved the plant problems would be an article of its own. Here, I only propose to touch on one or two aspects of the problem.

A constant worry was the provision of suitable operators. The plant troop of my squadron had only eighteen operators and not all of these could be allotted to the road task. The field squadrons, with ten to twelve operators on establishment, were often milked of some of these for operation Crown before the squadrons moved to Aden. Nor can you take a B3 operator of a Michigan LWT and put him on a D8 and expect immediate results! When the field squadrons "worked up" in UK before coming to Aden, as much as possible was done to give operators more experience on different types of machine. This was the basis on which we had to build. Such was the experience they gained and improvement they showed in plant work that many of the operators were upgraded after their tour in Aden.

REME support was provided by 22 Engineer Equipment Workshop—a unit for which sufficient praise can never be given. Initially, it was under Sapper command but for technical reasons (some other unit in the Command had two C vehicles) it was taken away and placed under CREME. But this did not affect, in any way, the support we received from it. It maintained an advanced workshop detachment with the upcountry field squadron, and in the latter stages we pooled all RE/REME plant fitter resources and allotted them to where the work load was. In the two years of my command I cannot recall one RE/REME demarcation dispute.

To start with, it was very popular to blame the delay in repair of machines on the non-availability of spares. In many cases this was true, as was true the fact that spares of engineer origin tended to arrive more quickly than those of ordnance origin. But

many of the problems of spares provision in the early stages were due to the failure of all concerned to understand the complexity and magnitude of the problem. Sufficient to say that once this was understood the problem was largely solved. Another factor which assisted to an ever-increasing extent was the use of air freight for re-supply from UK, even to the extent of complete assemblies such as gear-boxes being flown out in the freight hold of BOAC VC10 aircraft.

The Dhala Road project demonstrated to all engaged on it the value of the large machine. One Size I dozer was worth any number of Size II or IV machines. It always paid to move the largest machine on to a site that could be got there.

Another lesson that was brought home only too clearly to me was that of cannibalization. When I took over command, I inherited two light-wheeled tractors and a 3 ton vehicle which had been the object of cannibalization (the 3 tonner was a particular problem because it possessed only three wheels). It took me all of my two years in command and a lot of hard and unnecessary work by many other people before we eventually cleared our books of these machines. Occasionally, it is essential to transfer a fit component from a machine awaiting workshop attention on to another machine which is urgently required to complete a task. But if this is done it is equally essential that the unserviceable component is fitted on to the unserviceable machine immediately and that the transfer of components is recorded. This sounds elementary, but was forgotten by some in a misguided fit of "bash on regardless".

Looking back on the problems of plant management as they affected construction of the Dhala Road, I am reminded of the remark, often quoted to me in inter-Service circles, that the Army differs from the other two Services in that whereas they man the equipment we equip the man. I am tempted to wonder if in the case of a major plant project we should not seek to reverse the traditional Army doctrine.

There is no question but that the construction of the Dhala Road taught many officers and other ranks many lessons about plant—its use—its capabilities—its limitations—its maintenance. Let us hope that our management of plant in the future will benefit from this.

COMMAND AND CONTROL

I do not intend to go into any great detail of the problems of command and control. The issues which faced us can best be illustrated by considering the case of the upcountry field squadron commander. He was under my command for engineer operations and technical control of construction of the Dhala Road. For local operations, he was under command of the operational commander at Habilayn—a Colonel of the Federal Regular Army who commanded the western area of the Federation. For local administration, he was under command of HQ 24 Infantry Brigade stationed at Little Aden, but who maintained forward supplies at Habilayn. And he was still expected to owe some allegiance to the CO of his parent regiment in UK or BAOR. And a further complication was that parallel to my organization was the STRE (Construction) who were responsible for certain permanent construction upcountry. The Squadron Commander was required to provide this team with certain tradesmen, but otherwise there was no official link between the two engineer organizations. That we succeeded says much for the versatility of mind of my squadron commanders. That we achieved such effective command and control also says much for our own signals organization. The link with the upcountry squadron on my command net operated over fifty miles of very difficult country and was worked nearly every day of the two years of my command. Field squadrons maintained wireless contact with every detachment out of camp whether upcountry or down country. Up-to-the-minute reports on progress were always available and when trouble arose—attacks by dissidents or the unexpected mine—the squadron wireless nets were invaluable in calling for artillery, infantry or mortar support or for calling for a "casevac" helicopter. Occasionally, a word of criticism was levelled at me for the number of sappers employed on squadron signals, but without them there would have been no command or control.

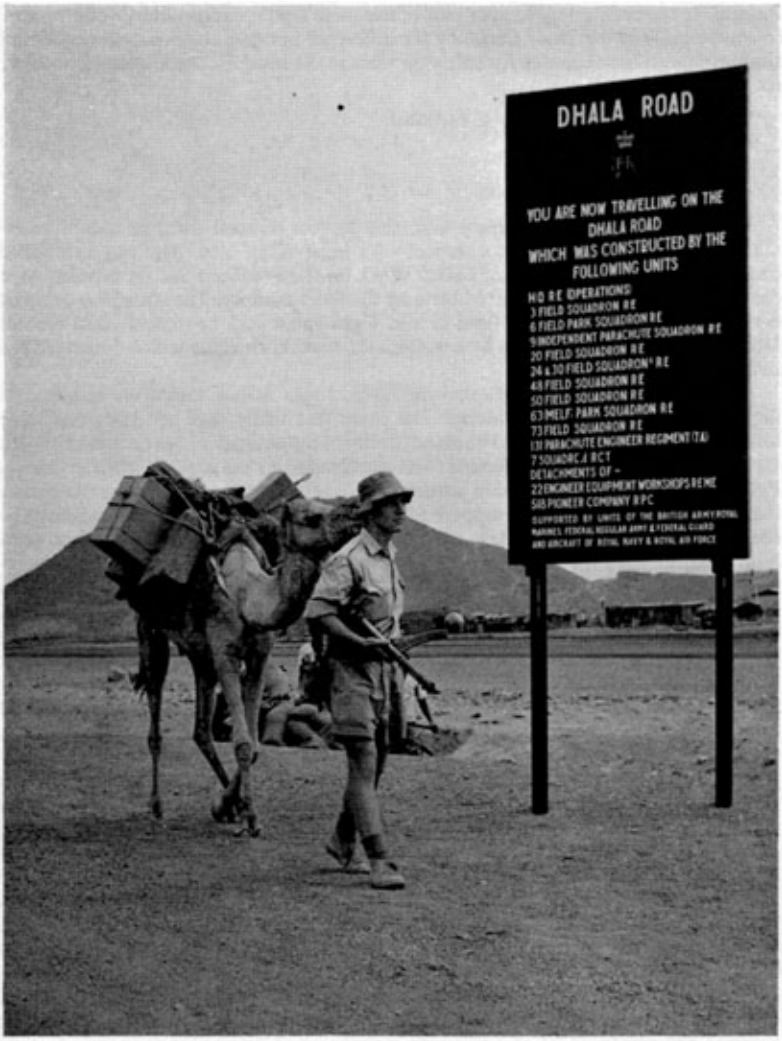


Fig 10. Completion—a Marine, with camel-borne supplies of water and food for one of the defence piquets, passes the Dhala Road Board at Habilayn (the wording of the board was carefully chosen to avoid offence to anyone—we still received one complaint).

CONCLUSIONS

At the outset it was expected that the Dhala Road, except for the section through Wadi Matlah, could be completed by one strengthened field park squadron in nine months. In the event, it took all or part of five more field squadrons thirty-one months to complete. Why was this? Certainly the difference between the expected and actual timings cannot be accounted for solely on work in the Matlah. There were, I consider, four reasons for this:

(*a*) Lack of a detailed plan at the start.
(*b*) The plant problem.
(*c*) The natural hazards.
(*d*) The operational situation.

Dealing with this last problem first, this project differed from so many undertaken by the Corps in one major respect—for most of the time there was a threat of enemy action to some degree or other. Work on the Southern Sector, running as it did across the desert, was affected little by dissident activity. The squadron camp at Al Anad had the odd bullets fired at it at night and a rock crusher sited at Nubait Dukaym was put out of action by a well-aimed rocket projectile which destroyed the main engine.

But shortly after 24 Field Squadron moved to Al Milah, they were attacked at night by a large gang of dissidents. The camp was badly shot up, two men were killed and a number wounded. From that moment the manner of operations changed. Upcountry camps became defended forts surrounded by bulletproof walls or banks. Pillboxes had to be constructed in positions covering the approaches to the camps and manned at night by the very sappers who by day were expected to be building the road. By day, on the work sites, every man had to have his personal weapon with him, ready at hand for use—and it had to be safely guarded. There was the remarkable case of a sapper driving a road roller on a fairly open stretch of road well within sight of the rest of his working party. An Arab appeared out of the nearby scrub and engaged the driver in conversation. Without any warning, the Arab suddenly produced a revolver and fired at the sapper from point-blank range. Luck was certainly with the sapper as the bullet missed him—but while he was recovering momentarily from the shock of still being alive the Arab grabbed his rifle, which was in the cab of the roller, and disappeared into the surrounding hills. As well as personal weapons, squadron LMGs had to be sited for use by piquets protecting the working parties.

Scout cars had been used as piquets, but casualties were so severe when these vehicles ran over mines they were withdrawn from upcountry and eventually replaced by Saracen APCs. And all these piquets were manned by sappers. Furthermore, every vehicle travelling between working sites had to carry an armed guard, and in the latter stages of the project vehicles had to travel in pairs—an added burden on the squadrons. In retrospect, it is easy to condemn this waste of technical manpower on guard duties, but the simple fact of the matter was that there was no one else to do it. When you are the man on the ground—the squadron commander—and you have experienced one of these night attacks on your camp, or a daylight ambush by a determined and well-trained band of dissidents, you don't take chances!

I have already dealt with the problems of natural hazards—floods and the extreme temperatures of the summer months—and the manner in which they affected the completion dates. Also with the problems of engineer plant. It remains to discuss the problem of engineer planning—or rather the apparent lack of it. Clearly, a project of this nature should have been planned in considerable detail before any work started. But if, in the operational climate which existed in 1964 when it was agreed that this road should be built, we had suggested that we required two or three months to plan the task before starting work we should have been "out of business". We had to be seen to be on the job as quickly as possible. To my mind, the mistake which was made in those early stages was to expect the first squadron on the task to

deal with the planning as well as the execution of the task. Had a planning team or part of a specialist team been provided, it would have been a different picture. As it was, successive field squadrons had to find their own project officers and provide their own project-office staffs with such assistance as I could provide from my small HQ.

Finally, when one recalls the events of 1967 and the British withdrawal from Aden, one is bound to ask, was it all worth it. On the debit side, eleven soldiers were killed in incidents or accidents directly connected with the construction of the Dhala Road. Several more were wounded, including one stalwart dozer operator of 63 MELF Park Squadron who was wounded twice, the first time when the blade of his D8 set off a Mark 7 mine and the second time when a vehicle, on which he was the armed guard, was ambushed and he got a bullet through that part of his body which he normally sat on! The keenness with which he returned to the charge after each incident gained him a well-earned Commander-in-Chief's Commendation. On the credit side, a number of other very well-deserved commendations were awarded. But above all, the construction of the Dhala Road gave a large number of members of the Corps very worthwhile experience as sappers, as tradesmen and as soldiers in operational conditions—something which is becoming increasingly difficult to obtain.

LAHEJ—THUMIER—ROAD ANNEX A

SPECIFICATION FOR IMPROVEMENT

Agreement

1. This specification was agreed at the first meeting of the Road Liaison Committee.

Classification

2. The route shall be capable of taking vehicles with a 10 ton axle loading.

Speed Classification

3. The route will be in most places unrestricted and therefore be capable of allowing vehicles to travel safely at 70 mph.
4. It will be permissible to put restrictions on the route, e.g. through villages, across wadis, through passes, etc.
5. For reasons of economy, at critical points, single-lane traffic is permissible, provided that drivers can see and control their own movement.

Gradient

6. Ruling 1 in 30. Maximum 1 in 15. In exceptional places this could be reduced to 1 in 8.

Curvature—Horizontal

7. Length of curves must be kept to a minimum.
8. Ruling curvature 1,000 ft. Minimum 500 ft.
9. At curves the width of each lane will be increased as follows:

Radius	*Increase in Width*
1,500 ft	1 ft 0 in
1,000 ft	1 ft 6 in
500 ft	2 ft 0 in

Superelevation

10.

Radius (ft)	*Superelevation*	*Radius (ft)*	*Superelevation*
1,200	1 in 14½	3,500	1 in 37
1,400	1 in 17	4,000	1 in 38
1,600	1 in 19	4,500	1 in 39
1,800	1 in 22	5,000	1 in 40
2,000	1 in 30	6,000	1 in 40
3,000	1 in 36	7,000	Nil

Sight Distance

11. Ruling 1,000 ft. Minimum 500 ft. This shall be taken at a height of 4 ft 0 in above road level, 3 ft 6 in from the edge of the bituminous surfacing.

Construction

12. Level the subgrade to a width of 30 ft. If this has a CBR of 25 per cent or more (as in the case of the gravel plain, etc), this can be considered to be the sub-base.

13. The base is then to be laid in two parts:
(*a*) Gravel to a depth of 9–12 in and a width of 24 ft. This is then compacted to a CBR of 25 per cent and a depth of 6–9 in.
(*b*) More gravel to be compacted to a depth of 12 in at the crown, shaped to a camber of 1 in 40. CBR to be 25 per cent, and a width of 24 ft as before.

14. The base is then bound to a depth of 3 in and a width of 18 ft with a macadam of:
(*a*) 1½–¼ in stone.
(*b*) ¼ in stone to dust.
This should be watered and compacted to a CBR of 80 per cent.

15. The wearing course is to be applied as follows:
(*a*) Prime with MCI cutback bitumen at a rate of 0·25 gallons/yd super.
(*b*) Surface dress with S125 (80/100) straight-run bitumen at a rate of 0·2 to 0·25 gallons/yd super with ½ in to ¾ in nominal size chippings applied at a rate of approx. 100 yd super per ton.

Henderson Field, Guadalcanal

LIEUT-COLONEL F. J. OTTEN, RE, BA, MICE

IN May 1967 I received a Warning Order that my next posting was to the MES Training Element (Civil Firms and Public Authorities), and that, together with a Clerk of Works (Construction), I was to go to Guadalcanal on attachment to the Public Works Department of the British Solomon Islands Protectorate (BSIP) to supervise the rebuilding of Henderson airfield.

Within minutes I found that the posting could be accompanied, rang my wife (who was enthusiastic), checked when my relief would arrive and borrowed an atlas to find out where the Solomons are anyway. I was intrigued by the name Guadalcanal, which, together with Corregidor, I associated with the US Marine Corps, and I was astonished to find that AG7 was entirely accurate. Guadalcanal is indeed in the BSIP, which lies between New Guinea and Fiji, roughly to the north of New Zealand.

My movement date was September 67, so there was plenty of time for a round of visits to the MOD, the Ministry of Overseas Development, the Board of Trade, the MPBW at Lacon House, and the Commonwealth Office, as well as for some correspondence with the Director of Public Works (DPW) BSIP.

I discovered that my wife and I would have a relatively sophisticated life with all modern conveniences, that I would be responsible to the DPW for the design and construction of the airfield using PWD plant and labour, that the project would be financed under a Commonwealth Development and Welfare (CD & W) grant and that there was absolutely no military purpose whatever behind the project.

The DPW had told me in a letter that the local plant operators were not of a very high standard, so with his agreement I suggested to HQ E-in-C that a Military Plant Foreman would be a very useful addition to the Project Staff. My suggestion was approved and Staff-Sergeant (MPF) Gowler was attached to me for the first three months of the project. We were later joined by Staff-Sergeant (CWC) Burton, who, like myself, was loaned to the PWD for two years.

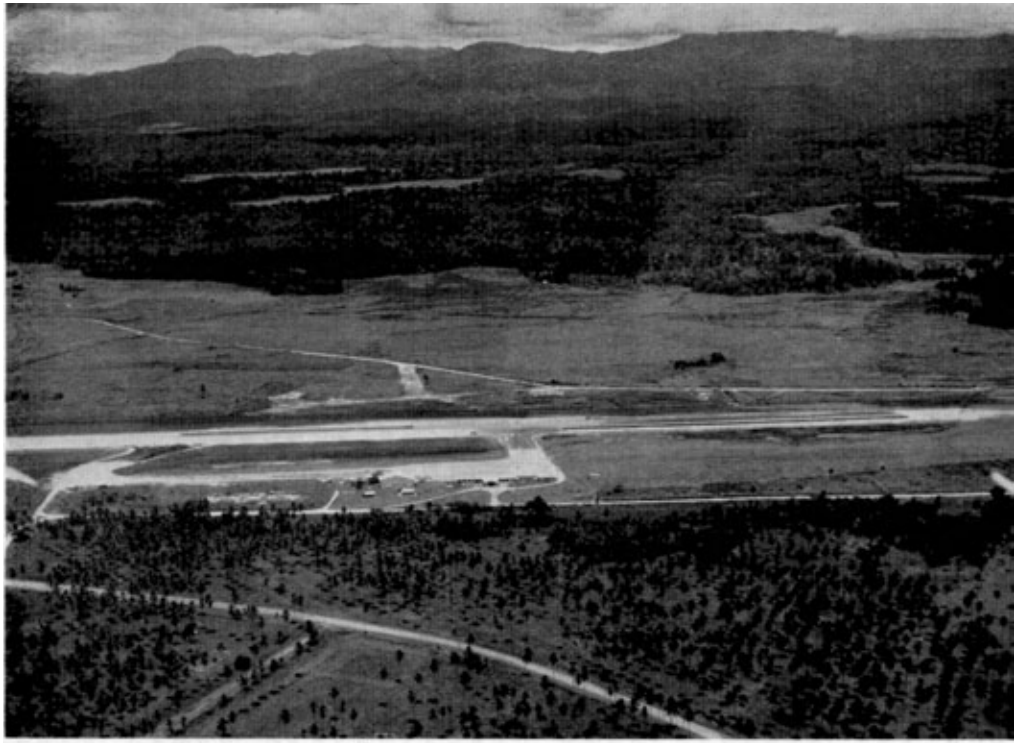


Photo 1. Henderson Field, Guadalcanal. View from the north, September 1968, showing the eastern half of the runway rebuilt, but not yet with its bitumen surface.

Henderson Field, Guadalcanal 1

My researches into the Solomons revealed that the Protectorate has a land area of about 11,500 sq. miles and has six main islands, Choiseul, New Georgia, Santa Ysabel, Guadalcanal, Malaita and San Cristobal, all high and rugged and of volcanic origin. Other islands in the Protectorate are either coral atolls or raised atolls.

Guadalcanal is the largest island of about 2,000 sq. miles and has the highest peak of 7,644 ft. Honiara is the capital of the Protectorate and is on the sheltered north coastal plain of the island. Henderson Field is eight miles from Honiara. The whole area is still volcanic and is subject to earthquakes. The climate is very like that of Singapore, but in addition to the heat and humidity, the area is the breeding ground for tropical cyclones which occasionally cause considerable damage in New Zealand and Australia. Probably the most fascinating fact that I discovered is that the Solomons are an area of gravitational anomaly. Apparently satellites passing overhead curtsy in recognition of the fact.

The Spanish names of most of the main islands are the result of the discovery of the group by Alvaro de Mendaña in 1568. No lasting settlement resulted from the discovery and the islands were left to internecine warfare and cannibalism until the early nineteenth century, when the demand for labour on Australian sugar-cane plantations led to "blackbirding", the recruitment of large numbers of the islanders. Poor treatment in some cases led to considerable bloodshed until, in 1893, the islands were declared a British Protectorate. Blackbirding ceased and so did the murderous intertribal raids that had characterized the islands' history.

Most of the 150,000 Solomon Islanders are Melanesians, although there are some Polynesians and Micronesians, particularly on the outer islands. The Melanesian is short and stocky, generally dark brown in colour and nowadays of a cheerfully religious and happy-go-lucky disposition. Since there are dozens of tribes, each with its own language, the general means of communication is pidgin English.

From the beginning of the century the Protectorate enjoyed peace and very little commercial development until, in 1942, the Japanese drive to isolate Australia reached south to Guadalcanal, on which they landed a construction force to build an airfield. An active enemy airfield there was a direct threat to the east coast of Australia, the Coral Sea, the New Hebrides and Fiji. The Americans and Australians reacted strongly and on 7 August 1942 the US Marines, supported by Army units, landed on the north coast of the island, captured the airfield site and completed it. There followed months of bitter sea, land and air fighting before the island was secured and a large Allied base built on the present site of Honiara. Apart from the original airfield, named Henderson Field by the Americans to commemorate Major Loftus Henderson, who was killed in the Battle of the Coral Sea, the Americans built four other airfields on Guadalcanal, only two of which, "Fighter One" and "Kukum", are relevant to this article.

When the British Administration returned to the Solomons in 1945 the Allied base became Honiara, the new capital of the Protectorate. The requirement for external and internal air services, which before the war did not exist, was then very small and could be met by light aircraft of the size of DH Herons and Doves. Kukum airfield only was used, mainly because it was the nearest to Honiara and was quite adequate for the small aircraft. The other airfields were not maintained at all.

By 1955 the post war commercial development of the Protectorate was well under way. Aircraft as large as the DC6 began to be necessary to carry the external traffic. Kukum airfield was too short and could not cheaply be sufficiently lengthened. It had other disadvantages as well, It was therefore decided to bring Henderson Field back into use, as it suffered from none of the disadvantages of Kukum. Its runway, still useable, was already 5,400 ft long and it was LCN 20 as opposed to Kukum's LCN of 15.

After a few years' use, the coral runway at Henderson Field began to give trouble. Its surface had become eroded, its camber inadequate and inaccurate and the airfield drainage system was largely lost. In addition, algae occurred in places on the runway resulting in a dangerously slippery surface in wet weather.

The BSIP Government asked for advice from the Board of Trade and the MPBW to solve these problems. Their advice was, broadly, to have the airfield lengthened and strengthened and to have proper drainage installed. The Protectorate could not afford to pay for the project and therefore asked for, and was granted, CD & W funds to do the recommended work using direct labour and PWD plant. Unfortunately, no PWD engineer was available to plan and supervise the project, so an approach was made to the MOD for RE assistance.

This article results.

I landed at Henderson Field in a Fijiair DH Heron in September 1967. The journey from UK, via Singapore, Australia, Fiji and the New Hebrides had taken a few hours under five calendar days. I learned my first lesson immediately. One is in no fit condition after a flight of that length to do anything constructive for at least a week. It took about a week for my wife and I to settle in, find out the geography of the place and generally to be introduced to people and life in the Solomons. We expected people there to be nice, and were not disappointed; and in addition we were very impressed by the standard of civilization and amenity.

The following day, I was given the requirement for the work to be done at Henderson airfield. It was as follows:

Runway—6,100 ft × 150 ft, LCN 35 (DC6 standard) (incorporating the existing runway, 5,400 ft × 150 ft, LCN 20)

Stopways (overruns)—400 ft × 150 ft at one end of the runway and 200 ft × 150 ft at the other. Construction to runway standards.

Slopes (runway and stopways)—1·5% camber. Longitudinal slopes and vertical curves to ICAO class A standards.

Flight strip—6,700 ft × 500 ft, to include a 25 ft wide hard shoulder on each side of the runway. Cross fall, 2·5%. Longitudinal slopes to ICAO standards.

Drains—Open ditches outside the flight strip.

Taxiways—Existing. To be strengthened to LCN 35.

Airfield lighting—Nil.

Pavements—To be coral with an unspecified bitumen surface.

All the planning up to then had been rather sketchy, in the form of feasibility studies rather than engineering plans. There was no survey of the existing field and the estimates on which the CD & W funds had been granted were not based on measurements on the ground. There was, of course, no design as such. Nevertheless, despite the difficulties of estimating for an unsurveyed project, the PWD estimate was close to the estimate which I made later. There were no engineering surveyors in the Protectorate, so I had to do the survey work myself. Before I became involved in this I decided to look into the aircraft operators' side of the picture.

I found that Henderson Field was in use by three airlines: Fijiair, operating from Fiji flying DH Herons (later replaced by HS 748); TAA, flying from Port Moresby using Fokker F27 Friendships; and Megapode Airways, the internal airline, using DH Doves and an Aztec. Henderson was the international terminal and also Megapode's maintenance base. During runway reconstruction I would always have to provide 3,000 ft of unimpeded runway for Megapode's use. The other airlines needed 4,500 ft as a minimum. Since the final runway length was to be 6,100 ft there was no way by which I could always provide the necessary 4,500 ft for Fijiair and TAA, but Megapode's requirement could be met.

Fortunately, Kukum airfield was still available, but on inspection I found that some work was necessary on the runway there before Fijiair and TAA could reasonably be expected to operate on it. Kukum runway could easily be extended by some 600 ft, but the existing runway badly needed potholing and generally tidying up. Like Henderson, the runway was coral.

My early tasks were, then, to plan the necessary work at Kukum, to make a complete survey of the runway at Henderson including the runway extension and

flight-strip area, to make a soil survey, to design the airfield, cost it, make a plan and programme, organize temporary works, collect plant and labour and then start.

It was clear that the outline plan for the complete project should be:

(*a*) Commence temporary works at Henderson Field.

(*b*) Bring Kukum airfield up to standard for temporary operation.

(*c*) Commence permanent works at Henderson Field by constructing the runway extension without interfering with aircraft operations on the existing runway.

(*d*) Divert Fijiair and TAA to Kukum airfield whilst work at Henderson progressed from the runway extension along the existing runway to the centre of the final runway. During this phase Megapode Airways would use the remaining portion of the old runway.

(*e*) Divert Megapode Airways on to the completed half of the final runway whilst reconstructing the other half.

(*f*) Reopen the airfield to all comers.

It was intended, in this outline plan, to do the required work on the taxiways and apron during phases (*d*) and (*e*). However, in discussion with the DPW and the Superintendent of Civil Aviation, BSIP, a new policy was worked out eventually to discard the existing terminal building and apron and, in a new and better position, to build a completely new terminal area which would be spaciously planned to take account of all foreseeable future developments. For economy, it was decided that only the minimum possible work would be done on the existing taxiways and apron and this boiled down to remodelling the runway turnoffs and the taxiways within the flight-strip area. The new terminal area could not be financed within the project, but the new runway turnoffs to serve it could, and were included in the programme of work.

The outline plan was approved by the DPW and shortly afterwards two gangs of labourers started work, one at Henderson Field setting up a labour camp, opening up the coral quarry, opening up haul roads and all the other small but essential initial tasks, whilst the other gang began to repair the potholes in the runway at Kukum. Both gangs had plant assistance.

Potholing the runway at Kukum was unpleasant work for the labourers. The direct heat of the sun was reflected by the near-white coral surface, so that, apart from the temperature, the glare was intense. Both of these factors helped to make the work slow. The potholes were mainly caused by vegetation which had been allowed to spread over parts of the runway. Its roots penetrated into and crumbled the otherwise concrete-hard coral. Every crumbled patch had to be cut out by hand.

At first, I found myself demonstrating daily the precise technique of "Raise, strike, break, rake," and my insistence on square vertical sided excavations took a little time to be accepted. "This fellah mastah him crazy too much" was the (cheerfully) muttered obbligato to my demonstrations.

The refilled potholes were compacted by a Galion 12-ton smooth-wheel roller that the Americans had inadvertently left behind in 1945. It had been re-engined by the PWD workshop, but its transmission was rather unreliable. This fine old machine was the curtain-raiser to almost endless compaction machinery problems which plagued the whole project. The basic problem was simply that the PWD had an unbalanced plant force—too few compaction machines to match its other plant.

The runway at Kukum had some surprises in store. On two occasions a rear wheel of the roller went right through the coral surface, exposing considerable cavities between the 4 inch thick coral and the underlying ground. In both cases we excavated and found that the failures were the result of wartime bomb or shell craters which had been refilled with any available material to get the runway back into use again in a hurry. From one cavity we took one 44 gallon drum, seven jerry-cans and a tree root, and from the other several cubic yards of used cookhouse tins. The metal was heavily oxidized, so the subsidences were not surprising, but the fact that the repairs had lasted twenty-five years without failure was remarkable.

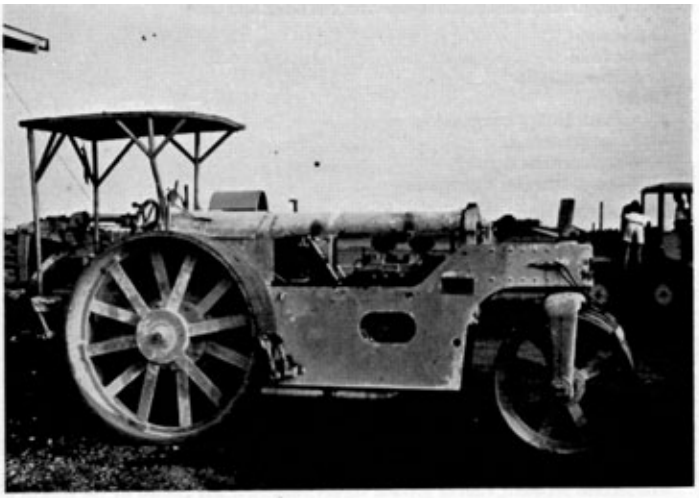


Photo 2. The quarter-century-old Galion roller.

The runway extension construction at Kukum was very little problem, as the ground available was so nearly the right shape that little plant work was needed. A simple 4 inch coral surface gave all the strength that was required, indeed, it later supported a C130 without distress. Six hundred feet of extra runway was provided at one end of the airfield and a turning pad at the other.

Once the work at Kukum was under way I turned to the survey of Henderson Field. So far as the runway and flight strip was concerned, I needed profiles and cross-sections. To save time, I had decided to combine my initial survey with control points for setting out the work. To do this I surveyed in two lines, parallel to the runway centre line and outside the flight-strip area, in the hope (unrealized, of course) that they would survive the attentions of the plant. Each line had a concreted steel pin set in every 300 ft. Once these control points were set in it was very quick and easy to take profiles and cross-sections. However, the control points were much slower to set in than I had imagined, because the ground was covered with 6 ft high kunai grass, liberally mixed with sword grass. This could only be cleared quickly by using a D4, followed by a Ferguson slasher.

On the other hand, the levelling work was far quicker than I had expected, because I used a Watts Autoset level. This is a delightful instrument, robust, accurate and quick to use with a good optical system (purists will be horrified by the upright image). It also has the great advantage that it need not be shaded from the sun, because it does not depend on a bubble for accurate level.

Once the ground survey was done, at least for the runway and flight-strip area, it was possible to design the finished levels of every part of the airfield with the exception of the drainage inverts. However, before the runway extension construction could be designed, I had to set up a soils laboratory and make a soils survey of the area and the proposed construction materials. Fortunately, the PWD had just received its first consignment of soils laboratory equipment, but there was, of course, no trained laboratory assistant. Later I was given an intelligent Gilbertese draughtsman to

train as an SLA and he rapidly became proficient and reliable. The tests for which we had equipment were the basic minimum for the work and were:

Liquid limit
Plastic limit
Dry-sieve analysis
CBR
BS and BS Heavy compaction
Moisture content
Sand-replacement density
Flakiness factor (for aggregates)

Fortunately, there was a highly efficient geological laboratory in Honiara which was able to do certain other tests which I needed from time to time, such as particle and chemical analysis.

Although the design of the runway profile was not difficult, the design of the drainage system was far from easy. There were two problems, the first of design criteria and the second of ground survey.

The design criteria problem was entirely caused by a lack of the rainfall records of the type needed for drainage design. Daily precipitation figures existed for Honiara, but none for Henderson Field. Although the two places were only eight miles apart, their rainfall was very different. There were also no figures for rainfall intensity. After discussion with the DPW, an intensity figure of 6 inches in the hour was assumed and used in the drainage design. Experience later showed that it was about the correct figure.

The second problem, that of ground survey, was basically caused by the lack of a contoured map of the area to a useful scale, so that drainage routes and invert levels could not be approximated on a map before being proved on the ground. The area was too flat for a reasonably accurate and economic guess to be made. Fortunately, the whole area had been air photographed earlier in the year. Using these photographs a New Guinea firm, without any special priority, produced by photogrammetry

Photo 3. Kunai grass makes survey difficult. Staff-Sergeant Burton has a problem.

the required contoured map. I estimated that it would have taken me at least six weeks to have the essential results by ground survey.

By using the map, which was to a scale of 1 : 2500 with 1 metre contours, the drainage problems were quickly resolved and the design finalized. I had to drain both sides of the airfield to the south, and to do this it was necessary to build two culverts across the flight strip and runway.

The two culverts, both 500 ft long, 4 ft × 3 ft internal dimensions, were designed in RC. To save time, I decided to precast them in 5-ft sections, the length being dictated by the capacity of the PWD's only mobile crane which would have to place them.

Whilst I designed the reinforcement, Staff-Sergeant Burton set up a highly effective precast yard at Henderson Field. Using a single 5T concrete mixer (all that was available) and wheelbarrows on an overhead walkway, the concrete gang managed to cast an average of fourteen sections per six-day week, not counting those periods when the Protectorate ran completely out of cement. The resulting concrete sections, after a good deal of initial instruction and persuasion by Staff-Sergeant Burton, were very creditable and certainly the best precast concrete seen in the Protectorate.

As soon as the runway design was complete, a start was made on the earthworks for the runway extension and the flight strip in the area. Two scrapers were initially available (later reduced to one), towed by a D6 and a D7. Staff-Sergeant Gowler, the MPF, took charge of them and trained the operators till their methods and mannerisms (but not their language) were practically indistinguishable from those to be found almost any day at Wainscott. He also planned each day's earth-moving to take account of the wet weather at the time, so that each day's work drained properly away from the next section to be worked on. The result was that the work progressed well with few weather delays. His influence was so marked that, after he had left at the end of his short attachment, the plant operators themselves kept a wary eye on the weather and, without being told, automatically tidied up and box graded whenever rain threatened.

Photo 4. Constructing a cross culvert under the runway and flight strip with precast sections.

For the most effective control, the project plant was divided into teams, each with its own ganger. The earth-moving team consisted of the two scrapers already mentioned. The runway team had a Caterpillar 12E Grader, a D4 and Grid Roller and a smooth-wheel roller. The third team, the import team, had a Caterpillar 944 front-end loader, a D6 fitted with a ripper, four Shawnee Poole dump trucks and any tippers I could lay my hands on, which was usually none. Certain other plant was attached to whichever team needed it and included a water truck fitted with a spray bar, a rubber-tyred roller and a Ferguson grass cutter. The labourers were loosely organized into gangs; the concrete gang; the coral-bashing gang, who broke the larger lumps too big to be crushed by the grid roller into smaller pieces with sledge-hammers, and, at a later stage, the bitumen and the stone-crusher gang. In support, there was the admin. team of cook, storeman, timekeeper and SLA, and lastly the Command Group of myself, the S/Sgts and Ilisa Tinai, the Fijian Works Supervisor.

In support of the Plant to make immediate repairs was a Fijian fitter with a Solomon Islander assistant. They were supported in turn by the main PWD workshop in Honiara and by a mobile servicing team.

All the plant was old, except for the two D6s, and not in the best of condition. The two stars of the collection were the quarter-century-old Galion roller and the water truck, which was a rebuilt, much-modified, written-off fire engine. The fitters were rarely idle as, if nothing else, we had the predictable tyre and electrics problems, but they still maintained a good rate of serviceability.

I mentioned earlier the outline plan of the work. Directly derived from this was the programme of work produced, which may come as no surprise to some readers, by CPM using current Civil Engineering School techniques. Unfortunately, the diagram was unsuitable for reproduction in this article. I had twice to modify the diagram, once when the scope of the project changed and the other time when the method of bitumen surfacing was decided which was not the method which I had originally assumed, but the modifications were easy to make. The diagram was used constantly for control and forecasting and provided a surprisingly easy way of making a costing cross-check, both for the original estimate and for financial progress checks.

The old American runway consisted of 4 inches of crushed coral on 4 inches of gravel on 4 inches of sand. To obtain the required LCN 35, this had to be overlaid with a minimum of 5 inches of coral and then surfaced with a bitumen treatment. My design for the runway extension was similar, but with slightly greater thicknesses of coral and gravel, mainly because I had not the means of winning such high-class materials as the Americans had used. All materials used were tested in the soils laboratory.

The coral (coral gravel to those who have done the RSME Exercise Pea Six) contained about 1 per cent of clay and was otherwise practically pure calcium carbonate. Surprisingly, its particle surface was anionic instead of cationic, and this probably contributed to the failure of a trial of a proposed bitumen surface treatment of the runway using an anionic bitumen emulsion. Soaked CBR tests on the coral gave results of the order of 70 per cent, but tests on specimens compacted at OMC and allowed to dry gave results of over 130 per cent. There must have been some pozzolanic action in the compacted coral, as CBR results increased with the age of the specimens. The coral was relatively easily won by a D6 fitted with a ripper from a geologically very recent upthrust reef only a mile from the runway.

The gravel, a textbook 1½ inch very slightly deficient of fines, was obtained from the runways of the disused "Fighter One" airfield just over a mile from the Henderson runway. This gravel produced CBRs of 70 per cent plus at OMC and soaked CBRs of 30 per cent. By the time that the project is complete the runways at Fighter One will have ceased to exist.

The sand came straight off a beach two miles away. It was close graded and a black basalt with sharp angular particles. It gave CBRs in the 7–8 per cent region.

All the materials were easy to use, although we had to learn the technique of compacting the coral by trial and error. It was fairly sensitive to moisture content

and, as the Speedi moisture content tester was not reliable with coral, we had to rely on our experience of the look of the material to compact to the required dry density.

One of the essentials when building a runway is to check that you have in fact obtained the designed strength. Nearly always this check is made by the plate-bearing test. Before I went to the Protectorate I had rejected this test in favour of proof rolling the complete runway. The PWD managed to hire a proof roller from the MPBW and it arrived by sea at Honiara in time to test the completed runway extension. Even unballasted the roller was far too heavy to be taken over the bridges on the only road to Henderson Field, so it had to be taken there by LCT and landed over the beach. Once on site, it was carefully ballasted with gravel to the required weight for LCN 35 and towed over every completed inch of the runway. It detected one weak place which was easily cut out, replaced and retested.

For this type of runway and for true natural surface strips, the proof-roller approach seems to me to be ideal. I believe the Corps should have its own proof rollers, possibly much smaller and lighter than the MPBW machines, and consistent with our tasks of building airfields for Medium Range Tactical Transport aircraft and airstrips for light aircraft. Any completed runway could then be proved to be adequate or not before any pilot has to risk his neck on it.

During the construction of the runway extension the scrapers uncovered a fair quantity of Japanese and American ammunition. Altogether we had a bag of some eighty assorted explosive objects ranging from one 500 lb bomb, through 155 mm shells to mortar bombs and hand grenades. The plant operators, like most inhabitants of the Honiara area, were quite used to finding these objects; indeed, it is quite a local industry (officially discouraged) to cut driving bands off shells with a hammer and cold chisel and to sell the copper to a scrap merchant. About every three weeks I had a disposal day and detonated the stock on hand. The higher-grade ammunition was not easy to set off, so, after a few failures, I had the PWD Plumbers shop make me up my own version of a Hayrick, from tin plate. When loaded with a few pounds of gelignite, these tin Hayricks were extremely effective for cutting open the objects

Photo 5. A day's bag of WW 2 ammunition.

so that their charges were exposed and easily subsequently detonated. I'm not at all sure if my methods would be blessed by the BD School, but at least they were effective.

Once the project was well under way, I was able to devote time to the problems of the final bitumen surfacing. I was quite determined that the design would be based on field trials using the plant, labour and machines that we had or could get. It took time to get the bitumen from Australia, so an order was placed for a few assorted types of bitumen for trials on two of the three proposed surfacing methods.

The plant available was one 500-gallon heater/distributor with slotted nozzles and one 800-gallon heater. The distributor was normally towed by a Fordson tractor which was not fitted with any useful form of tachometer. One was immediately ordered and arrived nine months later. No macadam plant existed, nor was there a quarry or stonecrusher.

The original MPBW recommendation for the bitumen surface was a 2 inch layer of wet sand mix, using the beach sand which was available in quantity. This would have produced a very satisfactory surface, but it had been rejected by the DPW before I arrived in the Protectorate and the necessary mixers and other equipment had not been ordered. The next alternative, proposed by Shell, was a mix-in-place technique using the coral, a grader and a slow-setting anionic emulsion. I ran a trial on this method and found the results unsatisfactory, partly because of the impossibility of adequately controlling the process with the plant and operators that I had and also, probably, because of the anionic surface of the coral.

The third and finally accepted method was a three-coat seal,—a prime coat of MC 0 cutback followed by two coats of 85/100 straight-run bitumen with $\frac{3}{8}$ and $\frac{1}{2}$ inch crushed stone, the first layer of stone being doped with diesel oil. At this point I should mention the help given me by the Road Research Laboratory in deciding the bitumen treatment. Although there was no quarry or crusher in the Protectorate, there was a considerable quantity of basalt gravel available in near-by river beds which could be won with some difficulty. Accordingly, we bought a granulator and screen from Australia and eventually installed them on a hillside near the runway. We built a retaining wall of rejected culvert sections and a loading gantry out of old Bailey bridge parts. The whole installation was fairly successful, but the makeshift feed arrangements were not the best.

On most airfield projects, once the job is properly under way it becomes largely repetitive. The task of the engineer in charge is mainly to maintain quality, but usually he will have time to spare to keep up the pace of the work and to think of ways to minimize costs. This project was no exception, but there was another added hazard. The plant force was so small that a breakdown of a key item brought work to a halt. In general there was no replacement plant available, although some breakdowns were covered by stopping another job elsewhere in the Protectorate and relocating machines. Key machines will alter according to the progress of the work. For example, at the start of the project the key machines were scrapers. When runway construction started there was only one key machine, the 944 Traxcavator which loaded materials to be carried to the runway. It obviously pays an engineer to devote time and energy into seeing that the best attention is paid to key machines by fitters and servicing teams and that they have the best plant operators. So far as saving costs were concerned, the most uneconomical part of the project was the transport of materials to the runway, as the four available Shawnee Pooles could not hope to keep up with the output of the 944 Traxcavator. For a period I managed to hire one tipper, and later managed to convince the PWD's Mechanical Engineer that a written-off unroadworthy PWD tipper was at least airfield-worthy, but to the end the transport of runway materials remained the major uneconomic section of the project.

After fifteen months in the Protectorate, I was posted and relieved by Major M. G. Hunter. The airfield was then about 75 per cent complete after twelve months' work. Major Hunter and Staff-Sergeant Burton had the task of completing Henderson Field and then the far more difficult task of forming up the Specialist Team RE

(Solomon Islands) and taking it, complete with PWD plant and labour, some 400 miles across the open Pacific to the remote Santa Cruz Islands, where two more airfields are needed, this time to be built from scratch.

Henderson Field was a small project. Earthworks totalled about ¼ million cubic yards and imported materials about 100,000 cubic yards. The whole project will cost the British taxpayer about £73,000,[1] of which nearly £10,000 are interdepartmental "hire" charges for one Major, one Staff-Sergeant and one proof roller. I found the project interesting and professionally valuable. It was, of course, pure Sappering, an odd mixture between combat, professional and BD engineering. Socially, my wife and I had a wonderful time and my thanks are due to all those "expatriates" in the Solomons who were so kind to us. I must also mention my "command"—Staff-Sergeant Gowler who saw the start of the project, Staff-Sergeant Burton who saw it all, except for the start, and the two corporals, Corporal Hulme (REME) and Lance-Corporal Hull (RE), who arrived just before I left. The corporals were lent by FARELF to stiffen up the overloaded PWD workshops. All four NCOs did excellent work.

This project was a good example, on a smaller scale, of the type of work about which the E-in-C wrote in the *RUSI Journal* of November 1968.[2] It may be of interest that this is not the only "Lone Wolf" project. Major B. O. Bown is at present in the Gilbert and Ellice Islands building airfields at an astonishing rate and Wing Commander E. St B. Kenny (who is, after all, at least an honorary Sapper) was attached to an airfield project in the West Indies in 1966. I know there have been many other similar examples in the recent history of the Corps. I hope there will be many more.

Water Supply in Ancient Persia:

THE CAMBRIDGE EXPEDITION TO KOMIS IN 1968

2ND LIEUTENANT D. H. GYE, RE

THE concept of an expedition as a band of intrepid explorers setting out into the unknown has changed a lot, even in the last ten years. Today the emphasis for a group which calls itself an expedition must, for financial reasons, be on the results that it will bring back. Expeditions, some of them nearer to being field-study groups, depart each year to carry out studies in every academic sphere. Many of these are university expeditions composed largely of undergraduates. University expeditions can often find finance more easily than others, even if the university itself does not give direct support. For example, last year thirteen expeditions left Cambridge, all with official encouragement, but without university sponsorship, and most of these groups were financed at least in part from external sources. The number of expeditions increases every year.

The Cambridge Expedition to Komis was just one of these, and I apologize at once for our use of the title "Expedition". We were essentially carrying out field-

[1] Costs include purchase of materials, profit *a prendre*, a Land-Rover and stone crusher, fuel, wages for PWD employees, miscellaneous small charges and the interdepartmental charges mentioned.

[2] *Royal United Services Institution Journal*, November 1968, "A constructive use of soldiers overseas", by Major-General R. L. Clutterbuck, OBE, MA.

work in Iran, but using the title that we did made fund-raising much easier. The expedition was very typical of its genre; it was composed of four undergraduates (two of them happened to be soldiers) and proposed to work in Persia at the archaeological site of Shahr-i Komis for a period of six weeks. The task had been suggested by Mr David Stronach, Director of the British Institute of Persian Studies in Tehran, and he became the Expedition's sponsor. Professor Sir John Baker, our Professor of Engineering and an Honorary Member of the Institution of Royal Engineers, very kindly agreed to be Patron to the Expedition. A prerequisite for success in this sort of project is proper academic support, and we found the interest of senior members of the University most encouraging.

As soon as we had agreed on the outline of the project and on the necessary personnel, fund-raising started. In March we had no money at all and we reckoned that we would need £900 altogether. We were each prepared to put in up to £100, which left an absolute minimum of £500 to be raised. We produced a printed prospectus and sent this out with a letter requesting money or goods to about 200 trusts, funds and companies which we thought might be interested in helping us. We were extremely lucky and through the generosity of about twenty bodies we collected over £1,000; we would in particular like to thank the Corps for its very generous contribution of £50 from Corps Funds. A company in Iran, as well as making us a large donation, lent us a Land-Rover, which meant that when actually working on the site we had two vehicles.

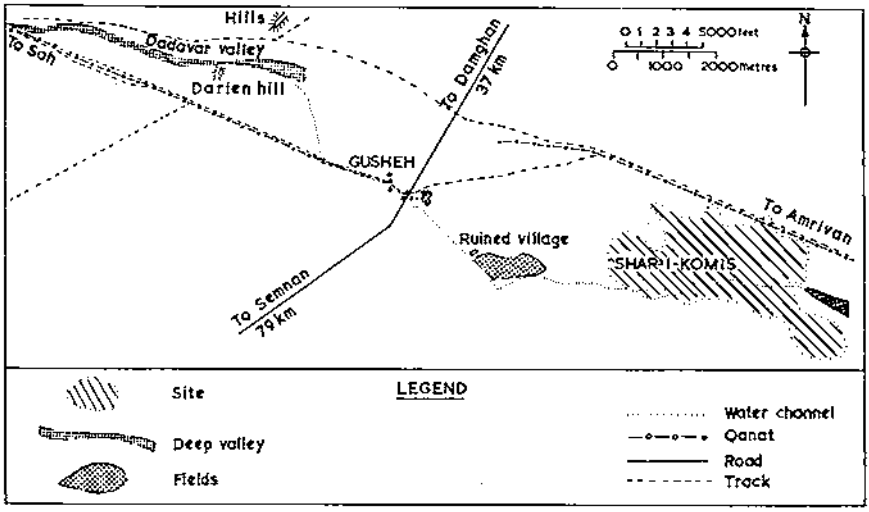
We bought our own second-hand Land-Rover at about the beginning of May Week, which left us two weeks for final preparations. There was by now no great financial problem and we had more or less sorted out the "academic" side of the work. However, the two weeks were busy enough with administration and when we set off it was not with the light-hearted confidence of people who know that they have thought of everything.

I will give only the briefest account of our journey to Tehran and back and of our administration in the field, as this is not likely to be of great interest. A full account of all that the Expedition did is to be found in the thirty-six-page Expedition Report.

We drove to Tehran through Europe to Istanbul, from there to Ankara and then to Erzurum by the Black Sea coast of Turkey. From Erzurum we took the obvious route to Tehran. The whole journey took fifteen days, which was much longer than we took for the return journey, when we travelled through the centre of Turkey. We found the central route better than the northern one. In Tehran we stayed at the British Institute of Persian Studies for four days, collecting letters of introduction and so on, before moving on to the village of Gusheh, where we were to live for the next five weeks.

Gusheh is a village about 150 miles west of Tehran on the Mashhad road. The site is about three miles east of Gusheh and so it was convenient not only to live in Gusheh but also to have the approval and encouragement of the landlord of the village, which meant that we were well received in other villages around the site. The landlord had kindly lent us his comparatively comfortable house and so we were really very pleasantly situated.

We had formed the expedition with the object of investigating the supply of water to the site of Shahr-i Komis during its period of occupation 2,000 years ago. The project had been suggested to me by Mr Stronach, who had co-directed an excavation at the site in 1967. He suggested that we should carry out a survey of the site, with particular reference to disused channels and water systems, which were hoped to be contemporaneous with site occupation. Our party consisted of three engineers who were to carry out the survey and to study channels to ascertain water-flow rates when they were in use. Our fourth member, a geographer, was to look at the problem from a less particular point of view. He was, for example, able to make an assessment of the amount of water available in Parthian times, on the basis of present-day conditions and local climatic changes in the intervening period. He was also able to comment on the very interesting erosion characteristics of the site.



PLAN OF GUSHEH AREA

An account, however brief, of the work we did at Komis would be meaningless without a preamble concerning the archaeology of the site; it will also be necessary to explain what a *qanat* is, and so I hope the reader will bear with me for a few paragraphs.

The site does not conform to the layman's first idea of what it ought to look like. There are no soaring marble columns or cuneiform inscriptions and it is barely even visible from the road two miles away, which might explain why the site was not investigated until 1966. The site is situated on the gravel plain which lies between the Elburz mountains and the Dasht-e Kavir (the Great Salt Desert). The plain stretches for about twenty miles southward from the foot of the sharply rising mountain range, and is covered in scrubby camel-thorn. Under a thin layer of gravel there is fine mud and wherever the gravel has been disturbed to any depth the mud comes to the surface, showing up as a blot on an aerial photograph. The site is essentially an area of this mud about two miles by three, covered with potsherds (sometimes ankle deep). The only detectable features to be seen on the ground are nine mounds, mostly Parthian funerary structures, up to 50 ft in height. There are also a dozen or so smaller features such as kilns, and with a little imagination street patterns can be detected on the air photographs covering the site. All the features are made entirely of mud, which is to this day a basic building material throughout Iran. Its advantage is that is is easily available and so very cheap; it is especially suitable because very thick walls can be made, which insulate well throughout the year. The major disadvantage of mud as a building material is its comparatively short life, between twenty-five and a hundred years. This would explain why so little is left of the site, and it would bear witness to the monumental size to which the buildings must have stood, if, even now, there remain mounds containing, say, 5,000 tons of mud. An interesting geomorhpological feature is the highly dissected nature of the mud surface caused by heavy winter rainfall. This surface made movement in vehicles on the site very frustrating, as many of the gullies were too deep to cross with a Land-Rover.

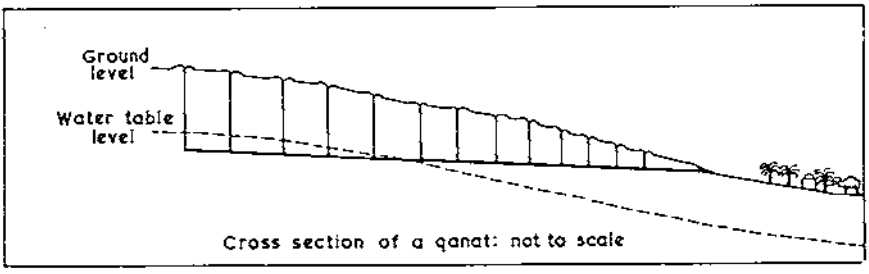
The archaeological interest of the site is considerable. It stems from the fact that this is the largest site of its type and period yet to have been discovered and also that its position could be compatible with that of the lost Parthian capital, Hecatompylos. The location of Hecatompylos has been the subject of debate for more than a century and there have in the past been concerted efforts to find its site. The brief

excavations and studies carried out in 1967 confirmed that the Komis site had had periods of Parthian and Sasanian occupation, although some anomalies were raised. Interesting discoveries were also made concerning the burial customs of the occupants of the site; the skulls of men and horses were found buried in the same graves, with slightly grisly implications.

The Expedition went to the site to look at its water supply in the periods when it was occupied. This was for two reasons; firstly water is of prime importance, particularly in Iran, and any information about the way in which the site was supplied might tell a lot about the way of life of the inhabitants. The second reason concerned this site in particular and the possibility of its identity with Hecatompylos. There is evidence that qanats were used at or near the city from very early times and we were interested in the origin of this ingenious water supply system. The evidence also points to the early use of qanats near Komis, whether or not the site proves to be that of Hecatompylos. Before describing qanats I will say at once that we signally failed to find out anything at all about their origin.

In the Middle East, where the existence of villages depends entirely on the availability of water not only for drinking but also for irrigation, it is usually necessary to tap the underground water-table. To obtain enough water from wells, with inefficient pumps, involves an enormous amount of labour, and so the qanat system has developed, primarily in Persia.

The qanat (see diagram below) consists of a long tunnel driven slightly uphill into sloping ground. Because the water-table approximately follows the ground surface in profile, the qanat will eventually penetrate it and water will run down the channel into the fields at the opening. The vertical shafts provide ventilation for the workmen while the qanat is being dug and allow the easy removal of spoil (see Photo 1).



Cross section of a qanat: not to scale

Qanats are very widespread and may be found in places as far afield as Peru Bavaria and Yorkshire (where they are used for mine drainage). They also go under about twenty-five different names, of which the most common are *karez* (Afghanistan) and *foggara* (North Africa). Numbers of excellent articles have been written about qanats (I can recommend, for example, George B. Cressey, "Qanats, Karez and Foggaras". *Geographical Review* ,Vol. 48, No. 1, January 1958). The quoted dimensions of qanats vary enormously, but I give below what seem to be taken as usual dimensions:

	Maximum	*Minimum*
Length	25 miles	500 ft
Maximum depth	1,000 ft	30 ft
Distance between shafts	500 ft	20 ft
Tunnel height (when new)	5 ft	3 ft
Slope of channel bed	1·5%	0·1%

There must be many exceptions to these limits and in fact we came across some ourselves.

We knew that on and near the site there were remains of disused qanats. When in use, all that can be seen of a qanat on the surface is a line of craters where spoil has

Photo 1. Maintenance of qanats. A wooden capstan is used to haul workmen up and down the shafts and to remove spoil from the bottom. The wheel is said to be safer than it looks.

been dumped around the top of each shaft. In a disused qanat the shafts soon collapse and after a few years all that can be seen is a line of shallow craters, marking the tops of former shafts. There were four such lines of craters associated with the site and we proposed to concentrate our attention on these. Our tentative proposals were (1) to identify and survey ancient qanats and their outfall channels in relation to the site, (2) to dig out the channels to reveal their original cross-sections and calculate how much water they carried, (3) to carry out a study of a modern qanat, both for comparative purposes and for its own sake, (4) to make relevant geographical observations in the area.

When we reached the site and made enquiries about the old qanats we were disappointed. Local information told us that one of them was in use until 100 years ago and this was the qanat in the most decayed state. It did not take us long to realize that any qanat of the order of 2,000 years old would have completely disappeared by now under local erosion conditions. This meant that one of our most interesting lines of approach would have to be abandoned, but it did not alter the other parts of the plans, viz. survey, a general study of water conditions and a close look at a modern qanat.

Survey. Ian Durie, a gunner and our only other soldier, directed the survey. He carried out a triangulation of the site area, and extended the scheme to include the

Photo 2. View north-east from Darien Hill. The emergence of the Dadevar Valley can be seen in the middle distance; Ian Durie in the foreground.

village of Gusheh and the qanat supplying Gusheh. This took about ten days, including computations (performed on a Curta hand calculator). Numbers of secondary points on the site were also fixed by triangulation and so no traverses were necessary. Traverses would have been difficult on account of the very rough nature of the ground surface. Tachymetry was carried out from the secondary triangulated points. A certain amount of plotting was done while we were still in Persia to get some idea of which areas required surveying in detail. Quite large areas of the site were only examined very scantily, as they were almost completely featureless.

The final part of the survey was a pace-and-compass traverse round the boundary of the site. The boundary was defined for our purposes as the limit of concentrated pottery, and the vagueness of the limit far outweighed the inaccuracies of the traverse. In fact, the boundary as determined by our traverse coincides very closely with the limit of the discoloration noticed on the air photographs.

Available Water near the Site. This was the central study of the expedition and was carried out mainly by our geographer, Guy Wilkinson. We had to ascertain the amount of water at present available and its distribution. We then looked at ways in which it might have changed in the last 2,000 years. Very briefly the situation is this; all the water naturally available comes from a valley at the foot of the Elburz Range (the Dadevar Valley). This water consists of a constant supply from springs about twenty-eight miles from the site and seasonal flooding, which does not appear to have any influence on the water-supply problem. The water from the springs is at present fully used by villages in the valley and near the valley mouth; it supplies approximately 2,000 people, supplemented by three or four qanats. Wilkinson concluded, mainly from research after our return, that there has been no significant change of rainfall since Parthian times.

We are led to the conclusion that if the population of the town at Komis was greater than 2,000, and it seems to have been of a very much higher order, then water

must have been obtained from artificial sources, i.e. wells, reservoirs and qanats. For various reasons the first two are somewhat impractical on an "irrigation" as against a "water supply" scale and one can only conclude that, as they probably knew the qanat technique, the inhabitants may have derived a large part of their water from this source.

Study of the Gusheh Qanat. It had been decided at an early stage that we should make an accurate plot of a local modern qanat, and although we would not be able to make comparisons between ancient and modern qanats, we felt that the study was still worth making. We chose the qanat supplying our village, Gusheh, as being the most convenient politically (*vis-à-vis* the owners of the qanat) and geographically, being the nearest to our house. However, it was rather long and so we took a long time to survey it.

A line of levels was run along the tops of the 360-odd shafts and the distances between the shafts were measured. Then a chain was dropped down approximately one shaft in four to find the channel-bed level. In this way an accurate profile could be plotted. At the same time readings were taken below ground to ascertain losses due to evaporation and seepage. Evaporation losses were found by taking temperature and humidity, and proved to be negligible. The total water loss was found by comparing readings of flow rate taken at various points. Flow rates were measured with a portable 60° notch dam. This was a primitive affair of tin sheet on a wooden framework which was jammed into place across the qanat with sticks. It was made waterproof with a polythene skirt. The dam was quite efficient, but lowering the apparatus down the shafts could be very trying, as dislodged stones would shower down on to one's hard hat like bullets. The hard hat, incidentally, was improvized from a punctured polythene water carrier.

From Gusheh to Tehran. A final part of the project, which was very minor but quite interesting, was our return to Tehran. Mr Stronach, our sponsor, had heard of a track which led up the Dadevar Valley and right through the mountains to the Caspian Sea. He suggested that the track might be of some importance in archaeological terms as a trade route. It is worth noting that an argument against the identity of Komis with Hecatompylos concerns the meaning of the name Hecatompylos —"The Hundred Gated City", i.e. where all roads converge. Even this track through the Elburz would only make the third or fourth road.

We hired a guide to come with us over the route (we had to take his sheep, too) and set off on the morning of 13 August. On the south side of the mountains the weather was, as ever, hot and dry, but on crossing over to the north the road became dangerous owing to the high rainfall. The surface as well as being steep was slippery. However, after eight hours and a hundred miles, we reached the main road on the other side with considerable relief. There were three quite deep fords as well as the other hazards and we managed to stall a vehicle in the middle of each of them. The road was not really dangerous, but it provided a fitting climax to the work at Komis.

TWILIGHT

It may be of interest to some readers that in the early '20s *Twilight* was owned by Lieutenant R. H. Maclaren, MC, RE (later Colonel R. H. Maclaren, OBE, MC).

Wishing to sail her to the Baltic in the summer of 1924, he got a crew of YOs to bring her round from Oban to Gillingham Pier in June, a memorable voyage of 950 miles which took a fortnight. On the last leg Beachy Head was passed at 3 am and anchor dropped at Gillingham at midnight.

The crew were Lieutenant G. L. Watkinson (skipper) and D. M. J. Murray, and 2nd Lieutenants H. S. Francis and H. A. Macdonald.

Twilight

Twilight's Trip from UK to Malta

COLONEL B. G. BLOOMER, OBE

WHEN I retired from the Army at the end of 1967 my wife and I went to live in Malta. Naturally also my 64-year old yacht *Twilight* had to be moved from her base at Upnor to Malta. I had one crew member to Gibraltar, a retired sapper, but unfortunately he developed internal trouble and had to return home from there. In spite of his illness he was a tower of strength, refused to be put ashore anywhere and never missed his trick at the tiller. I am full of admiration for him, and it was his determination to stick it out which resulted in our fast trip (11¼ days) to Gibraltar.

The journey on from Gibraltar was single-handed. It was an interesting experience. I do not think I would like to repeat it, but I am glad to have done such a trip once.

The log, or should I call it diary, that follows is word for word as I wrote it up in the evening of each day on the voyage, from the last port in UK (Salcombe) to arrival in Malta, although I have added one or two notes in brackets since. The point that interested me most was that I never felt alone, there was always someone very real there to talk to. Those who bother to read the log will note how frequently, and quite without thinking, I have used the term "we" or "us" on this part of the voyage.

Twilight was not specially rigged nor prepared specifically for the voyage. Naturally I thoroughly checked over everything, but, except for additional stores and petrol, she was exactly as fitted out for a normal summer sailing in UK waters. I have no radio direction finder, but do have a sextant. This was, in fact, only used in the Bay of Biscay. She carried no self-steering vane; it would be difficult to fit one because of the mizzen, and in any case, as I think the log shows, she manages very well without one. I had plenty of sleep, I never missed a regular meal, and only missed shaving on one day, that of the gale. I can honestly say it was a long time since I felt so full of energy and life as I did when I entered Valetta harbour after 20 days single-handed, of which the last 17½ were continuously at sea.

What the log does not show was that I finally discovered the charging fault, a loose connection on the ammeter. Also the mainsail block was repaired and back on the day after the pin started to work loose. *Twilight* therefore finished the voyage with everything working and all the original gear except the lost log rotator intact.

I think morale must have been low on 25 June when I wrote "time for taking stock", because, in fact, very little had gone wrong. What did amaze me was the amount of chafe modern synthetic ropes will stand. None of the running rigging was new this year and certainly none will require renewing next year. To my mind, *Twilight* is a wonderful and comfortable ship for this kind of trip, but then I am biased and wouldn't change her for anything.

"TWILIGHT"—UK TO MALTA 1968

29 May. Left Salcombe at 0815 hrs on a lovely day with a light easterly. Did some motoring, but made reasonable progress.

30 May. Soon after daylight sea mist came up and with it a freshening breeze. The mist cleared about midday, and the breeze then freshened still more. We went through the stages of reefing, and then downed main. Must have passed Ushant during the afternoon, but saw nothing of it. However, there were plenty of ships and we were right amongst them all night. The wind gradually died during the night.

31 May. A fairly calm day on the whole and we did a fair amount of motoring. Topped up the petrol tank from the cockpit can and then thankfully stowed that below.

1 June. After a dull start the day suddenly cleared about lunch-time and gave us a touch of the breezes and sunshine one always wishes for. Took some photographs.

The atmosphere was now very clear and there were nearly always five or six ships visible. Made excellent progress and continued to do so throughout the night.

2 June. Dawn brought two slight rain showers which caused us to reef, but wind was NW and we continued the excellent progress. The sun came out at 1000 hrs and then started a perfect sail. Had trouble with the water-tank tap. Hoped to sight Finisterre before the night was out, but the best we could do was raise the loom of Cap Villano still some way off. Had trouble with heavy rolling and slatting during night.

3 June. NW coast of Spain lay before us in the morning. We passed westernmost tip Cabo Torianana at 1245 hrs. It was a glorious day and during the afternoon the Portuguese trades set in in earnest. We reached up to 7 knots dead before them before deciding to down main. They increased well into the night and it was rather trying because of the heavy rolling. Finally set reefed staysail, storm jib and mizzen under which she steered herself. The coast of Spain hereabouts was magnificent.

4 June. A magnificent dawn with the mountains of Spain and also, now, Portugal silhouetted against an absolutely golden sky. The wind had let up slowly, and we were not making the best use of it, so after a good breakfast of porridge and scrambled eggs we set the double-reefed main. She now went beautifully and this was almost perfect sailing with cloudless skies and blue seas. The run in 24 hours since we turned the corner yesterday was 106 miles. Unfortunately the evening suddenly clouded up, and it became a most unpleasant night in which we gradually reduced sail to mizzen and storm jib. Worst effect was nil visibility. I had been hoping for a fix from the many powerful shore lights in order to allow me to set a safe course to clear the Berlenga Islands.

5 June. (One week up.) A most unpleasant morning, but managed to find Berlinga OK at midday. The skies then cleared. The run to midday was 110 miles. This finally proved to be quite a day. After the morning near gale and grey skies we had a rip-roaring sail in sparkling seas down to Cape Roca, but at this point were hit without warning by a squall of extraordinary violence. Fortunately we were able to down all sail very promptly, but not before I had seen *Twilight* move faster than ever before. We spent the next two hours under bare poles and trailing warps. A most unpleasant period.

6 June. Started getting under way properly again just before dawn. Later during the morning the helmsman allowed her to gybe whilst the boom gallows was still up. We were very fortunate in being able to pick up the top part of the gallows which had fallen overboard. Distance run in previous 24 hours was about 95 miles.

7 June. The morning brought a complete change of sea on rounding Cape St Vincent. The swell went and also the breeze. Slow progress was made all day. We had not enough petrol to finish the journey to Gibraltar, so every catspaw had to be used. Put remaining petrol into tank during afternoon, but whilst doing so fouled the log line round the propeller. Managed to free it at the cost of 2 knots. By dark we were only 36 miles east of Cape St Vincent.

8 June. During the previous evening a nice little breeze sprang up from the SW and we set the genoa and held it all night. The breeze died for a bit in the morning, and we motored judiciously as petrol is now running short. Set the topsail mid-morning and shortly after that another nice little breeze settled in from the SW. A perfect day.

9 June. We had lowered topsail and genoa just before dark, but the pleasant SW breeze continued throughout the night, and bowled us along merrily. Cap Trafalgar and Cap Spartel were sighted shortly before dawn. The breeze held throughout the morning and early afternoon, and we entered Gibraltar harbour at 1500 hours, just over 11 days and 1,060 miles out from Salcombe. Thus ends the first part of the voyage to Malta. Total distance from Upnor is 1,388 miles.

10 June. It was Whitsun Bank Holiday and it rained all day, so this was a complete loss. Unfortunately my crew seemed little better, so decided to try to book him an air passage back home on Tuesday.

11 June. Fixed him up for the night flight and saw him off at midnight. He was a great deal better today and managed to keep down a decent meal. Feel happier about him now.

12 June. Spent ordering stores and general make and mend for the next stage. Bent on smaller mainsail.

13 June. A glorious day. Stores, water, petrol, etc all arriving during the day. Went out to supper in the evening, and got talking to the Gilberts, senior RAF Met Officer. They took me back to their home for a drink.

14 June. Up at 0500 hrs and underway at 0635 hrs. Cleared Europa Point to a nice little westerly at 0725 hrs. Made steady, although not spectacular, progress throughout the day until midnight, when wind gradually fell away.

15 June. A completely windless day, very depressed, saw no hope of ever reaching Malta. Ran the engine most of the time and decided to put in to Almeria to top up petrol.

16 June. After a windless night a gentle zephyr finally took me into Almeria. Very Moorish old town, but also modern seaside resort. Yacht Club a wash-out, had to anchor and use dinghy. Distance made good towards Malta 144 miles with a further 5 into Almeria making a total of 149. Very hot in the afternoon.

17 June. Managed to get money and petrol during the morning. Sailed at tea-time to a gentle southerly and set genoa. Had to hand this just before Cape Gata, which was abreast at 2230 hrs. Managed to ger her to sail herself downwind whilst I got some sleep, but wind gradually increased to gale and finally hove-to under bare poles.

18 June. Set storm jib during the morning, and in a couple of lulls got under way but full gale returned suddenly at 1130 hrs, and had to heave-to once more after a number of minor poopings. Thank goodness it is warm. The gale persisted all day. I did get under way again for a bit during the evening, but it was too tiring for long. Hove-to again at 2030 hrs and at long last got some sleep. Had been feeling very depressed and very tired. Woke for some supper at 2200 hrs, then back to sleep again.

19 June. Woke at 0100 hrs to find that the wind had dropped. Set storm jib and mizzen and let her sail herself more or less on course. I then had a really good sleep and woke at 0630 hrs to 18 miles on the log, moderate seas and the sun shining. Had a shave and good breakfast and morale was by then very much improved. Made steady progress during the morning, and after lunch I set the main and sailed fast all afternoon until making snug again for the night at 2115 hrs. In 12 hours we sailed 50 miles by the log. This day was a tonic after the previous day, and I felt much more cheerful. Am now on the next passage chart and the following one has Malta on it. at last we are getting somewhere. Let's hope it continues. Three weeks ago we left Salcombe.

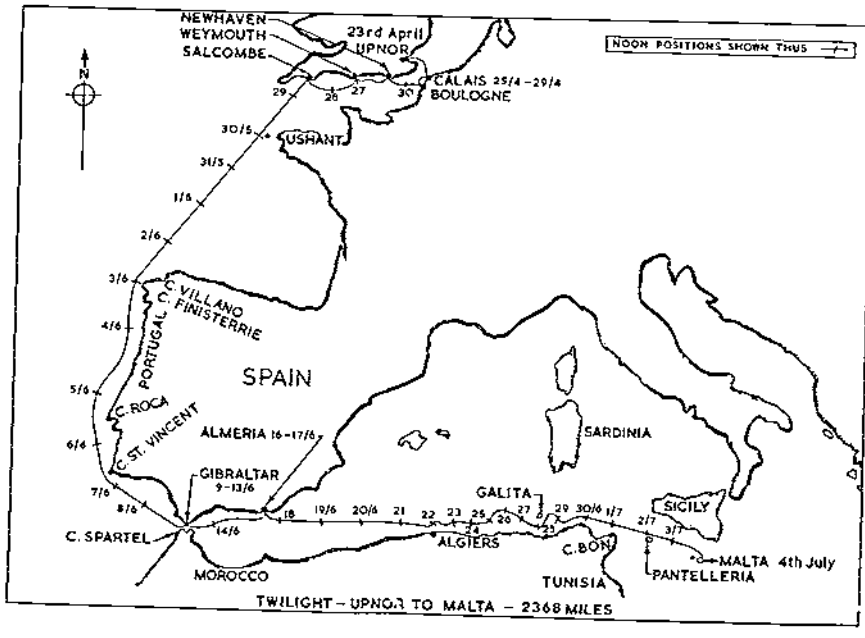
20 June. Twilight had sailed herself perfectly all night. I had set the alarm for midnight, when I checked all round, and I did not stir again until 0600 hrs, and the sun was up. A grand night's sleep and progress as well. Shaved and had breakfast and then set the main and steered. Saw a turtle at 1100 hrs.

21 June. After another good night's sleep I woke to find a zephyr from the south. This never amounted to much, and then gradually backed through east to northeast with most of the time an annoying popple. I became very disheartened at not getting anywhere, and at one moment worked out that at the present rate of progress I would take 60 days! However, I was cheered by suddenly seeing the coast of Algeria clearly about 1100 hrs. During the afternoon the breeze freshened and some progress was made on a SE course, but nothing spectacular. As it looked like a land breeze I thought it would die at sunset and give me a peaceful supper. Not a bit of it. It freshened if anything and, even after downing main, supper was quite an effort in the bumpy sea. However, the day had its reward in that Cap Cazine (near Algiers) was sighted after dark, which put my DR only 10 miles out, 10 miles behind, which wasn't bad after 4 days at sea including one hove-to.

22 June. A rather trying night beating to windward under headsails and mizzen and not much sign of a let-up in the morning. Felt very depressed again. Boat was slamming; trying to do anything in the cabin was sheer murder and we would be lucky if we gained 10 miles in the day. Took the helm for a bit just before lunch, but this seemed to little purpose, so decided to change to storm jib and reefed staysail and heave-to. The effect was miraculous. When will I remember that reducing sail hardly ever slows *Twilight* up; it only makes her more comfortable? She will not gain much, but every mile counts. I then had lunch and shaved in comparative comfort. I deserve a break of a good fair breeze after this. Today's wind, as it is now could put me in Malta in just over 3 days if it would only turn round! No lights visible at dusk, but Cap Matifou and glare of Algiers came up at 2215 hrs. Twenty-five miles progress since last night! Rotator for log unfortunately lost during afternoon.

23 June. Got what I asked for. After a thundery, gusty dawn it settled down to a steady westerly 5–6 and we bowled along under headsails and mizzen and were only 5 miles short of Sighli light by the time I shut down for the night, i.e. 62 miles since early dawn. This puts quite a different view on the rest of the journey. With a bit of luck *Twilight* may well make quite a bit on her own overnight.

24 June. Quite right. By dawn, on a plotted position, *Twilight* had added another 11 miles. Weatherwise this turned out to be a delightful day, but unfortunately the light but steady breeze just would not let me lay the next headland. It was just after starting to motor-sail that I discovered that the charging had ceased. This was serious, since I must conserve the battery for starting. However, after taking off the dynamo (and starter) three times in a gruelling sun, I think I have found the trouble. It is a corroded joint between two field windings. I have soldered a new piece of wire across it. Keep my fingers crossed. Whilst doing all this *Twilight* was not sailing well, and by sunset we had only covered 46 miles since the previous sunset. It will take weeks at this rate. It all seems worse because the magnificent mountain scenery can be seen for miles and you can still see where you were yesterday. Who lives in these hamlets and villages, I wonder? Let's hope for better progress tomorrow. Am going to turn over a new leaf by taking into use the final passage chart which we are now firmly on, and a clean tea-cloth!



25 June. Got the breeze I wanted, but completely ruined by a very lumpy sea until we got to Cap Bourani at tea-time. It really was most trying and the strain on gear from slatting terrific. The pin of one of the mainsheet blocks started coming out, so replaced the block with another one. The charging packed up again. Had another go at repairing it during the cool of the evening, but no luck. This is a nuisance, because, although I can use the gas lamp in the cabin, I dare not use the steamer scarer or navigation lights whilst sleeping. I must preserve the battery for starting. A nice little breeze, but dead ahead, came up in the evening and at long last the seas went smooth. I let *Twilight* potter on on her own and retreated early for two stiff gins and my supper. However, we had made good 52 miles, not too bad, although hardly good enough.

A day for taking stock. (I must have been feeling rather depressed when I wrote the next few lines.) No charging and therefore no electric light for the rest of the trip, some gear beginning to show signs of strain. Still 420 miles to go, but I firmly believe that half of it should be downhill. Only 6 gallons of petrol used to date, have 27 left. This should give me 150 miles if used sensibly. And, most important to my mind, we have got off that middle chart with its long inhospitable Algerian coastline. There has been a jinx in that period—charging stopped, block pin worked out, log rotator lost, bracket for boom gallows broken and a small leak started. Also a gale and force 6 headwind. Things will now improve, I hope!

26 June. Certainly the weather and sea changed overnight. But E × N when course is east. Result, having sailed hard all day, and including that done during the previous night, only 42 miles on the way. Fortunately I had had a good night's sleep, but this is getting us nowhere with 380 miles still to go. There was too much breeze for motoring straight into it and there is every sign that tomorrow will be the same. If no improvement tomorrow, may try sleeping by day and motoring at night, when it goes quieter, but I shall find it very tiring. Position is 18 miles NE of Cap Fer.

27 June. Definitely a better day. Firstly the seas had gone right down and I was able to top up the petrol tank whilst sailing. Washed some pants and had a bath in the cockpit during the afternoon. Progress was slow but peaceful in the morning, but during the afternoon it improved considerably and yet remained smooth until dusk, when it got a bit lumpy. It also had slightly more north in it, and we laid on course for a bit. Was all this in answer to my prayer of yesterday. Let's hope this really is the turning-point and we are getting into the prevailing westerlies. We just made our 50 miles today. She is sailing on well tonight, but, of course, half the speed a helmsman would give her. Picked up Galita light at dusk. Must now watch out for the other islets, which are only just north of course. A perfect sunset.

28 June. A perfect sunrise, but breeze picked up and sea rather earlier than usual. By afternoon the sea was a pig, and I had to put a reef in to relieve the thumping on boat. Progress was painfully slow, although every inch was hard work. Stood right in towards shore in the hope that water would become quieter and possibly land breeze take effect. Downed main at supper-time after only 30 miles made good, about 10 miles west of Cape Serrat. Hoped *Twilight* might make some headway on her own by tacking her about every hour in the smooth water. Whilst having supper suddenly realized that there was a deadly stillness. Looked out, and sure enough not a breath nor a wave. Never have I seen such a quick change. Decided to cheat it and, although tired, motor some way up the coast tonight in the calm, even if I have to sleep tomorrow. I must turn the corner somehow tomorrow.

29 June. If you must go to windward, what a perfect afternoon and evening for doing it. A lovely breeze and smooth seas. In the morning in spite of motoring a bit I did not seem to be getting anywhere until I realized that I had been taking bearing on the wrong Cape and had in fact done 10 miles extra. The shores are now less mountain-bound, so for a change tacked close inshore. This proved more interesting and I think gave even smoother water. Managed to top up the petrol tank during the evening. We only achieved 30 miles again, but this was virtually all in the afternoon

and in comfort. The vital thing is that we are now rounding the tip of Tunisia and beginning to line up for the run in to Malta (even though 200-odd miles). In theory, anyway, we should now have finished with dead nose-enders. We shall see!

30 June. The wind, if you can call it wind, became a fair one all right, but only zephyrs all day. Part engine and genoa doing enormous good at times allowed us 39 miles, but it will still take weeks at this rate. 215 miles to come. In spite of the lack of progress it was a wonderful day. I have never seen sea so smooth or such a colourful sunset. I had supper in perfect peace sitting at the table. We are just slowly drifting eastward. Position is now at the western end of the gulf of Tunis. We are at least pointing towards Malta and only have Cape Bon and Pantelleria to watch go by.

1 July. The best day since Gibraltar. A fair wind on the quarter of pleasant strength, although a bit weak till mid-morning. It is also continuing this evening and giving us some 2 knots although partly hove-to. Did 65 miles, and am now looking for the lights on Pantelleria. No petrol used, so still have a tank full. Had another cockpit bath.

2 July. This morning my morale was very low; reason, fog (Pilot says practically unknown), headwind, and not absolutely certain of my position relative to Pantelleria, also petrol getting low. However, by stages during the day things improved. The fog lifted soon after the sun got up to reveal Pantelleria where it should have been. I also discovered that I had a gallon and a half more petrol than I thought. It was a day of frustrating zephyr headwinds, but managed to make progress, particularly close inshore of Pantelleria. This is more of a place than I realized. I hesitated whether to put in to top up with petrol, but it would have meant a whole day what with getting to a bank and harbour clearance, etc. It was very hot in the afternoon and the sea absolutely still, so the slightest zephyr had quite a good effect. The fog returned with evening, but to my joy brought with it a gentle northerly which is still hanging on. Anyhow, I have no islands in front of me to worry me tonight. Made 46 miles during the day; about 112 miles to come, but at any rate there are no further headlands or islands to be passed. We are definitely in the finishing straight.

3 July. "O's" birthday and I had hoped to be with her. Was lucky in that the breeze turned westerly, although there was a good deal of fog and haze till midday. Progress was also mediocre during the day. Had expected to pick up Gozo light that night, but did not. Am now slightly anxious as, due to the heat haze, it will be difficult to find anything by day. Felt very depressed all night and quite stupidly began to think I would be wandering aimlessly about the sea for ever.

4 July. A certain amount of common sense prevailed after a good breakfast and a wash. The to and fro of aircraft began to confirm my DR position and at any rate I made a plan for closing the land. Unfortunately, due to the slight uncertainty, I cannot make full use of the breeze. Had no sooner written the above than lo and behold there was Gozo on the starboard bow quite reasonably close. My navigation cannot have been very much out; it must have been haze obscuring the light all night. What a relief and what a wonderful thrill after 2,340-odd miles. Motor-sailed all afternoon in order to get in before dark. Decided that Gozo and Malta look even better than I thought from the sea. *Twilight* wanted no hand on the tiller, she knew the way whilst I tidied self and ship. Frankly you wouldn't know that she had not just come in from a week-end down the Medway if it were not for the extra petrol cans on deck. What a wonderful evening entering Grand Harbour at 1800 hrs.

* * * *

So ended the 2,368 miles trip from Upnor. *Twilight* really was in good shape and needing only minor maintenance. She is a grand ship for serious cruising. You can store unlimited stores on her and retain every comfort. She sails herself when required on practically any course. This was a voyage to remember, although I would not like to repeat it.

REYC/RESA *Ravelin*

On Saturday, 8 March 1969, Lady Jones, wife of General Sir Charles P. Jones, GCB, CBE, MC, the Chief Royal Engineer, launched *Ravelin*, the new 43 ft ocean racing yacht for the Royal Engineers Yacht Club and Sailing Association.

Ravelin was built by Camper & Nicholsons at their Gosport yard. The yacht is a Nicholson 43 glass-fibre sloop, identical to the one awarded a Gold Medal as Boat of the Show at the International Boat Show. Music for the occasion was provided by the Band of the Army Apprentices College, Chepstow. The piper in the picture is Apprentice Pipe-Major Hoffman. On board *Ravelin* are Captain J. G. Tulloch of the REYC and Corporal M. Wood of the RESA.

The Royal Engineers Yacht Club, the oldest Services yacht club and one of the pioneers of ocean racing, intends to try for a place in the British Admiral's Cup Team with the new vessel.

REYC. RESA Ravelin.

Construction Plant Management in the Army

LIEUT-COLONEL P. G. L. MITCHLEY, MBE, RE,
FIPLANTE

Introduction

The need for economy in the Armed Forces was emphasized in the Supplementary Statement on Defence Policy 1968 (CMMD 3701), and nowhere is this more vital than in the field of construction plant used by Royal Engineers. Economy of plant means good management. In commercial practice this is reflected in profits; that is getting the highest output possible from each machine while plant is on site and minimizing periods when it is not being worked. The key to this is having the most modern and up-to-date equipment, training operators, fitters and plant managers to a high standard and having a good repair system.

In operations and in training for operations the Army has exactly the same requirement as the commercial contractor. There will always be a shortage of time for completing a task, so plant has to maintain a high output and remain serviceable over long periods. Failure to achieve this will have more serious consequences than in the commercial field, as lives will be at stake rather than money. Good plant management is, therefore, of vital importance in the Army.

The Lonnon Report and the Lindsell Report went a long way towards rationalizing the Army's plant holdings and providing up-to-date equipment. This is one side of management, which can be termed Staff Management, and is already resulting in better equipment coming into service. If this equipment is to be fully effective, the remaining facet of management, Field Management, must be efficient. The term Field Management here covers the deployment, operation and repair of plant, and ensuring that downtime due to bad planning and breakdown is reduced to a minimum.

Aim

The aim of this paper is to examine the Field Management of construction plant in the Army and make recommendations on how it can be improved.

DISCUSSION

General

In the Army construction plant is mainly used to carry out tasks identical with those which are met with in commercial practice. This was recognized in the Lindsell Report and led to the recommendations that where available standard commercial equipment should be used. This policy is now being implemented with the exception of a limited number of military specials which are necessary to enable plant to operate in peculiarly military environments, eg Rough Terrain Crane, Combat Engineer Tractor and Light Mobile Digger.

In considering plant management in the Army it is, therefore, relevant to make comparisons with efficient commercial firms with similar holdings of plant. In the main civilian plant contractors operate in a limited area and not worldwide; in drawing comparisons, therefore, it is proposed to equate plant management by a big civil engineering contracting company in UK with that of the Army in one operational theatre—BAOR.

Before considering the management system in the Army in detail, it is important to define clearly the term "construction plant" and to clarify what constitutes good plant management.

Construction Plant

The term construction plant covers all vehicles mainly used by sappers on engineering tasks and projects. At present these fall into the following three categories:

(*a*) *Engineer Construction Plant* (*ECP*). Road and airfield construction plant covered by DCI 13/69.

(*b*) "*B*" *Vehicles*. Mobile equipments and specialist trailers whose primary role is in support of engineer construction tasks, eg tippers with special bodies, compressors and transporters designed and provisioned mainly to carry "C" vehicles and ECP.

(*c*) "*C*" *Vehicles*. Vehicles allocated solely or mainly to sapper units. These are road mobile construction equipments, including some cranes.

The Lindsell Report recommended that these three categories should be combined in a single one called E (Engineer) vehicles, to improve management. This recommendation has not yet been accepted, but it is an essential step towards improving managements at both Staff and Field levels.

Field Management

Plant used by engineers, in common with the majority of other engineer stores, differs from most other stores and equipment used by the Army in that the types and quantities required in a particular circumstance cannot be based on predetermined scales, but will vary with the environment. For example, the number of bulldozers to build a road cannot be fixed in the same way as rifles to equip a battalion. This difference is fundamental in understanding plant management.

The full scope of Field Management includes the following facets and desirable aims:

(*a*) *Training*. Operators, fitters and management staff concerned with the employment and operation of plant must be trained in their tasks.

(*b*) *Provision and Manning*. Types of plant provided for each project must be carefully selected and phased in to carry out the various tasks involved. The numbers of each type must be balanced so that machines are not underemployed nor idle while other tasks are being completed. If all plant is to be used economically there must be sufficient operators to allow 100 per cent manning at all times.

(*c*) *Control*. The output potential of engineer construction plant is very great; a heavy tractor can do the work of 600 men. However, this potential is only developed to capacity when plant is deployed economically, is in good working order and is being operated correctly.

(*d*) *Maintenance and Repair*. A good system of routine maintenance and inspection is necessary to keep equipment in top working condition, to give advance warning of mechanical breakdown, and execute repairs with the minimum delay.

(*e*) *Spares Backing*. Efficient routine maintenance and rapid repair will demand a system of spares backing which reduces downtime to a minimum, and at the same time does not impose unnecessary administrative overheads.

Comparison between Army and Commercial Plant Management

There are major differences between Army and commercial plant management systems. Some of these are due to basic differences in role and method of operation. In war the Army must be prepared to carry out a large variety of tasks at short notice and without the immediate backing of civil industry; training in peace must simulate these conditions. Stocks of equipment and spares have to be bought to meet a general requirement which must be to a very large extent a matter of guesswork, so types and quantities will not always be suited to one particular task. In this respect the Army has a more difficult problem.

Another major difference is in the overall role of the Army, which is to fight; it is organized to deal with units of all arms using tanks, guns, aeroplanes, ammunition, clothing and rations, in addition to engineer stores and equipment. The command

and administration by the G, A and Q Staffs of engineer units and their equipment is carried out to a general Army pattern in the interests of uniformity, and does not always suit the special requirements of engineers. The civil engineer contractor on the other hand is concerned wholly with engineering and both command and administration is tailored to meet its special management problems. However, although the role of the commercial contractor is different from that of the Army as a whole, it is very similar to that of the Royal Engineers. Both are concerned with construction tasks which have to be completed efficiently in a variety of environments. Their management problems are therefore the same and where good plant management does not fit the standard Army pattern, exceptions should be made.

Training

An Industrial Training Board school exists to train civilian plant operators, and some firms have their own training schools; most firms, however, rely to a large extent on site training or on hiring already trained men. A potential operator for a large excavator or tractor can spend two years as a banksman or greaser before being given a smaller machine of his own. He then graduates to a larger machine as he becomes more experienced. General labourers are used as drivers for dumpers and to operate concrete mixers, etc. Staff concerned with the management and operation of plant also learn by experience and do not attend formal courses of training; tradesmen employed on maintenance and repair, however, graduate through normal apprenticeship training. Experience over a good number of years produces efficient managing staff and operators with a wealth of practical know-how.

Military operators are trained to operate a greater variety of types of equipment than their civilian counterparts; in addition it is unlikely that they will have any previous experience on enlistment and there is insufficient time to train on the job. Therefore the basic training of all those concerned in the management, operation, maintenance and repair of plant is carried out on courses; these last from seventeen to thirty-six weeks at Army schools. On these courses a soldier is taught the basis of his trade or management responsibilities, but he only becomes proficient and capable of developing the full potential of the equipment he is responsible for after considerable practical experience. This can only be obtained in the unit.

Individual training in the Army is superior to the commercial system of learning by experience, but is wasted unless trainees consolidate what they learn on courses through practical experience. Military plant operators and supervisors are usually less skilled than their civilian counterparts due to lack of opportunity to exercise and develop; given the same amount of practical experience, their better initial training would make them superior. Military Plant Foremen who have been attached to civilian contractors have on occasions effected a 100 per cent increase in output by applying methods taught on RSME courses. The Corps is increasing the scale of project training involving the use of plant and this should lead to an improvement in standards.

Provision and Manning

In the Army, plant is held in units in sufficient quantities to meet routine operational roles in support of all arms: this scale is sufficient only for basic tasks in a stereotyped setting and a reserve of plant is held in Engineer Pools. The number and types of equipment in these Pools is arrived at by making a compromise between what could be needed to meet all eventualities and financial limitation. Further stocks of "C" vehicles are held in Ordnance Depots, but these are used for replacing unit holdings and equipping reserve units and cannot be released to meet other demands except under the authority of the General Staff.

Where additional plant is allocated to units from pools, the machine is supplied without operators or fitters. This often means that a unit tradesman has to operate and maintain more than one machine, with resultant poor maintenance and underutilization: the latter becomes chronic where more than one shift is being worked.

Where the additional plant is complicated and unfamiliar, it will not be used efficiently until the unit has become experienced in its operation; in the meantime it may be misused and damaged. These major defects in the Army system of provision and manning can be overcome by including a small establishment of operators and fitters in pools so that the more sophisticated types of plant (e.g. SGME concrete batching plant) can be issued with one or two trained operators, and by increasing the operator establishment of field units. Greater economy in plant operators can be achieved by following the civilian practice of training non-tradesmen to operate dumpers and simple construction plant.

The main difference in commercial and military use of plant is in the utilization rate, which on average is in the proportion of 5:1. As a result civilian plant wears out more quickly and is normally cast after about two to three years' use as opposed to the Army's ten to fifteen years. As commercial projects last on average two to three years, plant is normally provisioned specially for a specific contract and written off against it. At the end of the contract plant may, in fact, be worth overhauling and using again; it is not, however, purchased against possible future tasks and kept in a reserve pool as in the Army. This makes the Army's problem of providing sufficient numbers of the most suitable types of plant for each engineer operation more difficult. Theoretically greater efficiency and economy would be obtained by withdrawing plant from field squadrons, concentrating it in support squadrons and pools and deploying it to meet specific demands. However, such a system has one great disadvantage in that the great majority of personnel in field units would lose familiarity with the day-to-day use of plant, and it is therefore not advocated except where plant is seldom used by units in their normal training.

Control

Site control of plant in the Army is a sapper responsibility which is exercised through the normal engineer chain of command, culminating in Plant Troop Officer, Military Plant Foreman and Plant NCOs. All sapper commanders should be experienced in the management of plant and all officer courses at RSME cover this subject. On a commercial site plant is controlled by the general foreman and gangers, who have general responsibilities and very rarely have had any formal training in plant management. Site control is therefore potentially better in the Army, as all those involved have had course training: in practice it is frequently worse due to lack of experience.

A high degree of technical knowledge and experience is needed by planning staff to select and allocate a balanced fleet of equipment for a complex engineer project. In the Army this is mainly the responsibility of Engineers, but Q Staffs, who control Ordnance stocks, and G and A Staffs are also involved. All have responsibilities for other functions and types of equipment, so none are expert or fully conversant with the technicalities of the plant they are managing. The complexity and divisions of responsibility of the Army system is shown diagrammatically in Annex A.

In commercial life a single plant manager, who is a specialist, controls all management function at each level. This obviously leads to far better management in all its aspects. The position in the Army can only be improved within the existing structure by appointing a Plant Manager at each level of command to co-ordinate the management functions of all the various branches and Corps involved. As RE alone are concerned in all aspects and are the user, this officer must be a Sapper: needless to say, additional manpower cover is not likely to be made available, so this will be one more "hat" for an existing sapper staff officer. This system is already working well in FARELF and BAOR.

Plant management requires a mass of up-to-date data on utilization rates, availability, performance, repair costs and repair delays. This information is now being collected through the REME "FORWARD" system and collated by computer. When sufficient significant data has been amassed, it will be disseminated through normal command channels.

Maintenance and Repair

In theory the responsibility for maintenance and repair of plant in the Army is divided between RE and REME; RE being responsible for ECP and REME for all other equipment. In practice, because the plant is working on engineer tasks and is being operated by sapper plant operator mechanics, Royal Engineers are concerned and involved in the maintenance of all equipments they operate and frequently also in the repair of "C" vehicles. At unit level an integrated RE/REME workshop is responsible for all plant repair in the Regiment but at formation headquarters, A/Q, RE and REME staffs have all responsibilities for policy and supervision. Unit establishments of fitters are designed to cover the unit and field repair of plant only and are on the scale of well under one fitter to four machines. Plant is backloaded to RE and REME plant workshops for base repair, which can deprive the project of the equipment for a matter of weeks. Repairs and replacement of components are carried out as they become necessary due to breakdown and not to a predetermined programme. This has resulted in some worn machines having to be returned for repair at frequent intervals for different reasons; with the introduction of the casting scheme this should improve.

On a commercial site, maintenance staff under a foreman fitter have on average a strength of about one fitter to every ten machines; this can vary with the complexity of the machinery. These are responsible for all maintenance and repair, which in most cases are carried out on site. Major repairs are effected by replacing complete assemblies, eg engines, gearbox, etc. Exceptions to this can be small pieces of plant, eg site dumpers, which are often replaced completely. Components are replaced when it is known that they are likely to be unreliable (preventative maintenance) and depots supporting a region carry out base overhauls on major items of plant which have not reached the end of their economic life. Costs of repairs and spares are charges to individual project accounts and reflect in the amount of profit made on the contract. This in turn affects the bonuses to all staffs and operators. When a machine is out of action the operator is not able to earn any production bonus and if the breakdown is due to his negligence he may well be discharged. In this way operators and staff at all levels have a personal interest in keeping plant working efficiently and serviceability rates are well over 90 per cent.

The Army has a lower serviceability rate than a commercial firm could tolerate and still remain solvent, despite an often higher proportion of fitters to machines. This is not due to weaknesses in the system so much as to breakdown in it, and to the lack of experience of those concerned with operating and repair. More experience and sufficient operators for each to be responsible for only one machine at a time will effect an improvement.

Even in a short economic plant life of three years, contractors find it pays to replace components and completely overhaul a machine after a certain amount of usage or when workshop facilities are free which would otherwise be wasted. The Army, whose plant may have to last three or four times as long, should consider introducing preventative maintenance and planned overhaul to eliminate a succession of minor breakdowns on site. In addition plant should be thoroughly checked and if necessary overhauled before it is sent on a major project in a remote area. To reduce delays to projects due to breakdown the Army should follow to a greater extent the commercial practice of carrying out all repairs, including base repairs, on site. These should be done by forward repair teams from unit workshops replacing complete assemblies where necessary; the assemblies could then be backloaded to base workshops for overhaul and subsequent reissue.

Spares Backing

The system of spares backing varies slightly between the Royal Engineers and RAOC, but in general scales of spares are held in units to cover unit and field repair and in base workshops to cover base repair. Further stocks are held in Engineer and Ordnance spares depots. A/Q, RE and RAOC staffs on Formation Headquarters

have responsibilities for policy and supervision. Where scales are correct there should be few delays in carrying out unit and field repairs, due to spares shortages. Where base repairs have to be carried out in the field, the only delay should be in the time taken to send spares or assemblies to the unit from the base workshop or spares depots. In practice the scales are frequently found to be inadequate and delays of weeks and months are experienced in obtaining spares which are sometimes not even available in Command Stores Depots. On the other hand, quantities of spares are held which are not required, causing an additional administrative load on units. The reasons for this can be:

(*a*) Scales are based on previous worldwide experience. The conditions of use for a particular project, due to environment differences, may bear little relationship to those planned for.

(*b*) Spares which have not been used for over a number of years are outscaled by Ordnance stores sections. The lack of demand for these spares is often due to individual items of plant being new or having low utilization; when utilization rates are increased or the equipment becomes worn, spares are not available when required.

In commercial practice no spares are bought with new equipment except those necessary for normal maintenance (filters, fan belts, etc). Spares stocks are built up in depots according to experience and ordered from the manufacturer to meet demands. On some sites where large numbers of equipments of the same make are used the manufacturer maintains a range of spares; at the end of the contract only those used are paid for. The minimum of the contractors own spares are kept to reduce capital lying idle and administrative overheads, and strenuous efforts are made to stop hoarding on site. When assemblies or spares are required, site staff contact their parent depot direct by telex or telephone. Whether available in stock or bought from the manufacturer, they are despatched by passenger train to the main-line station nearest to the site; from there they are picked up by site transport. In this way assemblies and spares reach the site within twenty-four hours of demand and downtime is kept to a minimum. This system depends on plant being new enough for spares to be easily available, and on it being reliable and robust; these latter characteristics can outweigh a higher initial capital cost.

Conditions in war make it impossible for the Army to rely to the same extent on the manufacturer for spares as commercial firms do. In addition the vulnerability and complexity of lines of communication make it essential to be self-supporting for a considerable period. A greater quantity and variety of spares must therefore be held forward with the plant. This is costly and cannot be justified unless the spares held are the right ones. The present scales are not suitable for use on projects where high utilization of plant takes place and need revising.

Delays of weeks or months in spares provisioning are unacceptable, and unnecessary where they are available from the manufacturer. Correct scaling should make the recourse to the manufacturer a rare occurrence, but when necessary the system should be rapid and allow delivery direct from the manufacturer to the unit. As a medium-size machine should be costed at about £4 an hour, any additional expense involved is far outweighed by the cost of keeping plant idle.

Conclusions

Plant management in the Army is not as efficient as that achieved by the best civil engineering contractors. This is to some extent due to management functions in the Army being standardized to cover all types of units and material. Although the roles of the Army as a whole and a civilian contractor are different, that of the Royal Engineers is in many cases the same; this is especially true where plant is concerned. In instances where the standard management procedures in the Army are not compatible with good plant management it is therefore necessary to deviate from the system to effect an improvement. This is already done for the Royal Army Medical Corps. The alternative is to accept low standards.

The main change required is to unify the Staff Management of ECP, C vehicles and specialist B vehicle. This has already been recommended by the Lindsell Report and is beyond the scope of this paper, which is confined to Field Management. Improvements can be effected in all aspects of Field Management within the present system in the following way:

(*a*) *General.* Giving all concerned with all aspects of plant management greater experience by undertaking more construction training.

(*b*) *Provision and Manning*

(1) Holding sufficient plant operators in units to enable additional plant to be absorbed without loss of efficiency.

(2) Operating dumpers and small construction plant with combat engineers to economize in plant operators.

(3) Including more plant operators in the establishment of Engineer Pools so that specialist items can be manned by soldiers who know how to operate and maintain them.

(*c*) *Control.* Designating a sapper staff officer as Plant Manager at each level of command to co-ordinate the work of all concerned with plant management.

(*d*) *Repair and Maintenance*

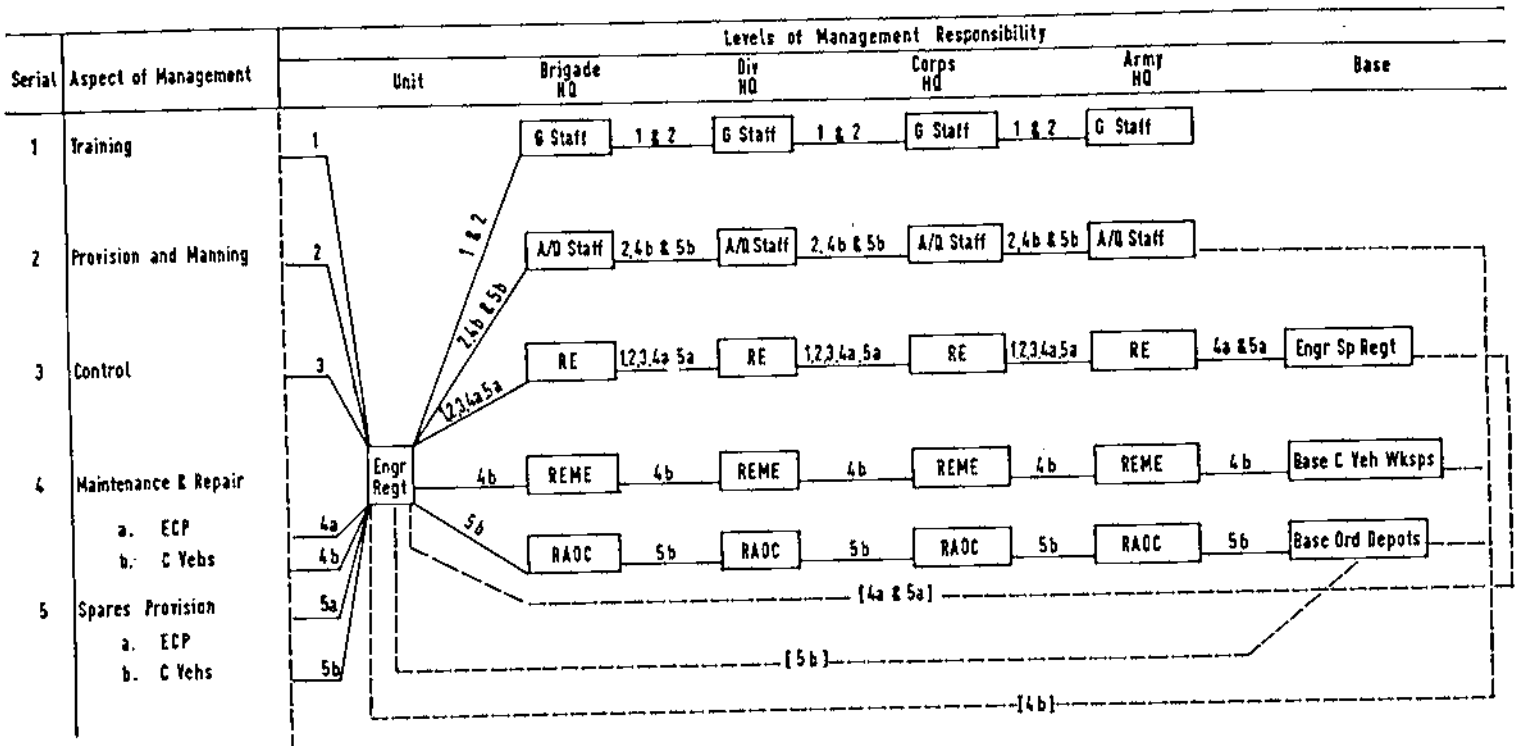
(1) Providing suitable fitter and spares backing so that all repairs can be carried out on the field. This may involve replacing complete components to a greater extent than at present.

(2) Introducing preventative maintenance and planned overhaul to increase reliability.

(*e*) *Spares.* Revising the system of spares scaling so that paper scales relate more closely to what is required to support units on engineer projects.

Annex A

CHANNELS & RESPONSIBILITY FOR FIELD MANAGEMENT OF CONSTRUCTION PLANT IN THE ARMY



The Works Manager

LIEUT-COLONEL F. A. RICHMOND, ERD, FIEE, MINSTF, MBIM

Being a Works Manager is rather like commanding a Regiment. When I was away at Annual Camp with the Army Emergency Reserve (I was Second-in-Command of an RE Regiment) orders were published that I was to command the Regiment and, a few days later, there came a telegram from my Divisional Managing Director telling me that I had also been promoted Works Manager. The ensuing Guest Night still lives in my memory as an extraordinary event. The rank of a Works Manager in a large firm is slightly higher up the hierarchy than the equivalent of a Lieutenant-Colonel. Above you will be perhaps a Divisional Managing Director, the Chairman of the Division who may be a Main Board Director, and the Chairman of the Main Board. That is three steps yet to go to the top, as opposed to five in the Army. If the works is a big one, with 4,000 or more people, then it is more like commanding a Brigade. My works was a small one of about 500 persons, but it was a highly capitalized chemical plant worth about £3½ m, and it was situated in the north west just across the border into Lancashire.

The process was hard and dirty and one that never shut down. It operated on a four-shift basis which gave a forty-two hour week. Three shifts worked each day from 6–2, 2–10 and 10–6, being known as the morning, afternoon and night shifts. The fourth shift was resting. This part of Lancashire does not have a great deal of continuous shift work and this, allied to the tough process, made it different from other works in the district, bringing with it its own peculiar type of morale. It was almost as though our workers felt that their hard and dirty shift work gave them a sort of superiority over others employed in easier, cleaner and more sheltered jobs. They were a splendid lot and the six years that I managed the factory were the happiest of my managerial life. The fly in the ointment was living in the Mersey Valley with its miserable winters and dirty atmosphere.

My period of office was during the last six years of the fifties and the factory had been operating since 1917. There were some men who had been there since the beginning and several who had started there after demobilization in 1918 or 1919. The Firm gave a gold watch after thirty years' service and several men went up to London to receive these from the Company Chairman. There was Albert Ashworth, who, when given his gold watch, said: "Thank you, Sir John. If it keeps as good time as I've kept, it will be all right." This man used to live in Cheshire countryside and cycled daily ten miles each way to and from work for a 7.30 am start. He had never lost a day's work through illness and hardly ever was late. He had the task of loading the chemicals and getting the right tanker to the right customer and he was absolutely reliable and never made a mistake.

There was Raymond Holt, who had spent all his life in the Manchester slums. He sold newspapers barefoot as a boy because, so he reckoned, "you sold more papers that way". He said that he used to sell them outside the *Manchester Guardian* office and that Scott often gave him two shillings as he mounted his bicycle to go home for lunch. This man was a real character. He had been brought up as a Socialist, but, on reaching more mature years, he rejected Socialism. He used to say to me: "I was brought up to believe that you beggars rode on the backs of the workers, but I can see now that we have to have people like you or else we would never get anywhere." He hated what he considered unnecessary running to shop stewards to settle grievances, believing that he would do things better and quicker by a direct approach to management and, by and large, he was probably right. He had a highly developed sense of humour. He ran a gang of men on a dirty job. He told me one day that they asked for an issue of gloves and he described what had happened and

how he had dealt with this, saying: "So I said to them—Gloves! you can't bloody well have 'em." Then in a lower tone: "You know, sir, you've got to use psychology with the beggars."

When I first got to the works his job was done in a higgledy-piggeledy way, with little method, and I wished for it to be made better. I therefore borrowed a method-study man to look at his job and the two were walking across the works to go to the boiler-house. As they went Holt told this man how men skulked about the factory hiding in corners and dodging work and, whenever they were found, it was always the same thing—they were reading the *Daily Herald*. As they entered the boiler-house they climbed to the top of the boilers and there was a man reading a paper. He put it down when he saw them and moved away to his work. "That's the sort of thing I mean," he said as he walked over to the paper and picked it up. It was the *Daily Mail* and without a blush or hesitation he said: "Of course, he isn't quite so bad as the others." He used to tell me that, when I went home and things were left to the shift men, the law of the jungle reigned.

Then there was the blacksmith who had amassed quite a small fortune in buying and selling property. He was on a jury where a pretty false alibi, which was fairly well shredded by the prosecution Counsel, was doubted by rather a wishy-washy jury, and he stuck it out for four hours, firstly as the only one wanting to bring a verdict of guilty and gradually winning all the others over. When the verdict was brought in it was found that the defendants had records from Borstal to prison and back again and were obviously a thoroughly bad lot. He made a pair of ornamental wrought-iron gates for the works out of scrap material. These were photographed and published on the front cover of the Firm's magazine and the directors ordered that he be given a present of £5 for his initiative.

There was the foreman fitter who just revelled in a crisis or breakdown, performing prodigious feats of work and infecting all the men with his enthusiasm. As we gradually brought methodical maintenance to bear the crises disappeared until one day he told me that life was now dull. I said that continuous sustained production was what we wanted, but he hankered for the old days and the excitement of crisis and breakdown.

It is hoped that these few little sketches have shown that this was a works with high morale, with men who could stand up and look you in the eye, with men that you could like and respect, and enough stories came back to me, since I went away, to know that there was some affection for me too.

In British industry in general there is not enough of this spirit. It is there in many small firms, but not usually in large ones. The case quoted above was a large firm, but it was a works in a small division with only three factories of which mine was the largest, and it was, in fact, almost like a little firm on its own.

Readers with Service backgrounds and professional people who look at industry from the outside and whose information is mostly based on newspaper reports must think that things look very grim. Rampant and militant shop stewards appear to rule the roost over a subdued and weak management, so that it appears that the whole country is held to ransom by the minority. Yet industry is the life blood of the nation. It is because industry has not done as well as it should that we have had our recurring economic crises. It is because our productivity increases do not match our income increases that the world at large is beginning to doubt our ability and the pound has fallen on hard times. The annoying thing is that we ought to be able to contain this. We have the expertise and the management potential in the country as a whole, but not apparently where it is wanted. Our record in war was so good. The way we geared industry to the war effort, and the way we expanded the Armed Forces at great speed showed what we can do, particularly when we bring all classes of people into the picture and when people are stretched and challenged. Look at the way we ran the Empire, with young men, not yet thirty, in charge of Districts the size of Spain and administering the whole area. It is not that we have not got the men, the courage, the traditions nor the leadership; it is just that we are not using

them, and this makes me both sad and frustrated. The shame is that we know how to do it and yet British industry by and large is not doing it. One great pity is that industry does not take lessons from the Armed Forces and the Civil Service about how to do things, particularly in the case of handling large organizations.

My Service experience is purely Army and, therefore, I relate my civil management experience back to that, but I do not think it invalidates the argument. The first thing we should discuss is communications. A regimental commander has many ways of communicating with his men. He has daily Part 1 Orders. By using a little imagination he can make them quite a good source of communication between him and all ranks. He can address the Regiment on parade. He can address his officers and they can address their squadrons or troops and, as this involves fewer persons, they can ask for questions and get a discussion going on any matter that is thought fit. So the channels of communication between a Commanding officer and his men and back again are many and various and there is no excuse for not using them. With a good Commander at the head who understands his men there is no excuse for bad morale. In addition Service commanders are taught to use these methods to get good morale, whereas industrial management is not. Perhaps this is being taught now in the new schools, although this is open to doubt, but it hasn't been taught in the past and it will be at least another decade before some managers, who have been taught these things, will be in a position to use them.

For the Service-trained manager, then, it is not impossible for him to address his men when an incipent strike is brewing and, by this action, to find out what is wrong and put it right, thus gaining prestige by showing that he is interested in the problems and not skulking in his office and hiding behind a personnel officer.

Of course, he must not address his men over the head of the shop stewards. Many readers may be puzzled about the shop-steward movement and so a little explanation may be necessary here. In the last century and the early part of this one men lived close to their work. The Trade Unions were organized in Branches. When a matter demanded attention the men attended a Branch Meeting to air their grievances and to decide what to do about it. Resolutions put by Branches about Union business pass up to higher conferences and can end up at the Union's Annual or Biennial Conference. The Branch is a properly constituted unit of the Trade Union hierarchy. The idea of the "shop convener" was first introduced in Scotland during the 1914–18 War as a man through whom grievances were channelled to management, but after that period he disappeared to reappear in the late thirties and forties in England as the shop steward.

People do not live close to their work any more. Trade Unionists at work may belong to different Branches of the same Union, as these are based on where they live, so the shop steward takes up Union matters at the place of work and Branch Meetings are very lightly attended. The Trade Union rules cover all aspects of Branch work, but have nothing to say about shop stewards except Unions that have been lately formed such as DATA.

The shop steward is, therefore, in an invidious, and at the same time advantageous, position. He has not the backing of the Rule Book for any position he may take up. On the other hand, however, he has no rules to break when he takes high-handed action. Nevertheless the shop steward is a sort of Trade Union Father and Mother to all the Union members in a shop, and he or she is elected democratically and properly and is recognized as such by the Unions. So sensible managements do not by-pass this properly appointed representative of their workers. On the contrary, if they know what he is doing and use him properly, as he should be used, they often get better communications and relations with their workpeople without losing their prerogative of managing properly. Some managements, however, never meet their shop stewards, or only meet them when there is a crisis. This, of course, is madness. There is nothing to stop a manager calling a meeting of shop stewards when there is nothing to discuss or only small items. A distinction can be made between meetings at which only discussion will take place and other meetings for negotiation. Usually

a negotiation which has been talked over earlier, at a previous discussion meeting, will go through much more smoothly than one that has not. Also there may be a choice of decision and obviously, if one of these choices will be accepted better than another, then the wise manager will make the first one and have a happier shop. His discussion meetings with his shop steward will inform him of shop-floor opinion so that he can gauge this and, by making the right choice, get better work out of the men.

So what does the manager do about communications? He meets and talks to his shop stewards as and when necessary or preferably regularly, say once per month. There is nothing equivalent to Service life here. He can issue a monthly Newsletter (Part I Orders). He can address his personnel at, say, a Christmas party, a pensioners' party, or in a crisis, formally (addressing the men on parade). He can talk to his foremen and get them to have a meeting of their men in their shop (telling the officers to talk to their soldiers and report back to the commander).

This leads up quite naturally to the subject of training. In the Army junior officers and sergeants are expected to stand up in front of their men and to talk to them. The average British industrial foreman is not trained to do this, nor is he usually trained in the basic fundamentals of man-management. He should be so trained. Until lately the average manager was not trained either. I was an engineer, and my management training was to be thrown in at the deep end and to learn the hard way. Although I had been the engineer at the factory for two-and-a-half years before becoming Works Manager, I had never seen the accounts nor the production figures. When I was shown these I was horrified with the complicated table I was shown. I said I did not like it, so the accountant said that he would present them in whatever way I liked. I had to have a good laugh then, because I did not know what way to suggest. Later I learned about standard costing and, after a year of opposition from divisional headquarters, got it established as a procedure. Obviously managers should have some knowledge of accountancy and cost accounting before appointment; in fact, they ought to have proper management training which is being improved now.

In the Services an officer usually starts by commanding troops. He then goes on to various sorts of work and then commands troops again. By this means is produced a good all-round man who knows a great deal and so can be trusted to tackle almost any job. In industry a man usually follows his profession in a watertight compartment: accountancy, engineering, personnel officer, work-study officer and so on. They are not changed around. It is obvious, for instance, that the job of personnel officer is an excellent one for potential managers and only potential managers should have these jobs for experience. Some may stay in this sphere and become the head personnel officer in the company or personnel director, others will come out for promotion in the management sphere. In industry there are far too many directors who have never commanded men on the shop floor; indeed, only something of the order of 1 per cent have actually so commanded men. No wonder we have Boards of Directors who show, by their inept handling of strikes, that they have not the slightest idea how to handle groups of working men.

In the Services the chain of command is distinct and understood. Advisory functions—staff functions—advise their commander, but he makes the decision, initiates the action and gives the orders. In industry this is not understood. In particular the personnel officer should act as a staff officer advising his manager of the complexities of the laws of employment, of National Insurance and Trade Union views. His task is to advise and decisions must come from the manager or director. In many branches of British industry the personnel officer takes far too much on to his own shoulders, so that the men, the foreman and shop stewards begin to think that he, and not the manager, is the boss. This is disastrous for good management and for morale.

If a man is put on a charge he appears before his CO. In far too much of British industry a man who has committed an offence appears before a personnel officer for

punishment and the line and staff functions are again not properly understood and are blurred. Part of the reason for the foreman's lack of control these days can be attributed to the erosion of his authority by personnel departments, by his lack of proper training and by other advisory-function men such as work-study and production engineers, and in some cases even shop stewards—having direct access to the men and sometimes even issuing orders to them. Also very often a foreman has up to 200 men under his control, whereas a troop of thirty men is enough—sixty at the very most.

In the Services every officer is taught a standard Orderly Room procedure. He takes the case through its proper steps, identifying the man on the charge, hearing the evidence, giving the defendant the opportunity to question the evidence, deciding whether guilty or not on the evidence, giving the defendant an opportunity to say anything in mitigation and then pronouncing sentence. He also understands the rules of evidence. As far as I know no British firm has any laid-down procedure like this and no British Institution of Management is working on this problem. That there is a problem here is not realized by British industrialists, except those who have had some legal training or have been in the Services.

In the Services there is a standard procedure for reporting on a man's fitness, or otherwise, for promotion and how satisfactorily he carries out his duties. These reports are made at regular intervals, are signed by the officer's direct commander and by the commander's commander and the officer initials it to show he has seen the report. This is a good procedure which should be introduced in the large industries, being worked by a central personnel department, and should be pursued until it really works properly. Also in the Army there are a series of pools from which various people are selected for special appointments and an officer's name is put down in these various pools as he becomes qualified. These are excellent schemes and large industries should follow a similar procedure. In some industries something like these two things are done, but often when they are done they are not done well enough.

It is easy to look at statistics and to say that Britain's record is not bad in that the proportion of hours lost due to industrial disputes is fairly low. There are, however, countries much better than we are on this score, but this is not really the point. It is the quality of management that must be improved. Britain should be better than most at pulling herself up by her boot-straps, which is really the exercise which is needed.

The points mentioned here may strike a chord in the breasts of the readers of the *RE Journal* because they are lessons that all Service personnel understand. The real tragedy, however, is that this sort of writing does not strike a chord in the breasts of many senior industrialists who have sufficient authority to promulgate changes.

It is nice to see that some Servicemen get on to the Boards of Companies and it is nice to see that Field-Marshal Lord Harding, as Chairman of Plessey, has set up an Industrial Relations Policy Committee under the Chairmanship of the Company's Director of Organization and Management Development, reporting direct to the Managing Director, to look into all the aspects of industrial relations and to make recommendations for their improvement.

This is excellent. A soldier knows about morale and he ought to be able to get it right. The important thing is that one cannot really separate the morale of the management from that of the shop-floor workers, and the aim should be that the whole morale of the firm should be boosted. It is easier to start with improving management morale and work from there to improve shop-floor morale. Good luck to the Field-Marshal and let us hope that other industries follow suit. This exercise is best done internally, because new ideas, brought in from outside, will often be resisted. So again good luck to the Field-Marshal—he is going about the job the right way.

Institution Subscriptions

MAJOR-GENERAL T. H. F. FOULKES, CB, OBE, MA, FICE
President of the Institution of Royal Engineers

You will have seen that the Agenda for this year's Annual General Meeting of the Institution, published in the May *Supplement*, contains an item dealing with the revision of subscription rates, and it is on this subject that I am writing so that all members may be told about the need for the proposed revision and what is involved.

Subscriptions have remained unaltered since 1959 and from that time everything has become more expensive year by year. More recently, however, due to devaluation, import surcharge, increased wages in the printing industry, increased National Insurance contributions, Selective Employment Tax, which affects the printing industry, and increased postal rates, costs have risen almost month by month and no end can be seen to this inflationary trend.

EXPENDITURE

The major item of expenditure, which accounts for about £6,500 in a total annual turnover of about £11,600, is the printing and distribution of the *Journal*, *Supplement* and *List*, and it is in this field that the Council has been seeking to achieve economies to offset rising costs.

The type set used in the *Journal* has been reduced so that it is possible to say more on each page of print. The size of the *Journal* has been reduced progressively to 88 pages from a former average size of 128 pages and this has lowered both printing and postage costs. The Council considers, however, that, if the Institution's standards are to be maintained, the *Journal* should not be allowed to fall below its present size.

Firms who used to advertise in the *Journal* have also felt the effects of inflation and out of the fourteen who previously advertised regularly only six now do so and revenue from this source has fallen correspondingly. The size of the *Supplement* has been limited and the charge for advertisements and notices in it has recently been increased. Considerable discussion has taken place on the possibility of reducing the number of times a year that the *Journal* and *Supplement* is issued, but the general consensus of opinion has been that the "periodicity of issue" should not be altered. A *Supplement* published, say, once every two months would lose its essential topicality and might not be much less in size than two monthly editions. Much the same applies to the quarterly *Journal*.

The bi-annual RE *List* is the most expensive single item of our publications and in 1965, when there was a drop in subscriptions due to the transfer of a large number of RE officers to the Royal Corps of Transport, shortage of money made the publication of only one *List* during the year essential. As subscriptions built up in 1966 it became possible to publish two *Lists* a year again and the Council feels that, so long as funds are available, we should maintain a twice-yearly issue. However, the *List* remains the most vulnerable publication if cuts have to be made.

Exhaustive investigations have taken place with three firms of printers to see if they could produce an adequate but cheaper service than that of our present printers in Chatham, with whom the Institution has dealt since 1888. Investigations have also been carried out to see whether the *RE List* could be produced and kept amended by computer methods. None of these investigations have, however, so far proved fruitful.

At the end of last year printing costs were raised by 5 per cent, and the recent Budget will inevitably produce further increases on top of this.

To summarize: the Council has not so far been able to find a printing firm that can give a more economic service than our present one; both the *Journal* and the *Supplement* have been brought down to an irreducible size compatible with the standards

of the Institution, and the Council considers that these should remain as quarterly and monthly publications respectively. The Council also considers that two *Lists* should be published each year but, if financial savings have to be made, then we must get by with one. Printing costs this year will be 5 per cent higher than last year, and the Chancellor's recent Budget will inevitably bring about further increases. Practically every other item of Institution expenditure will be similarly affected.

INCOME

I now wish to turn to our sources of income, namely our receipts from annual subscriptions, tax refunds on covenanted subscriptions and dividends from investments.

For some years our income from annual subscriptions paid by regular retired officer members and other full members amounted to about £3,800 a year. In 1968, however, this figure fell by over £200, the drop being due to several of the more elderly members resigning their membership on the expiry of their deeds of covenant, and this in its turn brought about a corresponding loss of some £100 in tax refunds. As the cost of living continues to rise we must expect this trend to continue.

The most fruitful source of augmenting the Institution's income is by getting more members to covenant their annual subscription, thereby increasing its actual value by 70 per cent. I have stressed this point at several Annual General Meetings and there has been a concerted drive to increase the number of serving regular officer covenant subscribers. I realize that covenanting is a personal matter and there must be some who cannot really see their way to entering into a seven-year undertaking, but the following figures taken from Sections (A) 1, 2, and 3 of the May 1969 *List* are illuminating and show that, among the Sapper officers of the Active Army, three out of every eight do not covenant their subscription.

Category	*Covenanters*	*Non-covenanters*	*Non-members*	*Total*
General officers	10	—	—	10
Brigadiers	29	3	—	32
Colonels	36	5	—	41
Lieut-Colonels	107	31	—	138
Lieut-Colonels (Special List)	11	1	—	12
Majors	206	208	1	415
Captains	106	104	—	210
Lieutenants	154	52	—	206
2nd Lieutenants	47	1	6	54
Postal and Courier	4	14	5	23
Quartermasters (QM)	43	69	2	114
Staff (QM)	—	2	—	2
Garrison Engineer (QM)	27	11	—	38
E & MO (QM)	26	10	—	36
Survey Executive (QM)	3	6	—	9
Postal Executive (QM)	—	1	1	2
Directors of Music	1	—	1	2
SRC Commission	62	43	3	108
SSC Commission	95	44	16	155
Total serving officers	967	605	35	1,607

Out of the 498 officers of the newly formed T & AVR, eighty-four have already become members of the Institution and of these fifty-three have covenanted their subscription. This is an excellent beginning and I hope that many more will join the Institution as a means of improving their military engineering knowledge and keeping in touch with the professional and domestic activities of their Corps.

The figures for other sections of the 1969 May *List* are:

Category	*Covenanters*	*Non-covenanters*	*Non-members*	*Total*
Retired regular officers	724	546	564	1,834
Other full members	245	370	—	615
Associate members	33	99	—	132
Members transferred to other arms	21	21	—	42
Totals	1,023	1,036	564	2,623

A study of previous *Lists* will show how the number of non-members among the retired regular officers has increased, and the overall number of members in the other categories has decreased sharply over recent years.

A particularly hard look has been taken at our investments to see if their performance can be improved, both as regards capital growth and dividend income, though these, in fact, have been doing well. However, steps are being taken to go on to the terms of a more recent Trustee Act which will give us greater investment freedom. It should, however, be realized that our capital is very small for an Institution of our size and activity, and the present income from dividends represents less than one-fifteenth of our total annual expenditure. The Council is of the opinion that we should try rather to build up our investments than sell any of our slender assets to cover current expenditure, and I am sure that all members will agree with this prudent view.

INCOME AND EXPENDITURE ACCOUNT

For several years now our income and expenditure account has been balanced on a knife edge, as the following figures show:

Year	*Turnover*	*Excess of income*	*Excess of expenditure*
1967	£11,651	£37	—
1966	£11,345	£7	—
1965	£10,908	—	£60
		Note: only one List was published in 1965	
1964	£11,304	£2	—
1963	£11,209	All square at the end of the year	

In 1968, however, due to the price increases about which I have spoken, there was an excess of expenditure over income of £100 in spite of all the savings achieved.

In 1969, because of still further increases in costs and a foreseen drop in subscription income, we shall become seriously in the red unless the expedient of publishing only one List is adopted. The Council has, therefore, reluctantly come to the decision that the May List will be the only one published this year, and that subscriptions ought to be raised next year.

NEW SUBSCRIPTION RATES

The Council is firmly of the opinion that the new subscriptions should not be only just sufficient for the Institution to keep its head above water with costs as they are at present, but must bring in enough revenue to maintain our traditional standards, assuming that costs will continue to rise, and avoid the need to raise subscriptions again for a number of years. Any surplus of income in the early years, it considers, should be used to increase our modest investment capital.

The Council also considers that, in view of present trends, retired officer and other full members should not be asked to pay more than they now do, and that it

must be the RE officers of the Active Army who should be asked to increase their financial support of their Institution. It feels, too, that RE Quartermasters should pay a subscription based on their substantive rank, and not a fixed subscription, irrespective of rank, which they have done till now.

The Council will, therefore, place before the Annual General Meeting to be held on 2 July 1969 a proposition that, with effect from 1970, the subscription rates for RE officers of the Active Army, based on their substantive rank on 1 January 1970, shall be:

Rank	*New rate*	*Present rate*
Lieut-Colonels and above	£5 0 0	£3 0 0
Majors	£4 8 0	£2 12 6
Captains	£3 15 0	£2 5 0
Lieutenants	£3 2 0	£1 17 6
2nd Lieutenants	£2 10 0	£1 10 0
Quartermasters		
Lieut-Colonels	£4 8 0	£1 10 0
Majors	£3 15 0	£1 10 0
Captains	£3 2 0	£1 10 0
Lieutenants	£2 10 0	£1 10 0

In the case of covenanted annual subscriptions it will take some time before the full effect of raising subscription rates is felt, since, in the case of Covenants still in force on 1 January 1970, tax refund will only be recoverable for the outstanding period of the Deed on the present subscription rate, ie the originally covenanted sum. Covenants expiring in 1970, however, can be renewed at the proposed increased subscription rates, and those entering into Deeds for the first time next year would do so at these rates also.

Covenants

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

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

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

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

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

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

Correspondence

Mr D. R. Trotman, MSc(Eng), BSc, CEng, MIERE,
Senior Instructor Nuclear & Electronics Wing RSME.
17 February 1969

"COMPUTERED"

Sir,—The article by Major G. K. Booth that appeared in the December 1968 issue of this *Journal* has touched on a number of points that many of us at the RSME have been considering for several years, as far back as 1963.

Clearly it is not possible to educate all the officers in the Corps in one sudden burst of enthusiasm, and our training efforts started fairly gently with the Long Civil Engineering Course in 1964. This Course was short, and was an appreciative study of what a computer was, and what it would do.

Since those early days, the computer course run by the Nuclear and Electronics Wing of the Electrical and Mechanical School has been more ambitious. Students of the Long E and M Course and Long Civil Course now include computer programming (with several days of programme writing) as part of their syllabus. Over fifty officers have now attended the computer courses run by the RSME.

In addition, I have promoted several evening courses in the RSME for any members of staff who wished to attend. These courses have been sponsored officially through the Unit Education Officer, and to date about forty staff have attended. The more recent course included an introduction to ALGOL programming, which promises to be one of the more universally accepted computer languages.

Repeated bids by the RSME for a computer have been made, and appear to fail at Treasury level on the grounds of:

(*a*) No money (always a very good reason).

(*b*) Cost effectiveness (the "OK" excuse).

(*c*) The Signals have the charter for Army computer training, in any case.

However, support for a computer installation has always been most enthusiastic by HQ E-in-C and the RSME. The computer would fulfil a training, design and "filing cabinet" requirement, the latter being basically a high-speed information retrieval and storage system for Intelligence, Resources, terrain evaluation, future project planning, etc.

The computer courses, mentioned in the article, at RMCS and the School of Signals are undoubtedly very good courses. However, Sappers who have attended these courses have felt that the course was not aimed at the beginner but at the already competant. In some cases the "students" attending these courses have spent two years in an ADPS complex.

At the RSME, the facilities for training include a CREED teleprinter, paper tape punch and tape reader coded to the Elliott 803 5-hole paper tape system. 803 Autocode is the main language taught at present, because this is typical of the more simple computer languages, and the logical thought processes involved are the same whatever the language. In addition a small analogue computer (built by a CW (E) Course studying electronics) is available. This computer has nine operational amplifiers and has an accuracy of a few per cent, and will give excellent dynamic results to quite complex differential equations, for instance. We are at present waiting for a large display oscilloscope to improve the output facilities of this computer.

The present thoughts at the RSME are in favour of a teleprinter terminal connected via GPO line to a powerful computer in the "conversational" time-sharing mode. This would cost about £100 per month, and involve no capital expenditure on equipment. However, in the interests of national security, the computer would have to be in a Government Department if the "filing cabinet" capability is to be fully exploited, and regrettably no such computer exists.

In conclusion, I would like to reiterate a sentence in Major Booth's paper, namely, that "a general educational need and a few engineer calculations do not justify a new Royal Engineer computer". It is highly necessary for the Corps to define exclusive Sapper applications of a continuous and time-consuming nature, and prove the cost effectiveness of a computer-based solution.

The following extract from a Conference in Manchester held during October 1967, sponsored by MPBW, and attended by 400 delegates, all experts in the use of computers in civil engineering, is very relevant to our cause (MPBW Report UDC.681.3:69.00, Part III, p. 8):

"The writing of large and complex computer programs is the job of a specialist. It will not be possible to train all engineers to the high level of expertise in the use of computers. It will, however, be possible to give all engineers a working knowledge of how to use computers and to write simple programs. Every engineer using a computer program should be capable of understanding the basis for that particular program even if he is unable to write it himself.

"If he is not, it would be better for him to leave the responsibility for the results and the interpretation of these to someone else.

"This means that any engineering organisation should have engineers who have been trained to different levels in the use of computers. These should be a hard core of computer experts who are permanently engaged in the use of computers, and who are capable of tackling any problem that is likely to come their way, but these experts should still have engineering as their fundamental training."—Yours faithfully, D. R. Trotman.

Colonel G. W. Kirkland, MBE(Mil), FICE, PPIStructE, MInstHE, PPIArb, MConsE.
Wellington House,
Strand, London, WC2.

THE FUTURE OF THE INSTITUTION OF ROYAL ENGINEERS

Sir,—As a Past President of a Chartered Engineering Institution, Member of CEI and a former Member of your own Council at the time the discussions on the future of the Institution (1958–61) were in progress, I was delighted to read Brigadier Finch's article and Brigadier Crosthwait's letter, both in the March issue of the *Journal*.

I appreciate Brigadier Crosthwait's questions and, while I endeavour to give you my answers to them, I find myself anxious to add more.

My reply to question (*a*) would be that there is definitely a place for a Military Engineering Institution *vis-à-vis* a civilian counterpart and in my view the role of the RE Institution should be that of sponsor. The Corps has originated many of the activities now covered by other Corps and Branches within the Army (and within the RN and RAF) and in consequence the RE Institution must take the lead. To question (*b*), I firmly believe that not only would Chartered status enhance the position of the retired officer leaving the Service, but more important, the possibility of achieving Chartered status should enhance the recruitment into the Corps of many young men who will increasingly feel the need of professional status in later life. This would further make the role of Military Engineer comparable with that of Civilian Engineer. In reply to (*c*) I would express the view that the Institution's present influence is barely adequate, but that a change on the lines discussed ten years ago would increase the influence of the Institution by improving the prestige of the Military Engineer in the eyes of the public.

In civilian life, retirement of senior engineer/administrators normally occurs at 65 years of age. In the Corps an officer may be retired at any time, probably from 50 years on. At 50 years of age a Chartered Engineer is fully conversant with his particular technology—so is the serving RE officer; the civilian no longer is deeply involved in design and detail, but keeps up to date on advanced principles of his technology by reading and/or attending courses—so does his RE counterpart; the civilian has become acquainted and probably skilled in the principles of Management and largely occupies his time and efforts in such activities—how much more so his RE counterpart.

On his retirement the Military Engineer has probably fifteen years of valuable working life ahead and provided that his professional status can be compared with that of his civilian counterpart in the same fields, then the upper echelons of industry could well be open to him.

Subsequent to the 1939–45 War, many TA and Emergency Commissioned Officers achieved high positions in the professions and industry and had learned to know and appreciate the value of the regular RE training. Many of these men have found places for retired RE officers in their own organizations, but these gentlemen are either retired or nearing retirement and the personal knowledge element of the value of an RE officer's training will disappear. This inevitably will be replaced with the quite erroneous "brave playboy" image of the officer of the Colonial Empire days.

The professional status through Military Engineering qualification within the Institution would dispel the false image and make a direct comparison with the civilian skills possible.

Finally, and I speak from experience, if an immediate start were to be made to develop a plan, it would be at least a decade before the impact of professional status began to be felt and if we really have the interests of the Corps and the Institution at heart, may I earnestly urge that a beginning is made now. We lost out once, ten years ago—don't let us make the same mistake again.—Yours faithfully, G. W. Kirkland.

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65 Corps Support Squadron, RE,
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Hameln Mil 311.

26 March 1969.

Sir,—After reading Brigadier Finch's article and Brigadier Crosthwait's letter in the March 1969 issue I would like to add my thoughts to the matter.

Firstly I was disappointed to read that the proposals outlined in 1961 have come to naught. One expects such matters to move slowly, and so I was under the impression that these proposals with which I was in agreement were making some, if slow, progress. Since they are not, I suggest we must make a reappraisal of our aims and objectives.

If we accept that there is a requirement for an Institution of Royal Engineers, which I believe there is, then I feel that there is ample scope for improvement and growth.

To be thoroughly critical, I obtain more interest and better benefits from my student membership of the ICE than from my membership of the Institution of Royal Engineers. I do not use fully the benefits of either. However, from the ICE (£2 2*s* 0*d* annual membership for students) I receive monthly copies of the "Proceedings", copies of the monthly newsletters, cheap Institution publications, luncheon club, access to meetings, etc, and really feel part of the Institution. I do not wish to suggest that we produce a copy of the ICE, but I do think that we can steal many of their ideas with a view to improving our Institution.

A few years ago, when I was even more junior, I was somewhat in awe of our Institution. I knew little of its aims (I am still somewhat vague) and would not have dreamt of submitting an article for publication unless forced to by my CO!

To try now to be more constructive—how can we improve this situation? May I suggest a system of degree of membership. Suppose we offer the categories:

(*a*) Junior Member—All officers on first commissioning.

(*b*) Associate Member—All officers who have completed a YO's course and submitted a paper on some aspect of Military or Civil Engineering.

(*c*) Full Member—All officers who have obtained an Engineering Degree or passed the CEI exam and submitted a paper as above together with two years' field experience or who are already an Associate or Member of one of the Chartered Institutions.

If we are to divide our membership up in this way, then a rethink of the benefits of the Institution is necessary. A differential in membership fees is a first step. I do not foresee a great variation from the present ones, but the establishment of a differential barrier (say £1 1*s* 0*d*) between the memberships. Then an alteration to the Constitution, whereby only Associate and Full Members attend certain meetings and have a vote in Institution affairs. As to benefits, providing the standard for Full Membership is compatible to and accepted by the CEI, then it can be argued that membership is recognized outside the Army and equates with membership of a civilian institution.

Having now created a Junior Section, it is here I feel that the most effort should be made. Visits, discussions and training in military engineering could all be organized and run by the Institution. However, far more important would be getting junior officers interested in the Institution from the start of their career.

The above is by necessity a rather sketchy outline of the course the Institution might take. However, I would like to put forward these additional proposals which could be adopted quite readily within the existing framework of organization.

1. Visits to Engineering Projects both Military and Civil are of benefit to officers, and could well be arranged by the Institution to be part of JO's education.

2. Appointment of a regional Institution representative, who together with assistants would be responsible for:

(*a*) Ensuring that papers are submitted covering interesting projects carried out in his area.

(*b*) Organizing visits for officers in his area to engineering projects.

(*c*) Giving guidance on engineering training to his officers.

3. Carry out a facelift of the *Journal*. The cover could well be improved—and a competition for this might stimulate more interest in the Institution. The inclusion of more Corps and Institution news in the *Journal*—perhaps in these days of higher postage disposing of the monthly supplement, and instead including the information in the *Journal*.

It is possible to continue with more ideas, but the above, if not practicable, will, I hope, lay the foundation for more discussion and produce better ideas, and this is basically what I consider our Institution needs if it is not eventually to collapse due to lack of support.—Yours faithfully, R. J. Lister.

Lieut-Colonel J. C. D. Montgomery, RE,
Air and Naval Section,
Logistics Division,
SHAPE,
B.F.P.O. 26.

3 March 1969.

THE "DOUBLE-JOINTED" OFFICER

Sir,—I was very pleased to see in the E-in-C's address to the Corps in the September issue that officers are going to be encouraged to be "double-jointed". This is a policy that I advocated during my three years as CI of the Engineer Planning School and, if the RSME staff haven't erased the tapes, they can hear my suggesting this at past E-in-C's conferences. There are, however, a couple of factors that must be taken into account if the Corps is going to obtain the greatest benefit from this policy:

(*a*) To remain effective a contortionist must keep in constant practice and, similarly, an officer will not be really double-jointed unless he exercises his professional engineering ability as well as his ability as a staff officer. A six-month engineering attachment will not make a *psc* officer double-jointed.

(*b*) The impression one gets is that emphasis is going to be given to widening of the knowledge of *psc* officers. This is a good thing; but, to be really effective, a human body must have two good arms and not merely a strong right one. In other words not only should the *psc* officer become *pqe* but the *pqe* should be given every opportunity to become *sq*.

In actual fact the Corps already has a "strong left arm" in its professionally qualified officer, but unfortunately the power of this arm often is not used to the full. During his two year's professional course every effort is made to improve the officer's ability to express himself clearly on paper and to enable him to cope with the administration and staff work that is necessary in any engineering project. Since my "long course" I have served in the then DREE, the then War Office and SHAPE. I have also been closely associated with HQ I (BR) Corps and worked in conjunction with two of the three Divisions in BAOR. From this experience I have no doubt that, apart from such appointments as the BM in a Brigade or GI in Division, there are very few staff appointments that an officer, who obtained an "A" or "B" pass in his Long Engineering Course, could not carry out efficiently. Such officers are, virtually, "double-jointed" already. The Corps would be well advised to recognize this and to try and increase its strength by using these officers accordingly.—Yours faithfully, J. C. D. Montgomery.

Professor Donald Portway, CBE, TD, CEng, FICE,
Honorary Member of the Institution of Royal Engineers,
St Catharine's College, Cambridge.

18 March 1969.

Sir,—In connexion with the excellent Cooper's Hill prize-winning essay in your March issue, I am surprised that no specific mention has been made of protection against coast erosion as an ideal civil employment of Sapper units. I believe I am right in stating that in the United States considerable use is made of engineer field units in this connexion. In Eastern England in particular, coast erosion is a matter of the greatest concern.

In Elizabethan times, Dunwich, twelve miles north of the newly built nuclear power station at Sizewell, and now a small village, ranked after London and Bristol as the greatest port in England and provided a dozen ships to fight the Spanish Armada.

As a lad I can well remember the last of the sixteen churches of Dunwich, which then stood some 200 yards from the edge of the cliff, whereas now only elderly people can ever have seen it at all.

Defence against sea erosion involves civil engineering technique in various directions and is certainly a matter of national importance.—Yours faithfully, Donald Portway.

Brigadier H. W. Baldwin, OBE,
Rocklyn,
Milverton,
Nr. Taunton,
Somerset.
20 April 1969.

WORKS SERVICES PUBLICATIONS

SIR:—I am undertaking, on behalf of the Royal Engineer Historical Society, a drive to build up, in the Corps' Library, a really comprehensive collection of Works Services publications and forms.

Before we handed over our overall Works responsibilities to the War Department Works Organization our activities stretched around the world. Apart from the wealth of publications distributed from the War Office, Chief Engineers of every Command and Theatre produced pamphlets, books on standard designs, and forms to suit the particular local circumstances. This was particularly so during the 1939–45 War. Yet despite this profusion of publications the Library holds less than 50 books, schedules and pamphlets and, of these, only six were produced during the war and only six pre-war. Only four publications were produced by Chief Engineers of Overseas Theatres.

On Army Forms the situation is rather better but the Library has no forms that were produced by Chief Engineers either in the UK or overseas.

I would greatly appreciate the opportunity to appeal, through the *Journal*, to the many officers, both serving and retired, who I am sure have stored away in cupboards some forms, pamphlets, handbooks and other records that they used during a Works tour.

Works officers were notorious for carrying around with them their own personal libraries. May I ask them to see what books and forms they have, and either send them to the Corps' Library at Chatham where they will be carefully sorted or to make a list of them and send it to the Head Librarian of the Corps' Library for examination. We are anxious, of course, to have the best preserved standard that we can obtain so it would be most helpful if, in sending a list, the condition of each book or form could be noted.

It is hoped that some retired officers may have documents related to the MES India, the pre 1939–45 period, and particularly to the 1914–18 war. Yours faithfully, H. W. Baldwin.

Memoirs

LIEUT-GENERAL SIR RONALD SCOBIE, KBE, CB, MC, COLONEL COMMANDANT RE (RTD)

The following memoir is republished by permission from The Times *of 25 February 1969.*

Lieutenant-General Sir Ronald Scobie, KBE, CB, MC, who died on 23 February 1969 at the age of 75, was commander of the Tobruk Fortress at the time of its relief in 1941, G.O.C. in Malta during the siege, and G.O.C. in Greece in the critical year after the liberation, when he played an outstanding part in saving that country from communism.

He was a first-class staff officer as well as a competent commander. As a young man he was a Rugby international, and played for Scotland against England, Ireland and Wales. He was a delightful man with a quiet, pleasant, sincere manner, and he inspired confidence and affection wherever he served. He had a special gift for getting on with foreign troops.

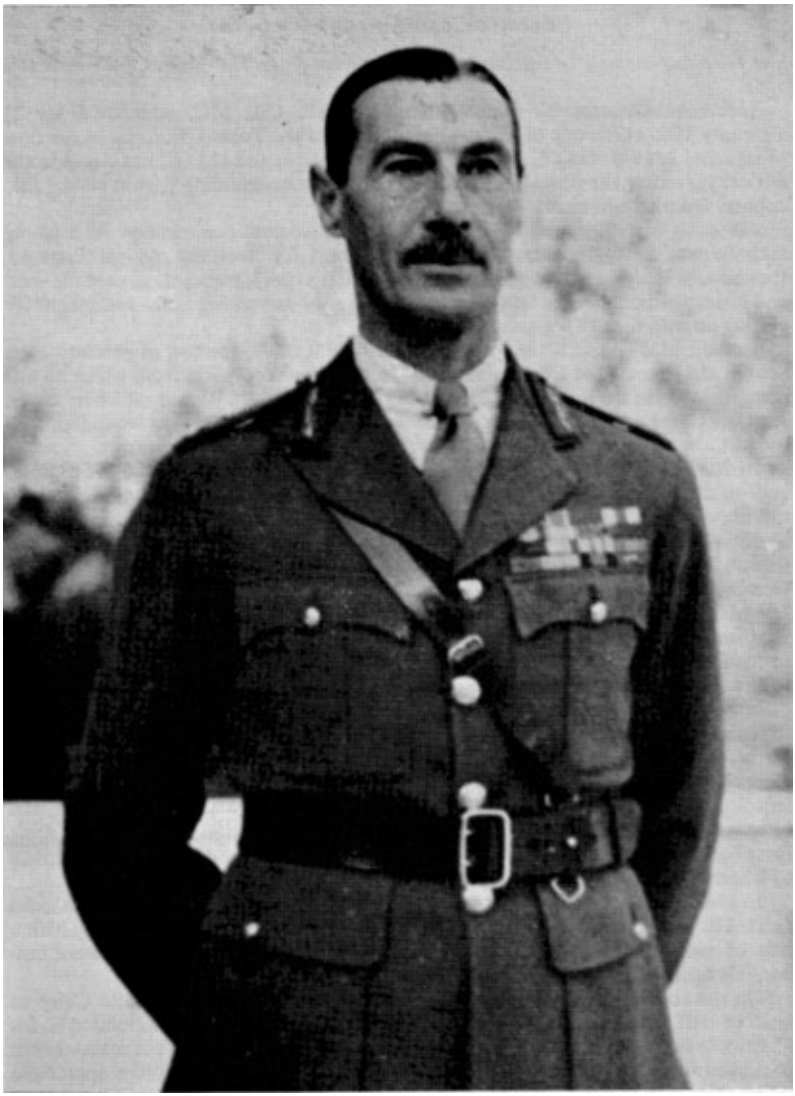
Ronald MacKenzie Scobie was born on June 8, 1893, the son of Mackay John Scobie and educated at Cheltenham and the R.M.A., Woolwich, from which he was commissioned in the Royal Engineers in 1914. In the 1914–18 War, in which he served with his Corps and as brigade major of an infantry brigade, he was wounded, won the M.C., was twice mentioned in dispatches and received a brevet majority.

In 1939 he was serving in the adjutant-general's department at the War Office, and on the outbreak of war he was made deputy director of mobilization. He held this appointment until he was posted in the following year to the Middle East, where he served first as deputy adjutant-general on General Wavell's headquarters, and then as brigadier general staff in the Sudan. His first employment in the field came in October, 1941, when, a month before Sir Claude Auchinleck launched his "Crusader" offensive against Rommel, he was sent into Tobruk to take command of the 70th Division and the other troops, including the Polish Carpathian Brigade, which formed the garrison of the fortress. In the opening battle it was the task of the right wing of the 8th Army to attack the enemy investing Tobruk, and the garrison was to make a sortie. The fighting was fierce and confused, and it was not for a week that the relieving forces succeeded in making contact with Scobie's troops and then only for a few hours before the Germans broke through the freshly opened corridor. Tobruk was again a besieged fortress, with barely 48 hours of artillery ammunition left. Scobie kept up his attacks while the battle of Sidi Rezegh raged to the south, and in another fortnight Tobruk was finally disengaged. By its vigorous action, Scobie's force had created a threat to the enemy's flank and rear, and so contributed materially to Rommel's defeat.

In 1942 he was posted to Malta to take over command of the garrison under Lord Gort. His arrival coincided with the running in of Admiral Syfret's convoy, with a loss of nine merchant ships out of fourteen, at a time when supplies were desperately needed to enable the island to hold out.

On the conclusion of the North African campaign Scobie returned to Cairo as chief of staff to General Sir Henry Maitland Wilson, who had been appointed C.-in-C. Middle East, and here he was concerned till the end of 1943 with the maintenance of the 8th Army, the mounting of the attack on Sicily, and the amphibious operations which were carried out against the islands in the Aegean.

When the Germans evacuated Greece in 1944 British troops were sent in to demobilize the guerrilla organizations and to keep order until a constitutional administration could be established. Scobie was put in command of the force, which consisted initially of a parachute brigade and an armoured brigade acting as infantry supported by the Navy and the Air Force. The country was in a state of complete disorder, and a real danger of civil war arose, when the members of the National Liberation Front resigned from the newly formed cabinet, and the guerrillas of the



Lieut-General Sir Ronald MacK Scobie, KBE CB MC

People's National Army of Liberation seized the port of Piraeus, and occupied most of Athens, in an endeavour to set up a communist government. The British troops were soon involved in heavy fighting and were, for a time, in danger of being overwhelmed. An additional division had already been sent in and now another was landed, with a corps commander to take over operational control under Scobie as overall commander.

After five weeks of bitter fighting a military truce was signed, order was restored, and the disarmament of the guerrillas and the creation of regular forces put in train.

It would hardly have been surprising if Scobie, as commander of a foreign force engaged in such a task as his, had become a much hated man. But the firmness, good sense, and fairness with which he carried it out were such that he not only gained the high esteem and even affection of the Greek authorities, but became extremely popular with the public, who greeted him in the street, whenever he appeared, with tremendous cheering and continual cries of "Scobie, Scobie, Scobie!" In 1945 he received the freedom of Athens and the grand medal of the municipality, and was decorated with the grand cross of George I of Greece. He remained in command until 1946 and retired from the Army the following year.

In 1961 he succeeded General Sir Bernard Paget, GCB, DSO, MC, DL, as National President of the Forces Help Society and Lord Roberts Workshops and the Society benefited greatly from his wise counsel at a time when the Society was being re-organized. His election to the Vice-Presidency following his retirement from the Chair, which was forced upon him by his medical advisers, gave him the great pleasure of retaining an active interest in all that the Society was doing for the benefit of serving and ex-Servicemen and women.

He was Lieutenant of the Tower of London from 1951 to 1954, and Colonel Commandant, R.E., from 1951 to 1958.

He married in 1927 Joan, daughter of W. H. Sidebotham, of Farnham, Surrey. They had one daughter.

At the request of his many Greek and British friends who had served under him and knew him well, the British Embassy, Athens, arranged a Memorial Service for Lieut-General Scobie on 4 March 1969.

The Military Attaché writes:

The Service, which was conducted by the British Embassy Chaplain, Canon C. S. Crowson, was held at the Commonwealth War Graves Cemetery, Faliron, and was attended by the British Ambassador, HE Sir Michael Stewart. The Greek Government was represented by the Second Deputy Prime Minister, Mr Patilis, Minister of Foreign Affairs, Mr Pipinelis, Minister of Justice, Mr Kyriakopoulos, and the Under-Secretary to the Prime Minister, Mr Vovolinis. The Regent was represented by Colonel Zanetis. On the military side the Service was attended by General Angelis, Chief of the Armed Forces, General Tsoumbas, Chief of the Army, Admiral Margaritis, Chief of the Navy, and General Kostakos, Chief of the Air Force, as well as the Chiefs of Gendarmerie, the City Police, Fire Services and some forty representative officers from all of the Services. There were many retired officers present, including Generals Tsakalotos, DSO, OBE, Tsigantes, CBE, DSO, Grigoropoulos, DSO, Papageorgopoulos, OBE, Zacharakis, MC, Manidakis, Spanoyiannakis, and Melas. Retired Ministers included Mr Averoff and Admiral Toumbas, DSO, both ex-Ministers of Foreign Affairs. Embassy staff and members of the Greek and British communities in Athens were also present.

Wreaths were laid by HM Ambassador, the Chief of the Armed Forces, the Mayor of Athens, the Secretary-General of the Greek General Confederation of Labour, the Chairman of the British Ex-Servicemen's Benevolent Fund, the Chairman of the Anglo-Hellenic League, and by General Tsakalotos on behalf of the retired officers.

During the Service addresses were given by HM Ambassador and the Second Deputy Prime Minister.

The Greek Armed Forces provided a guard of honour, a band, and a trumpeter to blow "The Last Post" and "Reveille". The ceremony went off extremely well, and was obviously much appreciated by the Greeks. General Scobie was a well-beloved figure in Greece, and the numbers and ranks of those attending showed that he had not been forgotten.

The Ambassador received letters expressing sympathy from Mr George Athanasiadis Novas, Academician and former Prime Minister and Speaker of Parliament, Lieut-General Tsakalotos who was Chief Army General Staff 1951–2 and Greek Ambassador to Belgrade, Lieut-Colonel Ioannou, Gendarmerie retired, Professor Lorandos, and Mr Lelakas. Telegrams were also received from Mr George Papandreou, the son of the former Prime Minister, and from Mr George Fioretos, Messrs Papaioannou and Spyropoulos, and Mr Markis, Secretary-General of the Greek General Confederation of Labour.

BRIGADIER G. J. V. SHEPHERD, CBE, DSO

GILBERT JOHN VICTOR SHEPHERD was born on 15 February 1887, the only son of the Rev T. C. Shepherd, MA, Chaplain to the Indian Government.

He was educated at Cheltenham College and the RMA, Woolwich, being commissioned into the Corps on 17 February 1906. After completion of a YO course at Chatham and a course at the School of Electric Light, Plymouth, he joined 33rd Fortress Company in Ireland in 1908, and thence to 36th Fortress Company in Sierra Leone in 1909. He returned from Sierra Leone to the 3rd Fortress Company in Dover in 1913.

He raised the 1st AA Searchlight Section, RE at Chatham in 1915 and took it to join the BEF in France in May 1915. He was appointed GSO III GHQ Intelligence in 1916 and GSO II Intelligence with 17th Army Corps in 1917. In February 1918 he joined the War Office as GSO II, where he remained until 1919. During the war he was mentioned in despatches twice in 1917, being awarded the DSO in the same year, and also the Order of the Crown of Italy (Chevalier).

In 1919 he received Brevet Majority, and joined the Ordnance Survey. He attended Staff College, Camberley, from 1922 to 1924, and then returned to the War Office in MI4. After a year as an Instructor at the RAF School of Photography in Farnborough, where he pioneered aerial photography, he was appointed DAA and QMG, West Lancashire Area.

Three years later he went to East Africa as Staff Officer to the Inspector-General, Kings' African Rifles. He served in Singapore as DCRE Ferry Point and CRE Changi from 1924 to 1931, when he returned to the home establishment as SORE at Southern Command Headquarters in Salisbury. After two years as CRE in Aldershot he was, on promotion to Colonel, appointed AQMG in India until his retirement in March 1939, when he settled in Farnborough, Hampshire.

He was recalled in March 1940, and was promoted Brigadier as DDQ at the War Office until his second retirement in May 1946, being created a CBE in 1944.

Immediately on retirement he found employment at the Ministry of Works, and one of his first acts was to send a terse reply to one of his own sharp letters from the War Office!

He retired from the Ministry of Works in 1954, and continued an active life with particular interests in the Officers' Association and Ex-Service War Disabled Help Department, both of which he represented in Farnborough until his death on 9 January 1969 in his eighty-second year.

He married Hermione, daughter of Leonard Wingfield-Stratford, originally of Natal, South Africa, who predeceased him in 1966. They had two sons, both commissioned into the Corps and still serving, and one daughter married to a serving Sapper officer.

A.B.S.

LIEUT-COLONEL B. H. C. COTTON, OBE

A NUMBER of Sappers may remember having seen Benjie Cotton at the Joint Meeting of the Institution of Royal Engineers and the Institution of Electrical Engineers at Savoy Place on 19 February 1969. He died at his home in Blackheath that night after driving back through the tremendous snowstorm which got up in the evening. He was in his sixty-ninth year.

Benjamin Harold Coode Cotton was educated at Harrow, from where he won a scholarship to Caius College, Cambridge, but threw this up to go to the "Shop". He was commissioned into the Corps on 18 December 1919. Originally in No 3 JO Batch, he broke his leg while on the Assault Course, which caused him to join No 4, No 5, and eventually No 9 JO before he completed his courses in 1925. He was then sent to Riga on six months' "Language Leave" in order to learn Russian. On his return he passed the examination for first-class interpreter in Russian. He then went to Rhine Army as Assistant DORE Wiesbaden, becoming DORE in 1927. While still at YO at Chatham he had shown decided mechanical leanings. At various times he had owned a GN, a Rover Eight and a Frazer Nash. He ended up with both the GN and the Frazer Nash, cannibalizing the latter for spares. Now in Rhine Army he was the owner of a two-cylinder, long-wheel-base Jowett, with which he went in for the BAOR Reliability Trial and won first prize.

In 1928 he was posted to Singapore, where he joined a group of Sappers who were laying out the future cantonment at Changi and the Eastern Defences of Singapore. They lived together in a little Japanese hotel, built in a jungle swamp, and spent their days in the planning, surveying and construction of roads, accommodation and defences. Lt. W-J. writes of Benjie Cotton at this period: "He lived with us in the Mess and was immensely popular. His huge glasses and quiet humour made him an attractive character which belied his rather serious demeanour. His ideas were practical and objective. Having bought the first automatic watch I had ever seen, he never took it off. He swam with it on invariably. He liked languages and took up Malay seriously. To get the feel of Malaya in those days he bought himself a *koleh*, or native canoe, which he paddled about Johore Straits. He was no great athlete, but joined in all the activities of our small community, treating games from an analytical point of view which was attractive. He walked miles sorting out routes and contours for his roads. He was always mechanically minded and his insistence on simplicity and good honest works showed itself in his cars—a two-cylinder Jowett followed by a microscopic sports Austin Seven out of which he overflowed." It was also during this time that he learnt to fly and obtained his A Licence.

In 1929 he went home on leave, by cargo boat to Suez, steerage in a Greek ship to Piraeus, and overland by train from Athens. While at home he became engaged to Susan Corner, daughter of Charles Corner, MICE, one-time Chief Engineer of the Beira-Mashonaland and Rhodesia Railways. On return, he was transferred to Colombo, where Susan joined him, and they were married at Mercara in Coorg in November 1930.

In 1931 he reverted to the home establishment and was posted to the 38th Field Company at Aldershot, with which he served for only a year, for in 1932 he was selected for a long E and M course. A brother officer on the same course records that his wife practically attended the course with him and they travelled about in an ancient BSA van in which they also lived from time to time. On the conclusion of this course he was posted to the SME as Instructor in the E and M School, in which appointment he served for four years. His car was now a Czechoslovak Tatra in which, with his wife as crew, he took part in both the Edinburgh and Land's End Trials of 1937 and won a gold medal in the former.

In 1938 he went overseas again, this time to the Middle East. Posted as ACRE Abbassia, he was engaged in the E and M side of the build-up of the Middle East Base immediately before and after the outbreak of war. In early 1940 he was transferred to Palestine as SORE, and the following year the Syrian campaign took place

Lieut-Colonel B H C Cotton,OBE

in which he was heavily involved in ensuring that the troops had the Engineer support they needed. He was awarded the OBE for distinguished services in that campaign. In 1942 he was posted to GHQ Cairo. After Alamein he was in the Western Desert when his jeep drove over an anti-tank mine and his arm was smashed. After hospital treatment he was evacuated to South Africa on sick leave. On recovery he was posted to the UK, where he served from 1943 to 1946 as E and M Instructor at SME Ripon and in the Civil Affairs Directorate of the War Office. He acquired another van, but this time, in deference to petrol rationing, it was an electric vehicle which recharged itself from the mains. In 1946 he went back to Egypt as ADW (E and M) at HQ MELF, which had by this time moved to Fayid. He retired in 1947, when he and his family settled in Blackheath.

He had kept up his knowledge of Russian throughout his career. While at GHQ Cairo in 1942 he was known to have his own Russian-character typewriter. Now in retirement he made good use of his knowledge. He became a Scientific Officer at the Fuel Research Station in Greenwich, where he was employed in the translation of technical Russian summaries. He was both FIEE and a Fellow of the Institute of Linguists and he came to be acknowledged by all as a master of combined technical and linguistic skill. He left the Civil Service in 1960, but continued to carry out similar work at home.

He and his wife were extremely happy in retirement. They had two sons and two daughters, two of whom are now married, and they remained a closely knit and devoted family. They were strong supporters of St James's Parish Church, and acquired a circle of close friends in the neighbourhood. R.J.W. writes: "Benjie Cotton was a very likeable personality. He was modest and unassuming and a little shy. But to my mind his outstanding characteristics were the gentleness and kindliness of his approach to life and to people in general. He was incapable of harbouring bitterness or jealousy, and he was always ready to help. These are the things which impressed me and explain why I admired him so much, and valued his friendship."

Benjie Cotton will be mourned by all those who knew him, and they will extend their deepest sympathy to his wife and family.

H.E.M.C.

Book Reviews

SIEGES OF THE MIDDLE AGES

PHILIP WARNER

(Published by G. Bell & Sons Ltd. Price 36*s* net)

Mr Philip Warner, a Senior Lecturer at the RMA, shows a remarkable knowledge of castles and their history. His accounts of the great sieges bring to life all the intrigue, the cruelty, the bravery, the cunning and the skill of the besiegers and the besieged in these classic examples of clashes in the Middle Ages. His quotations from contemporary writers often show brilliant flashes of humour. He tells us that the men in charge of siege machines were called "gynours"—it is not hard to imagine how this could change to "engineers". Nothing apparently is new; frogmen were used in 1203 to aid in the capture of Chateau Gaillard; the scorched-earth policy was used regularly; flame-throwers are only a modern refinement of "greek fire"; and germ warfare was used at Petrary, when dead horses were flung by catapult over the castle walls to cause disease. Mining and countermining were commonplace.

When we are told of the marshland and water complexes that surrounded many of the castles before drainage removed these natural hazards, we realize how cleverly our forebears sited their fortresses. The manner in which William the Conqueror held the country in subjugation by a complicated system of fortresses, and how he brought over a prefabricated castle to erect at Senlac Hill, shows his great faith in the value of having secure bases from which to launch assaults.

We learn of the reason for heraldry. It was only an early system of unit flashes and badges. We are told of the effect the use of cannon had in castle sieges when, in 1449–50, the French successfully attacked sixty citadels in 369 days, an average of one a week.

To the student of fortification and war in the Middle Ages this book will give many hours of intriguing reading.

H.J.

FORTRESS ARCHITECTURE AND MILITARY HISTORY IN MALTA

QUENTIN HUGHES

(Published by Lund Humphries, 12 Bedford Square, London, WC1. Price 63*s*)

The author of this book is Professor of Architecture in the Royal University of Malta and he writes with deep knowledge and love of his subject. The many splendid photographs by the author and David Wrightson, the fascinating charts and maps and the drawings of old fortifications and siege operations magnificently illustrate the turbulent story of the George Cross Island from ancient times through countless vicissitudes to the present day. Three guineas is not a high price to pay for this artistically produced book, and it is surely a "must" for all who have ever had the good fortune to be stationed in Malta.

J.L.

SOLDIERS' BATTLE TALES FROM "BLACKWOOD"

(Published by William Blackwood, Edinburgh and London, 1968. Price 21*s*)

Many military authors have cut their literary teeth through the media of *Blackwood*, and this fascinating selection of soldiers' Battle Tales consists of thirteen personal stories which range from Bowman Bates's experience at Agincourt in 1415—where he and his half-clothed, dysentery-ridden comrades, with their strong right arms, longbows and goose-feathered arrows, destroyed the legend of invincibility that had, hitherto, been accredited to the armoured knights of France—to the exploits of National Service soldiers on jungle patrol in Malaya in the 1950s. Of particular interest to Sappers is the "Battle of Arnhem Bridge" by Captain (now Colonel) E. M. Mackay, RE, which relates the experiences of the British parachute assault force and its eighty-strong RE contingent. To quote the summary given on the dust cover, "there is something here for everyone"—and very worth while it is at 21*s*.

F.T.S.

STAM SERIES ON ADVANCED MECHANICAL ENGINEERING THREE VOLUMES AS TITLED BELOW

(Published by H. Stam International, N.V. Culemborg, The Netherlands, 1958)

(*a*) Applied Mechanics of Machine Elements in Advanced Use (Price 93*s*)

This textbook covers some of the author's work in aeronautical and mechanical engineering and provides the designer or production engineer with information which could help to improve a design or make better use of a given material, or improve the material available for use.

The aeronautical text covers: energy absorption by the tyres of an aircraft undercarriage, riveted joints in light alloys, stress systems caused through diffusion in materials, piston-ring investigations, aero-engine piston and cylinder failures and thermal stresses in the piston and cylinder of an aero engine.

The more general mechanical engineering text covers: the mechanical requirements of castings in engineering, tooth-coupling design and manufacture and the design of machine elements in relation to damping, vibration and noise.

It is emphasized that the text is presented in the language of the specialist designer and qualified production engineer, with the mathematics of scientific and engineering post-graduates.

(*b*) Couplings and Bearings (Price 76*s*)

This is another textbook by the same author, with the difference that the text is more descriptive and pictorial and less mathematical in style. Its range of readership is, therefore, greater and suitable for draughtsmen and technicians.

Eighty-two pages of text are given to the design of couplings and twenty-nine pages to bearings, with four appendices covering viscosity units and lubrication information applicable to the subject components.

(*c*) Design of Gears (Price 105*s*)

This volume analyses and correlates the gear-design theory and gear-design practice of a number of authorities both British and foreign.

Design descriptions are given in the thirty-one pages of Chapter I, which is amply illustrated. Chapter 2, of fifty-nine pages, compares the primary design (classification) rules for industrial and marine gears, other additional considerations, and the actual rules of the American Bureau of Shipping, Bureau Veritas, Germanischer Lloyd and Lloyds Shipping Register.

Chapter 3 deals with design calculations and its eighty pages cover deformations and stress systems in gear-wheel tyres and rims, gear-wheel design, analysis of the design of carburized, hardened and ground pinions in relation to heat treatment, dynamic and temperature loads in marine gears and their weight, and the torsional frequencies in a propulsion unit. Fifteen pages are given over to materials and their specifications. The Lloyd Register of Shipping Rules, Chapter 4—Main and Auxiliary Engines and Gearing—are included as an appendix.

As the text covers the foreign classification rules, the reader expects a mixture of British and metric units to be used, but the ten-page reproduction of the Germanischer Lloyd rules in German is unexpected in a textbook produced for English readers.

F.T.S.

COUPLINGS TO THE KHYBER

P. S. A. Berridge

(Published by David and Charles. Price 84*s* net)

Not least of the legacies left by the British when India and Pakistan gained their Independence in 1947 was one of the greatest and most complex railway networks in the world. Mr Berridge in his book deals with just one part of this system—the North Western Railway—which was built over some of the most hostile terrain to be found anywhere in the world. It crossed barren, waterless deserts, where the temperature rises to 125 degrees in the non-existent shade, and climbs mountains where the cold is such that, in winter, frostbite is a real danger. It stretches to the furthermost outposts of the North West Frontier, to Quetta, Fort Sandeman and Peshawar, stopping only when it reaches the Afghanistan border, and connects Pakistan, over its north-west mountain barrier, with Iran. In climbing the mountains the locomotives faced gradients of 1 in 23 for long stretches and ruling gradients of 1 in 33 for many miles. The highest track in the system is at nearly 6,000 ft above sea-level.

The bridges built to carry this railway over the great rivers, where monsoons and melting snows produced rises in the water-levels of 100 ft in a few hours, and where currents of 13 knots caused scour necessitating the sinking of bridge footings 170 ft into the river bed, were monuments of engineering skill.

Started in 1858, the building of the North Western Railway is a story of man's determination to overcome nature. Hampered by heat and cold, by floods and lack of water, with labour gangs decimated by epidemics of cholera and other diseases, harried by hostile tribesmen in the hills, and tormented by mosquitoes and sand-flies, the permanent way was forced through by British engineers, many of them Sapper officers, backed by a magnificent workforce of Indians—Pathans, Sikhs, and Punjabis—all of whom showed great determination, skill and industry in carrying out this almost impossible enterprise. Only when tunnelling conditions became very bad were Welsh miners brought in to bolster up the local labour.

Mr Berridge, with the experience of twenty years as a bridge engineer with the NWR behind him, concentrates mainly on the problems of bridge-building, but he also gives us a good insight of the general history of this great railway. The book contains a large number of excellent plates and maps, many of them of great historical interest, which illustrate the enormous problems faced by the engineers in constructing and maintaining this transport system. It is a book to gladden the heart of any railway enthusiast, especially those who have been lucky enough to travel over the NWR, and it will be read with pride by Indians, Pakistanis and British alike, as it is a record of magnificent achievements by teams and individuals from these three nations.

H.J.

Technical Notes

THE MILITARY ENGINEER

NOVEMBER—DECEMBER 1968

The main feature covers the methods used to lengthen and deepen an existing dry dock without rebuilding the dock walls. The manner of attacking the problem is most interesting.

Other articles include one on the rebuilding of a bridge in Korea, and another on the use of a 20 megawatt barge-mounted generator for use on Kwajalein Atoll.

Road construction is covered by a short article on cement-stabilizing a road in sand dunes, and a detailed article on up-to-date design techniques for asphalt roads. P.W.H.

CIVIL ENGINEERING

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

BELFAST'S EAST TWIN DRY DOCK. This new dry dock, which projects into Belfast Lough, has just been completed and is now the largest in UK. It has been designed to be able to accept vessels of up to 200,000 d.w. tons. It was constructed under an arrangement concluded by the Government, the Belfast Harbour Commissioner and Messrs Harland and Wolff Ltd. Ideally situated, adjoining a large turning circle, the site was reclaimed from the sea many years ago and has been reserved for a dry dock by the Commissioners since the 1930s. The consulting engineers were Messrs Rendle, Palmer and Tritton and the main contractor was Charles Brand and Sons Ltd. An interesting construction technique used was the method of tying down the 10 ft thick concrete dock floor, with high-tensile steel bars grouted 30 ft into the underlying bedrock of sandstone, to resist hydrostatic upthrust. Major R. G. Osborn, RE, worked on this project as a section engineer for Charles Brand and Sons Ltd, in 1967 during his attachment to a contractor on No. 14 Long Civil Engineering Course.

NEW CARGO FACILITIES AT HEATHROW AIRPORT, LONDON. Two articles are included on the development of the cargo terminal at Heathrow. The first, by W. R. S. Hill, BSc, who is Chief Civil Engineer, British Airports Authority, describes the engineering programme and the extent of the work involved. The total expenditure will be in the region of £25 million. The work includes the construction of a cargo tunnel. The second article describes the design and construction of this tunnel, which passes under the two existing runways.

PORT TALBOT TIDAL HARBOUR. Work is well advanced on the construction of a new tidal harbour at Port Talbot which was designed to provide accommodation for iron-ore carriers of up to 100,000 d.w. tons initially and ultimately up to 150,000 d.w. tons. Messrs Rendle, Palmer and Tritton are the consulting engineers for this £17 million project, which is being carried out by Marples Ridgway Ltd, and Kier Ltd, as a joint venture for the British Transport Docks Board. A major part of the work has been the construction of two large breakwaters to impound a dredged basin. These breakwaters are "armoured" with large quarried stones of 6 to 8 tons in weight. During the planning of this project the British Transport Board Research Department carried out extensive wave model tests which are described in this article.

Notes from *Civil Engineering and Public Works Review*, January 1969

A SURVEY OF THE TEACHING OF STRUCTURAL DESIGN IN CIVIL ENGINEERING. I. Robb, MSc, AMIStructE, who is a lecturer at the University of Salford, has carried out an analysis, as a result of questionnaire sent to 500 chartered structural engineers, to try to determine the best balance between the academic and practical aspects of teaching civil engineering. The article provides some useful statistics and highlights the need for teaching establishments to promote and reflect modern techniques and to keep teaching syllabii up to date. In particular the author notes that the continuing development of load factor methods into limit state analysis and the acceptance of new steels and composite construction as prime examples of fields in which the educationalists cannot afford to be five years behind industry.

HOW, WHERE AND WHEN TO APPLY FOR POSTGRADUATE GRANTS. In this short article T. K. Chaplin, MA, PLD, FICE, FASCE, gives some very useful information, in question and answer form, on postgraduate grants and how to apply for them. Although primarily written to help the young graduate engineer, much of the information given may well be useful to members of the Corps contemplating a career in the civil engineering profession on leaving the Service.

Notes from *Civil Engineering and Public Works Review*, February 1969

MILFORD HAVEN HIGH-LEVEL BRIDGE. The recent expansion of Milford Haven as an important tanker terminal has necessitated considerable modification to the harbour and its facilities. While the deep-water channel is to be enlarged and new navigational aids are to be installed to help vessels through the harbour entrance, a new high-level road bridge is being constructed at Pembroke Dock to improve access to the various installations around the harbour and to handle the increased traffic loading. In order to handle tankers of up to 250,000 d.w. tons, a £12 million dredging service is being planned to straighten out the existing channel by chiselling away the corners. The contract for the new high-level bridge has been awarded by Pembrokeshire County Council to A. E. Farr Ltd., as main contractors in the sum of approximately £2 million. A well-illustrated article by Colonel W. Brunden, OBE, DL, MEng, FICE, MIMunE, gives brief details of the proposed new bridge and its conception.

SHEAR FAILURE IN REINFORCED CONCRETE BEAMS WITHOUT WEB REINFORCEMENT, by R. W. Swamy, PLD, MEng, MICE, MASCE, AMIE(Ind). Details are given in this article of research work carried out by Dr Swamy at the University of Sheffield. There are still many unresolved problems and conflicting opinions concerning the shear failure of reinforced concrete beams. This research should make a valuable contribution to knowledge of this subject. Part 2 of the report will be included in the next edition. R.C.G.

CIVIL ENGINEERING

Notes from *Civil Engineering and Public Works Review*, March 1969

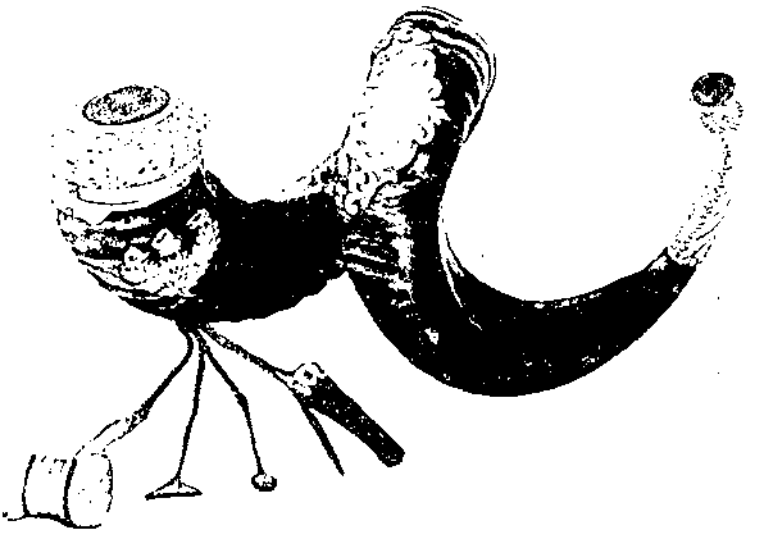
CONSTRUCTION OF THE WESTERN AVENUE EXTENSION. This article, by F. S. Nundy, CEng, FICE, who is Chief Engineer to John Laing Construction Ltd, describes the construction of this £15 million contract for the Greater London Council. The contract includes the Western Avenue Extension, which is an elevated structure throughout its length, and the West Cross route, which is a ground-level motorway which connects into it at a flyover. The design of the elevated structure, which is probably the most advanced at present under construction in Europe, by G. Maunsell and Partners, Consulting Engineers, was developed as a result of their vast experience in this field on the Hammersmith Flyover and Mancunian Way. The elevated structure and motorway will be the first major contribution to the Inner London Motorway Box. Major R. D. Holland, RE, BSc, MICE, was attached to the main contractors, John Laing Construction Ltd, in 1967 as a CF/PA attachment, and played an active part in the early stages of the contract. The elevated section in the main consists of precast high-strength concrete sections, which are constructed near the site, and prestressed in three directions. The design of these units was extremely complex and entailed extensive use by the Consultants of their computer in addition to experimental work.

COMPUTING MOMENTS IN TWO AND FOUR COLUMN BRIDGE PIERS. This short article by Y. Bangash, BSc, MSc, CIT (USA), MASCE, describes a time-saving method for calculating dead and live load moments in two-column and four-column piers carrying a single-bridge deck. It would be of use in the field to RE officers required to design continuous-span improvized bridges.

SHEAR FAILURE IN REINFORCED CONCRETE BEAMS WITHOUT WEB REINFORCEMENT. Part 2 of this article, reviewed in last months' Technical Notes, has been included in this edition.

It was contributed by Dr Swamy of the University of Sheffield.

R.C.G.



This snuff box was presented to the Mess in 1844 by George Sim, Bengal Engineers. It is one of the many historical pieces of the RE HQ Mess collection. Photographs and descriptive details, written by the Late Colonel J. M. Lambert, of fifteen Mess portraits and forty one pieces of Mess silver are included in a beautifully illustrated booklet entitled.

THE PORTRAITS AND SILVER OF THE RE HQ MESS

The book is obtainable from the Secretary, Institution of Royal Engineers, Chatham, Kent. Price 30/-, post free in the United Kingdom.
