THE ROYAL ENGINEERS JOURNAL—DECEMBER 1965 VOL LXXIX No 4

# THE ROYAL ENGINEERS JOURNAL

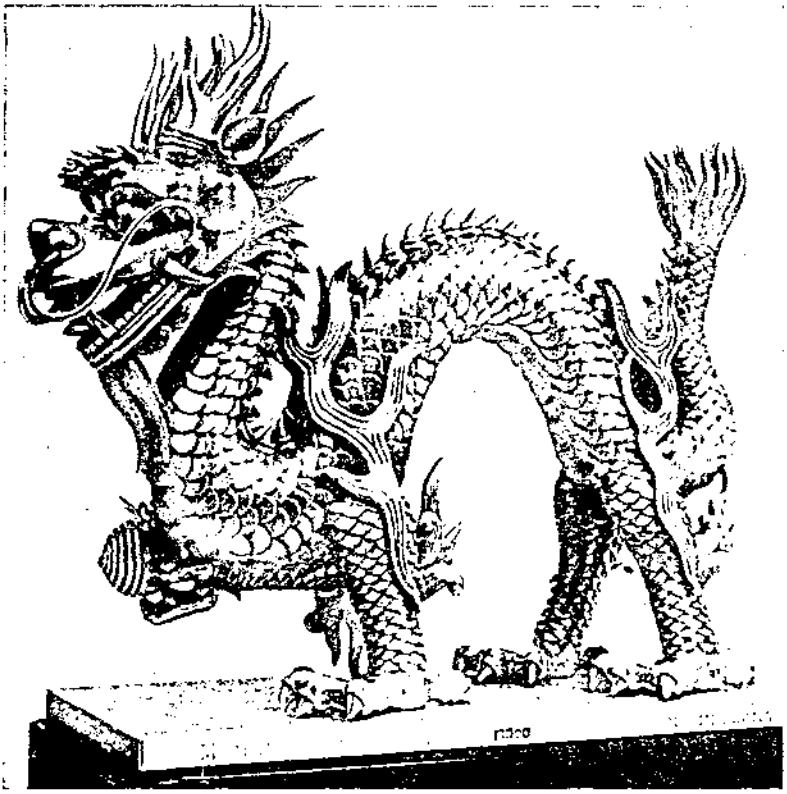
Vol LXXIX DECEMBER 1965 No 4

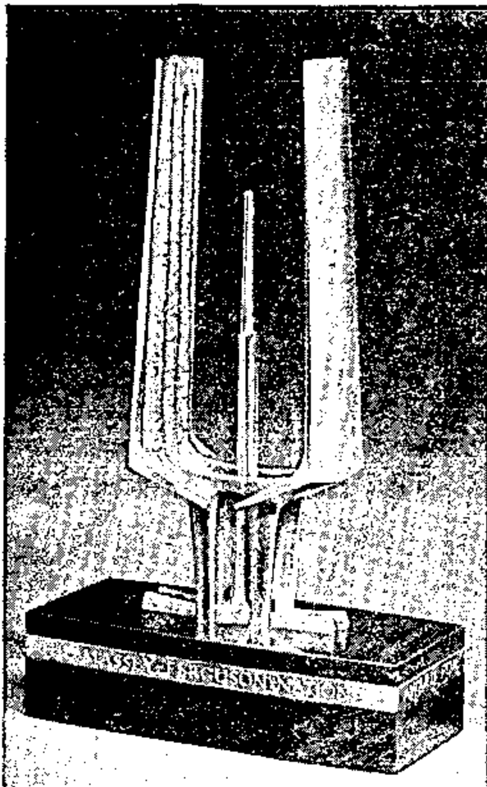
CONTENTS



PUBL ... ERS

AG ... M





# THE COUNCIL OF THE INSTITUTION OF ROYAL ENGINEERS

*(Established 1895, Incorporated by Royal Charter, 1923)*

Patron—HER MAJESTY THE QUEEN



4,000 1.12.65

THE ROYAL ENGINEERS JOURNAL

*Authors alone are responsible for the statements made and the opinions expressed in their papers*

VOL. LXXIX CONTENTS DECEMBER, 1965

# Ceremonies in Connexion with the Formation of the Royal Corps of Transport

ON 15 July 1965 the Royal Corps of Transport was formed and a number of ceremonies took place to mark the occasion in various parts of the world, of which the principal were at Longmoor, Aldershot and Chatham.

At Longmoor, which was for so long the headquarters of the Railway Troops and later of the Transportation and Movements Service, a parade and a beating of retreat was held on the evening of 14 July, before the RE flag was finally lowered. 8 Railway Squadron were on parade and the salute was taken by General Sir Frank Simpson, Chief Royal Engineer. Amongst the distinguished guests who attended were General Lord Robertson, Major-General Duke, the Engineer-in-Chief, Major-General de Rhé Philipe, Colonel Commandant of the Royal Corps of Transport, Major-General Russell, lately Chairman of British Road Services, Major-General Foulkes, late Engineer-in-Chief, three members of the Engineer and Railway Staff Corps, five past Commandants of Transportation Centre RE Longmoor, all five Inspecting Officers of British Rail and many senior retired officers of the Corps of Royal Engineers. In all nearly 1,000 people were present and amongst them were many whose association with Longmoor stretched from 1905 to the present day.

After the parade of 8 Railway Squadron, commanded by Major F. X. S. Carus, RE, the Chief Royal Engineer addressed the Squadron, in the course of which he said: "Let us look back on your history as Royal Engineers. For the past 159 years your unit has served with distinction in many parts of the world, including the Crimean War where it was commanded by a very famous Sapper indeed, Captain Charles Gordon, destined later, as General Gordon, to add lustre to the name of the Corps in China and then in the Sudan and to die in that immortal stand at Khartoum.

Eighty-three years ago you, as 8 Field Company, were the first regular Railway Unit in the British Army, and three years later your company took part in the Sudan campaign, with Sir Garnet Wolseley's Force which was trying to relieve Khartoum, where your old OC, General Gordon, was besieged.

The company then returned from the Sudan to build the light railway from Upnor to Chattenden for the Naval Armaments Depot. Many of you here on parade today went back to Chattenden last year, and as one of your last Sapper tasks, constructed the Petroleum installation now in use by the Royal School of Military Engineering.

The company gave fine service in both World Wars, finishing up in North-West Europe for the final victory. In 1948 you were reformed as 8 Railway Squadron and you sent a detachment for your last active service to Port Said in 1956.

Tomorrow you become 8 Railway Squadron, Royal Corps of Transport. But we are all Sappers here on parade today and I want you to know that the Corps is proud of the unit's long and distinguished service in it. I myself am very proud to be taking your last parade as Sappers and I congratulate you all on your smartness, your bearing and your turnout, and wish you the best of luck in the future, both individually and as a unit."

Then, addressing both the spectators and 8 Railway Squadron, the Chief Royal Engineer said: "In a short while, during the beating of retreat, the flag of the Corps of Royal Engineers will be lowered for the last time at Longmoor. A great many distinguished people connected with Longmoor and with the Railway and Transportation side of the Corps have come here today to mark the occasion. The association of the Corps with Longmoor Camp began from the very outset when two companies of the Royal Monmouthshire Royal Engineers started to build it in 1900. That was, and still is, a Militia Unit, and I am particularly glad to see today 72 and 73 Movement Control Regiments, who are in camp here representing the Reserve Army which has had so much to do with Longmoor throughout its history.

You all know the story of how 53 Company moved part of the camp from Longmoor to Bordon by rail and how the construction of the standard gauge railway from Bordon to Longmoor began here in 1905. How well the wisdom and foresight of those early Sappers paid off in World War I, no less than 62,000 trainees passing through Longmoor on their way to France.

After demobilization in 1919, the Transportation Service almost ceased to exist, but eventually those Sappers who were concerned with it managed to get together in 1924 the Supplementary Reserve which was formed here from the four mainline Railways to provide for wartime expansion. I am glad to see some of their representatives here today as well as to know that some of the old pre-war Supplementary Reserve personnel are watching the ceremony.

The Docks Units too when formed were trained here in spite of this place being so far from the sea. The Movement Control Service was also established here in 1938. Once again in World War II this wisdom and foresight paid off because the Transportation and Movement Control Services, which were trained either here at Longmoor or at other places at home and overseas by Longmoor personnel, grew to a total for the Commonwealth as a whole of 167,000 all ranks—almost the size of the whole British Army today.

Tomorrow Longmoor will cease to be a Royal Engineer establishment and will become the School of Transport, the professional centre of the Royal Corps of Transport.

Of course for many of us here today this is a sad occasion—particularly so to those many officers and men who for so long have regarded Longmoor almost as their military home. However let us take pride too in what has been achieved. We in the Royal Engineers have had a big share in many military innovations and have then passed these on to other hands. For example, the Royal Artillery in 1716; the Submarine Mining at the start of this century; start of mechanical transport in the Army handed over to RASC, the Royal Flying Corps (which became the great Royal Air Force of today) in 1912; and the Royal Signals after World War I. Tomorrow when the Transportation Centre becomes the School of Transport, it will not be the least of our contributions in this field. And we must remember in all these instances I have given you that the part handed over by the Corps has always gone to even greater distinction in its new guise. I am sure it will be the same with Transportation.

To all those who are transferring I wish the very best of good fortune. We in the Royal Engineers will watch their progress, and indeed that of the whole of the new Royal Corps of Transport, with interest and pride.

I repeat—good luck to you all."

When 8 Railway Squadron marched off, the RE Band Aldershot remained on the parade ground and beat retreat. Besides the RE flag of the Transportation Centre, the flags of 16 Railway Regiment and 8 Railway Squadron, 17 Port Regiment, HQ, AER (Tn and MC) and of the 72 and 73 Movement Control Regiments (AER) who were in camp, were lowered at the same time. After the parade the Chief Royal Engineer visited the REA Club at Longmoor and met many old Sappers who had been associated with Longmoor and with the Transportation Service over the years.

A cocktail party was then held in the Officers' Mess attended by over 300 guests. The WOs and Sgts' Mess held a similar function and entertained many of their old comrades and RE Chelsea Pensioners.

The weather which had been threatening all day cleared up in the evening and there was sunshine for the ceremonies and for the functions afterwards. Although it was in many ways a sad occasion it was an impressive ceremony and it was a great pleasure to welcome such a large number of people including many of distinction in the world of transport, whose connexion with Longmoor span so many years.

The following morning, 15 July, the formation of the Royal Corps of Transport took place ceremonially at Buller Barracks Aldershot. The parade was taken by General Sir James Cassels, Chief of the General Staff, and was attended by many members of the Army Board as well as many military and civilian dignitaries. On parade were 8 Railway Squadron, RE, and a detachment from 1 Training Bn, RASC, and 65 Company, RASC.

After the parade had formed up and the Inspecting Officer had arrived the RASC flag was lowered finally to the tune of Auld Lang Syne and the new Royal Corps of Transport flag broken out and given the General Salute. The main part of the rebadging ceremony then took place and consisted of issuing new hats to the Sappers and new badges to the RASC. It was an elaborate and carefully rehearsed ceremony and was performed perfectly with everyone getting a hat of the right size. Amongst the crowd of photographers that were following the CGS as he carried out part of the ceremony was a man in a black felt hat. However, it was not true that he was a representative of a well known firm of Military outfitters making an offer for the now surplus Sapper headgear. Finally the parade marched past and off the parade ground to the tune of the RCT march. After the parade there was a march past of the various types of transport that the RCT operates and finally the CGS and Lady Cassels left in the RCT coach for lunch at Buller Barracks, where the other guests were also entertained.

On 22 July the Sapper officers who had transferred to the Royal Corps of Transport were dined out in the RE Headquarter Mess, Chatham. In all 114 regular and short service officers were able to attend the dinner besides four officers of the AER (Tn and MC). After dinner Brigadier Woollett, the last Commandant of the Transportation Centre, presented to the Corps a silver centrepiece to commemorate the Movement and Transportation Service. In making the presentation Brigadier Woollett said: "As the last Commandant of the Transportation Centre it is my privilege to make a presentation on behalf of the Transportation and Movement Control Services. Originally a centrepiece was planned to be provided for the RE Mess, Longmoor and funds were provided by the Corps and by subscription from Transportation and Movement Control officers. However, the McLeod reorganization meant that Longmoor would cease to be an RE Mess, and that in turn meant that there would be nothing belonging to the Corps to commemorate the Tn and MC Services. The Longmoor Mess, therefore, voted sufficient funds to enable a replica to be made—most appropriate since the funds had been built up in the past by many hundreds of RE officers.

In selecting a design for a centrepiece of this nature there were two extremes—the technical and the symbolic. The former leads to locomotives and craft, which are not really very beautiful in silver, whilst abstract designs tend to be incomprehensible and lead to arguments.

This centrepiece is the result. I think it is a happy compromise between the technical and the symbolic for which we are greatly indebted to the designer, Mr Lewin Tugwell, even though he is an ex-Gunner.

The three plaques represent a railway scene which has a distinct Longmoor flavour, a typical port scene and a lighterage scene in a Far East setting. The three figures are those of the three basic Transportation tradesmen, a locomotive fireman in his distinctive Transportation hat and overalls, a lighterman casting a warp, and a stevedore holding a hook and sling. Movement Control is symbolized by the chain encircling the base of the centrepiece—binding together all Transportation activities. The Dolphin on top is a speedy, efficient, intelligent and kindly beast symbolizing the existence of those qualities in the Transportation and Movements Service. Lastly there is the Lady riding the Dolphin, symbolizing perhaps the off-duty thoughts of the soldiers.

Finally, I have been asked to express the thanks of the officers transferring to the RCT to you, Sir, and to all of their brother officers who have entertained them so well and so kindly tonight.

Because I am not transferring myself, and because I am so closely associated with most of them, I think I can express their feelings of sadness at being separated from the Corps to which they have been so proud to belong, and their hope, which this gesture of dining them out has done much to sustain, that they will continue to be regarded individually as part of the family.

I would ask you, Sir, to accept this centrepiece to commemorate the Transportation and Movement Control Service."

Finally, Major-General de Rhé Philipe thanked the officers of the Corps on behalf of the officers who were transferring. Amongst the officers dining were General Sir Charles Jones and General Sir Charles Richardson and the occasion was also one when the retiring Engineer-in-Chief, Major-General Duke, was being dined out and Major-General Bowring, his successor, was being dined in.

In lighter vein, the final RE guest night at Longmoor deserves to be recorded. The inevitable explosions, without any such celebration would be incomplete, were cunningly connected to various booby trap devices, and dinner was eaten in an atmosphere of excitement and apprehension. Afterwards the Mess adjourned to Longmoor Downs station where they joined a train with a bar and detachment of the RE band aboard, and proceeded to beat the bounds of the Longmoor Military Railway to musical accompaniment. The journey was accompanied without incident, except that at Bordon, whilst the locomotive was being run round to a spirited rendering of the Post Horn Gallop, a lady was seen to come out into her garden in her nightdress, shaking her fist. However, a visit and a gift of flowers the following morning by one of the more personable young officers restored good relations.

# 1965 Cooper's Hill War Memorial Prize Essay

## THE TRADE STRUCTURE OF ROYAL ENGINEER FIELD UNITS

*By "Pro Bono Ingeniator"*

*The role of the Royal Engineers has often been stated to be "to enable the Army to live, to move and to fight". The individual trade skills needed in the Royal Engineers for Army support in General War may be expected to be appreciably reduced due to, firstly, the shorter anticipated duration of the next General War and, secondly, the increasing self sufficiency of All-Arms. The full range of trade skills, however, is still required in limited and cold war and for national disasters.*

*Discuss this with reference to the organization of RE Field Units. Give your views on whether it would be preferable to economize in training time and effort by including fewer individual trade skills in field units and providing for re-inforcement of units by small, highly specialized trade teams when on tasks outside the General War environment.*

### INTRODUCTION

IN commenting on any possible change of trade structure in Royal Engineer Field Units, it is necessary to decide the possible period over which this might take place. The sort of change that is envisaged in the setting of this paper could not make an effective start for some three to five years and would then take full effect over the next five to seven years. Trade structure in this paper only concerns what might be called the constructional and fabricating trades, carpenters, bricklayers, plumbers, etc. It does not concern such administrative trades as clerks and storemen, nor such common-user trades as drivers and driver operators; neither is it directly concerned with such trades as plant operator and plant fitter.

It is also necessary to make certain assumptions of the probable changes that will occur in the two types of war under consideration during the time scale. As far as the Army in BAOR is concerned, its function will be very much as it is now; to provide a properly balanced element of a credible NATO deterrent to General War. There will, however, over the period be an increase in the number and effectiveness of weapon systems and particularly in their capability of target acquisition and response times. This postulates an even greater reliance on swiftly-moving, heavily-armoured columns with full cross country mobility.

For Strategic Reserve type operations, it must be assumed that we shall continue to retain most of the bases that we have now. In the event of certain of these not being available to us, it should be possible to operate in most areas by means of the new landing ships assault and landing ships logistic which will be coming into service during this period. Although limited war on any large scale appears less likely over this period than counter-insurgency, internal security and emergencies short of war, it will still be necessary to plan and train for participation in limited war. In all these types of operation, which for simplicity will be known as cold war operations throughout this paper, it will be necessary for forces to rely to a large extent on air movement both of men and equipment. Furthermore, even where theatre stocks of military equipment exist, it will still be necessary for intra-theatre movement to be carried out by air and, therefore, there must be considerable reliance on light scales and airportable items of equipment.

Having now defined the time scale, trade structure as it applies in this paper and, in very general terms, the developments in general and cold war over the period which are particularly likely to affect Royal Engineer Field Units, we can consider how the trade structure of such Units might be varied to meet these foreseen circumstances.

The defence forces provide an insurance policy for which the country pays a relatively high rate of premium. To be of real value, and what is more, to be seen to be of value by Ministers of the Crown, Members of Parliament and the general public, the services must be constantly tailored to fit a changing world pattern and a changing economic situation. In this respect no Service requires to maintain a modern image more than the Army, and each component part of it can only continue to be properly justified if it can perform its functions, not to its own satisfaction but to the satisfaction of the rest of the Army and, where applicable, the Defence Services as a whole.

The Royal Engineers can be no exception to this rule. Many changes have recently been made to the structure of the Corps by circumstances outside our control and some of these have not been to all our tastes. We must, however, accept that it is part of our job to advise as to our future role as constructional engineers to the Services as a whole, even though such advice on broad structural alterations required to existing units and existing means and methods of training may have repercussions on tradition and accepted practice which are not always palatable.

We must examine whether in Royal Engineer Field Units the present trade structure is applicable to all types of war or whether it should be modified to meet the foreseen changes over the next ten years. In doing so, we must realize that any major changes in the trade structure of Field Units must inevitably have far reaching effects. It may affect, amongst other things, the standard of technical training of officers and senior NCOs, the trade structure of static units and Reserve Army Engineers; it is also bound to have considerable effect on the trade training, both at the Army Apprentice School, Chepstow, and at the Royal School of Military Engineering. It will certainly affect our recruiting and the standards of our recruits. None of these factors however, are reasons for deferring or refusing to examine the necessity for changes in trade structure, if such changes are found to be necessary, when considering the operational role of Royal Engineers in all theatres and under all conditions of war. This must be the only real criterion by which this evaluation stands or falls. Tradition, recruiting of officers and men, influence in the Reserve Army are all factors that must be looked at. But they can only be considered as secondary factors compared with the operational efficiency of field units worldwide.

## Roles of RE in General and Cold War

To support our forces in general war in Europe, the main role of the Royal Engineers will be to ensure the mobility of our forces and their tactical nuclear weapons and, on the other hand, to restrict the movement of enemy forces. To work efficiently with the rest of the Army, engineer field units will largely have to be mounted in armoured vehicles; combat engineering tasks will have to be done in extremely quick time using standardized drills and equipment with improved means of communication. This is not to say that there will never be need for improvization, but there can be little doubt that the primary task for Engineers must be increasingly geared to highly mechanized and sophisticated types of bridging, mine laying and demolitions. Even in such humdrum tasks as road and track maintenance and repair and the construction of field defences, where these are not within the province of all arms, mechanization and prefabrication will have to play a much greater part if we are to perform our role adequately. It matters little whether in the general war concept we are dealing with full scale nuclear, tactical nuclear, or if it is conceivable, conventional weapons only. The weight of fire and the speed of movement of both sides will tend to increase all the time, and Sapper techniques must, therefore, be slicker and more highly mechanized.

In cold war, the roles of the services and the Army in particular, are far more varied, whether this be for forces stationed in overseas theatres or in the UK based Strategic Reserve. It can range from, on the one hand, disaster relief emergencies, through various stages of cold war and counter-insurgency, to limited war with or without tactical nuclear weapons. In addition, forces stationed in the UK as part of the Strategic Reserve must under certain conditions, be available to take part in general war in Europe. In order to support the Army and in certain respects, the Services as a whole, over this very wide spectrum of roles, the Sappers must, first and foremost, retain real versatility. Field Units must be prepared to undertake both logistic and combat engineer roles in a ratio which might be assessed at somewhere about 60 : 40, and of which the logistic aspect will increase if, as current trends show, counter-insurgency and emergencies short of war become increasingly the main role. This does not take engineering back to the days of "stick and string" and hand tools; modern techniques have their application in cold war. In addition, wherever engineers work, they will always be up against shortages of skilled and semi-skilled labour which can only be redressed by machine power. These machines must, however, be air-transportable wherever possible, both from the UK to theatres overseas, and even more important within theatres overseas. The high cycle general purpose tool kit which is now coming into service, gives one a good example of this. However, in many cases heavy equipment will have to be locally impressed and old fashioned power stations, water supply installations, cold stores, etc, will have to be maintained, repaired and operated. The need, therefore, is apparent for a versatile unit and a Sapper well trained in standard military equipments but prepared to improvize with unfamiliar equipment, either military or civilian.

### Trades Requirements in General and Cold War

Having examined the basic differences between possible engineer roles over the period of this paper, it is necessary now to see how these differences are likely to affect the trade structure of Field Unit of the Royal Engineers. In general war in Europe, fought increasingly from armoured vehicles, with a considerable radio network of an advanced type, with heavy sophisticated equipment, amphibious bridging and mechanized mine layers, the need for constructional type tradesmen is a diminishing requirement. Administrative trades, drivers, driver operators and driver specialists and a limited number of plant operators and fitters, will continue to be required with a very heavy build-up of the number of driver operators as units are converted to an APC basis. There will be a continuing need for a number of combat engineer skills requiring considerable training and very quick response times. On the other hand there will seldom, if ever, be time under operational conditions in general war for improvization and fabrication in detail. This must surely eliminate the need for the majority of construction trades such as carpenters and joiners, concreters, plumbers, etc. Judged therefore purely on the requirement of the operational role in general war in Europe, it is hard to justify in the future any large numbers of constructional tradesmen in Engineer Field Units in BAOR.

On the other hand, in cold war roles, the need for constructional tradesmen becomes more and more apparent. In combat engineering, there will continue to be a small requirement for a number of trades, but in logistic engineering such as camp construction, bulk petroleum installations, airfields and associated services, and other tasks in the base and communications zone there will be an ever increasing role for a variety of tradesmen of all types. A lot can and is being done to simplify trades work in such tasks, but there will always be a requirement for special fabrication particularly in areas remote from existing bases and installations. In Aden, in Christmas Island and in Thailand on recent major logistic tasks in support of cold war operations, the need has always been for more and better trained and more recently-practised tradesmen. In fact so great is the accent on this, that a recent innovation has been to propose a new establishment for field squadrons in the Strategic Reserve Worldwide with a number of nominated tradesmen and the balance, heretofore combat engineers, now shown as being drawn from selected but mainly constructional trades. This means that if such proposals are accepted this type of Squadron will in future have a very much larger number of constructional tradesmen of all types and this proposal has been based solely on the lessons of the recent past and prognostications as to the future. Of course all the tradesmen of such a unit will have been trained as combat engineers and many of them, including a majority of the NCOs, may develop this as their primary trade. It is likely however, that in such units there will in future be no Sapper designated purely as combat engineer, troop working number of general duties man.

We have seen, therefore, that it might be possible to reduce the numbers of tradesmen in field units in BAOR, but not in engineer units of the Strategic Reserve Worldwide. The reduction being almost entirely a direct result of the foreseen role of the engineers, and having very little to do with the increased self-sufficiency of all arms; this latter would be largely confined to combat engineer skills. These include an increasing ability of all arms to plan and execute their own protective works; to assist far more in the laying of small minefields and in minefield breeching; and to help to a certain extent in the preparation of tracks and repair of routes, other than main ones. These, however, are basically combat engineer tasks and as such, have only limited effect on the trade structure of Royal Engineer field units.

### Possible Solutions

It is clear, therefore, that if we base establishments for engineer field units wholly or mainly on the foreseen operational engineer tasks, there is now and will be in the future a growing requirement for completely different trade structures for units in BAOR as opposed to those in the Strategic Reserve. It could well be argued that since we have in any case to make numerous changes in vehicles equipment and trades particularly those concerned with driving and radio, we should make a clean break and have entirely different establishments for BAOR and the Strategic Reserve squadrons, with completely dissimiliar trade structures. Experience over the past few years has shown that there are difficulties inherent in adapting a BAOR squadron for Strategic Reserve operation roles and vice versa. If squadrons are to be moved between these theatres either on a squadron trooping programme, as has sometimes been advocated, or as an emergency measure for a particular crisis, then it is obvious in the future that wherever possible some reorganization, re-equipping and re-training will be essential, and that the period necessarily devoted to this will grow longer until such moves become extremely difficult to undertake. Advocates of this idea could well argue that we have for too long tried to preserve the "one world" tradition with all units of the same type on the same establishment and that this is now a paper theory only; as far as Royal Engineer field units are concerned "two worlds" are with us and must now be recognized. It could be argued that with a substantial reduction in tradesmen in BAOR field units there could be a saving on trades training with a considerable reduction of "non-effectives" in the training machine, and a small saving in officers and senior NCOs as trades instructors. Many a regimental commander and squadron commander would rejoice in the thought that no longer on his regimental/squadron state would somewhere up to a quarter of his total strength be held against the mystic letters BTT or HTT.

However such a reorganization will make it very nearly impossible to redeploy units from BAOR in Strategic Reserve tasks even after a considerable period of retraining. Equally, it would make it very difficult to redeploy Strategic Reserve squadrons in a general war role. Furthermore, and even more fundamentally, although such a reorganization might promise a reduction in training effort, it would make it almost impossible for the majority of Sappers to be employed in turn in BAOR and Strategic Reserve units, with minimal retraining within their new units. This can be done at the moment but only because they have had basic combat and trades training. Such a complete lack of flexibility is not acceptable as regards units and certainly not as regards individuals. This must dispose of carrying the "two worlds" theory so far that the Sapper is not basically trained so that either he as an individual or his unit as a whole can with some retraining be capable of adequate performance in both roles.

We have seen, however, that it might be possible as far as BAOR is concerned, to reduce substantially the trades structure in field units, retaining a few tradesmen either in field park squadrons or possibly in specialist teams or both. In order to achieve some degree of "oneness" would it be possible to achieve something of the same order in Strategic Reserve units with a consequential greater saving in all trade training. Lessons from all cold war campaigns have, however, made us propose for an airportable field squadron of the Strategic Reserve a far higher number of tradesmen than heretofore. The field park is already so full of tradesmen, most of these are in constructional or fabricating trades, that there is scarcely one GD man available. It would seem therefore, that no scheme to reduce tradesmen in field units of the Strategic Reserve by this means would produce any economy at all, as these units are, in fact, simply teams of mixed tradesmen of all types. There is, of course, in addition a need for certain specialist teams, either for particular skills, such as well drilling or to contain tradesmen of a special type and a very high grade such as the bulk petroleum specialist team, but this is a separate problem which will be dealt with later.

We have now examined and rejected as impracticable a complete disparity between the trade structures of field units in BAOR and those in the Strategic Reserve. We have also tried to see whether any reduction in trades in BAOR units with a reliance on a few tradesmen in field park squadrons and Specialist Teams could be matched by a similar arrangement in the Strategic Reserve. We have found that no economic system could be considered viable in view of the continuing requirement for more and more highly skilled tradesmen in all field units of the Strategic Reserve. Even though it is not justified on operational grounds in that theatre, it would seem that, in order to achieve even a reasonable degree of flexibility, and it can be no more than that, we must retain approximately the same trade structure as now exists in field units in BAOR. Before however we argue further on the acceptance of such a compromise with operational essentials, we must examine the other matters on which any major change of this nature would have effect.

### The Effect on Recruiting

One of the strongest recruiting factors of the Royal Engineers has always been the appeal to the man to be both a soldier and a tradesman. If there were to be a considerable reduction in the trades content of field units in BAOR, there must inevitably be a considerable reduction in the number of men coming into the Royal Engineers who would receive basic and higher trades training courses. This is bound to reduce the recruiting attraction of the Corps, and particularly this would be so because most of the trades in question are those that have considerable application in the civilian market. If the Corps is reduced in a theatre where little less than half its field units are deployed to what might be considered to be a glorified "Assault Pioneer Corps", there is the strong probability that we should cease to attract, both as junior soldiers and recruits, the type of man that can be trained as a really competent soldier-tradesman and that our general impact on the Army would fall very strongly as a consequence.

Nor would its effects be confined only to the recruiting of soldiers; it is bound in the long run, to influence the standards and training of officers. It has always been maintained that, in order to keep up our professional status as a Corps, a large proportion of our officers must have taken degree courses, either at Cambridge University or at the Military College of Science. This has been justified in the past on the level of work carried out by all types of engineer units, including field units. However, if a large number of our field units are not to contain any sizeable number of tradesmen and therefore will, in the future, have no ability to carry out real engineering tasks, there must surely be a case for the financiers to try and restrict the professional training of Royal Engineer officers. This would not only apply to the professional training at University but also to the further professional training on Long Engineering Courses. Mistaken though such an action might be, it would be difficult to resist and would, of course, ultimately very greatly qualify the chances of obtaining for the Corps of Royal Engineers, the officer of both brains and character whom we have always hoped to attract.

There is one further point which must be taken into consideration. There would be a considerably reduced requirement for men trained in (trades, constructional and fabricating) both from the Army Apprentices School and from the Royal School of Military Engineering. This would in its turn reduce the field from which NCOs can be chosen to qualify on a Clerk of Works Course. If we are to retain this highly skilled body of NCOs, and if they are to be, not only skilled trades supervisors, but also good NCOs, then it is essential that we should have a large number from whom to choose.

### Trades Employment

So far we have dealt only with the operational aspects in general war and cold war but before we can decide how the trade structure of field units should be fixed we must see how the tradesmen in units are to be employed under peace or semi-peace conditions.

In BAOR it is going to be more and more difficult to employ tradesmen at their trades other than on minor tasks in the maintenance of barracks, possibly mainly under the auspices of the MPBW. This is unlikely to give satisfactory trade employment of the type that fits men for future employment in Strategic Reserve roles, but it can give some trade practice even if under rather limited circumstances. It is, however, during his time in BAOR that the soldiers will be fully trained in up to date combat engineering techniques and he cannot expect, during this period, to be employed at his trade for any great period of time. One other point is worth mentioning. Without a proportion of tradesmen and some trades experience it might be very difficult at some future date to meet from BAOR resources a crisis of the nature of Skopje, where men from a Regiment in BAOR helped in the erection of hutting and connected facilities for the temporary housing of schools and other essentials.

However, in the Strategic Reserve, both on operations and in training, much fuller trade employment under varying circumstances and in different theatres is the role. In all forms of operations and in most major exercises, trade skills will be required. There must, of course, be considerable time devoted to training in combat engineering techniques. This is a basic necessity and in addition the Sapper must receive far more training in basic military skills than he does at this moment. Recent events in Middle and Far East have shown the necessity of Sapper units being capable of dealing with ordinary military tactical situations when they arise. The old military virtues, use of weapons and ground and slick practised deployment drills were never more necessary. However, even allowing time for these aspects, both on operations and in training there is no limit to the trades employment of units of the Strategic Reserve.

For units permanently or temporarily deployed in an overseas theatre one cannot foresee a time when this will not be the case. However, if at any time there is a shortage of operation employment for Strategic Reserve units stationed in the UK, there would appear to be plenty of work for such units together with specialist teams in assisting those parts of the world for which the United Kingdom has a continuing responsibility to achieve a better economic standard and a better standard of livelihood for their people. There are innumerable tasks that engineer units could undertake to improve transportation facilities, ports, airfields, and roads and to produce some type of hutted accommodation for public services and improve or increase the scale of utilities. It is often said that the British Serviceman is the country's best ambassador. In underdeveloped countries, this somewhat well-worn cliche might really have some meaning for peoples who saw soldiers not with a rifle but with the training, equipment and ability to make life a little easier. In many parts of the world from Aden to the Gilbert and Ellice Islands and from British Honduras to Kenya, the few small attempts to win 'Hearts and Minds' that have been made by the Corps have been a great success. Perhaps it is not too much to hope that, if we could do more of it, we could both spend money allotted for this type of development more wisely and help to counteract the unrest at low living standards that so often blossoms out into rampant violent rationalism and insurgency.

To do this, however, we shall require an even better level of trades skill in the field unit and we shall require young officers and senior NCOs who have experience in the management of engineering projects and can insist on reasonable quality control in any jobs that are carried out. Above and beyond this we shall require a Military Engineer Service which can provide teams of experts, to reconnoitre projects, to work out how they are to be done and to give the high level of technical management that will be necessary if we are to show up well in these fields and increase the complexity of task that can be undertaken.

We have already discussed and discounted the possibility of replacing the bulk of tradesmen in field units by men having purely combat engineering skills and by a number of specialist teams being established in lieu. However there will indeed be a requirement for certain types of specialist teams in connexion with particular aspects of engineer work. This will occur when there are special skills, such as well drilling to be learnt, or where one requires a particularly high level of tradesmen as in the bulk petroleum specialist team. In addition, specialist teams may be needed for the planning and technical management of major works projects, and for transportation construction. These will generally provide only the specialist management for the jobs and they will need to have numbers of tradesmen produced for them from field units of the Strategic Reserve and in addition, skilled and semi-skilled labour, either from the same source, or from local resources.

## Conclusion

It is quite clear that the operational roles of Royal Engineer field units in General War over the next ten years will pose less demand for the majority of trades of a constructional or fabricating nature. It is also abundantly clear that the converse will apply to field units whether stationed at home or overseas who have roles of a strategic reserve nature. They are likely to require not only more but much better trained and exercised tradesmen of all types. It would, however, be a grave mistake to assume that because of these divergencies of roles and because of the changes necessary in organization and equipment, savings could be made in trades training by eliminating a considerable proportion of tradesmen from field units in BAOR. This could only lead to a complete lack of adaptability not only of units but also of individual junior NCOs and Sappers. It would lead to the training of two different types of Sappers, one highly skilled in the latest combat engineering techniques for general war, but with no trade skill, and the other a well-trained tradesman but with no knowledge of sophisticated combat engineering.

To some extent over the next ten years the differences between the roles will lead to divergencies in organization, equipment and training but provided Sappers are basically trained in the same way, it will be possible to move them from BAOR to Strategic Reserve units or vice-versa with only a short period of intensive retraining. It should also still prove possible to move whole units at reasonably short notice in emergency and thus retain the essential of flexibility which is an absolute essential for a small Army with world-wide commitments.

Training in BAOR must be based on the operational role and trades training will, therefore, be limited in opportunity and scope. Trades training for the Strategic Reserve both in operations, major exercises and where opportunities permit in aid of a full-scale "Hearts and Minds" programme will be very much easier to achieve. However, provided men are shifted between respective units at periods not exceeding three years, it should be possible to maintain a reasonable degree of flexibility and to keep the individual soldier reasonably up to date as a tradesman and able to compete with the sophisticated combat engineer techniques essential for general war.

If too slavish attention was paid to the operational role as the sole criterion and the trade structure in BAOR field units was drastically reduced, there would be a number of harmful side effects. Recruiting of other ranks, and in the long run, of officers would be bound to suffer. Smaller, and therefore generally less effective, trades training schools would result and this must in turn ultimately have an effect on the top level of the trades structure, technical Quartermasters and Clerks of Works. The net results of all these would be to reduce the Corps' potential ability to undertake any major engineering task. An Operation "Grapple" or even a "Hurricane Hattie" would find us woefully short of trades experience and technical management.

Specialist Teams will continue to be required, mainly in the central reserve of the Strategic Reserve in the UK, for Worldwide deployment. These will exist to perform tasks either which require continual practice as a small team, such as well drilling, or which require special high grade trade skills not generally required in normal field units. Proliferation of such teams must be closely watched.

Ever since the direction of Works Services for the Army was taken out of the Corps' hands, there has been considerable anxiety, not unmixed with gloom, over "Whither the Corps". It is easy, but unwise, to lay too much stress on the operational needs of the problematical general war whilst giving too little thought to the real role, and therefore the organization, of engineers in the ever present cold war. To ensure that we can deal competently with both, we must retain something approximating to our present trade structure world wide and retain the training organization that can supply the "soldier and tradesman too".

# Military Requirement and Employment of Engineering Equipment

*A paper to be presented for discussion by Colonel T. H. Egan, MBE and Lieut-Colonel E. Mac L. Mackay, MBE, RE at a Joint Meeting to be held with the Institution of Mechanical Engineers on 9 February 1966.*

## PART I MILITARY REQUIREMENT

### INTRODUCTION

DURING the past few years, the emphasis of British Military doctrine has swung from the concept of the general war in North West Europe to that of the limited war in more remote parts of the world. Such limited war operations by small well equipped forces in comparatively undeveloped parts of the globe inevitably place a premium on mobility. In these operations, speed is vital and the key to success lies in the use of aircraft for the transport of men and supplies. The traditional role of the Royal Engineers is to assist the Army to live, move and fight, and it therefore falls to them to develop engineering equipment and techniques required to achieve this aim. Such work may involve the selection and phased development of landing grounds for light and medium transport aircraft, landing sites for helicopters and other vertical take-off aircraft, and the progressive opening up of land communications. Much of this work can in the first instance only be done by bringing in lightweight equipment by helicopter, or by dropping it from aircraft, while the work on communications may involve either light work at widely spaced sites suitable for wheeled plant, or heavy work at selected sites suitable for tracked plant. Whatever the location or the task, the proper selection and use of equipment is of paramount importance. Thus, although the tasks of the Royal Engineers may differ widely from those of the average civilian contractor, the nature of the problems confronting him remain the same—namely the selection and deployment of the right equipment, at the right place, at the right time. The first part of this paper outlines some aspects of Ministry of Defence policy in relation to the development of Engineering equipment, particularly construction equipment. The second part discusses the use of engineering construction plant in the current operations in Borneo, describes some of the problems encountered, and the lessons learned. It is hoped it will stimulate thought and discussion amongst all those responsible for design and manufacture of engineering equipment which may be used by the Armed Forces.

### THE NEED FOR LIGHT-WEIGHT EQUIPMENT

Under conditions of limited war, brush fire or natural disaster the prime need is for a small force, self contained, capable of moving rapidly by air, and able to exert the maximum effort on their tasks as soon as they arrive. It follows that military engineers must be able to work rapidly, using to the full their manpower and machines. Generally speaking they and their equipment will be carried by air and in the initial stages of the operation at least, will be supplied by air.

Aircraft are always at a premium. For this reason, only the minimum of men and equipment necessary for the task may be despatched. The importance of the machine is at once established. It has been said before but bears repeating, that the D8 size of tracked bull-dozer is the equivalent of 250–300 men with picks and shovels. Unfortunately plant of this size is not airportable. The first requirement then is for equipment which is airportable, and within this limitation will exert the maximum tractive effort possible. This however is not the complete story. In many parts of the world the only means of getting such a force established is to airdrop them. Simple enough with men, but with equipment it imposes a further weight restriction, and in many cases makes it necessary to break it down into airdroppable loads. The conflict will be clearly apparent; viz: the work requires "man-sized" plant and the aircraft provides a "boy-size" container. Plant which is easily sectionalized and as easily reassembled will be worth its weight in gold.

*Military Aircraft parameters.* Perhaps it might be as well at this stage to fix in our minds the aircraft lifts which are available now or will be coming into service in the early 1970s.

| | |
|---|---|
| Helicopters | 3,000 lb lift over 50 r.m. radius |
| | 4,000 lb lift over 50 r.m. radius |
| | 8,000 lb lift over 50 r.m. radius |
| Short-range aircraft | 6,000 lb lift over 150 r.m. radius |
| | 12,000 lb lift over 200 r.m. radius |
| Medium range aircraft | 14,000 lb lift over 1,000 r.m. range |
| | 35,000 lb lift over 2,000 r.m. range |
| | 57,000 lb lift over 2,000 r.m. range |

Not all these aircraft are suitable for airdropping operations. Moreover the lift limits are reduced when the aircraft has to operate in hot climates or from high altitude airfields. They can however be used as a general guide in our later considerations. Other important criteria are, the size of aircraft doors, the dimensions of the freight compartment, the strength of the door sill and floor, and hence the axle and wheel loadings of the equipment to be carried.

The first difference between the requirements of the military engineer and those of his civilian counterpart has been defined: airportability. There are others. The civilian contractor generally has detailed knowledge of site conditions and local resources before he submits a tender for work. The military engineer often has little or no information of this kind and may not be able to carry out more than a sketchy reconnaissance before he is emplaned to carry out his task. Civil works of any size either take place near centres of communication, or adequate preparation is made before the work starts. The military engineer will often have to establish a supply of water, limited accommodation and means of communication between elements of the task force in the shortest possible time after landing, and before he can concentrate on the main task of opening up or rehabilitating airheads to improve the supply chain. The civilian contractor carefully selects the machines he requires for each task, whereas the military engineer has to make the best possible use of the few machines which fit air and other parameters, for a wide variety of tasks. Another important difference is that the civilian will make use of expert operators for all his most important machines, whereas the military engineer often has available only an inadequately trained operator for the particular machines he is having to use. This factor is of special importance under conditions of war, when there may well be casualties who are replaced by inexperienced, albeit willing, operators.

As a counter to these arguments two important facts should be set down.

The first is that very seldom does the military engineer have to work to the same high standard of finish as the civilian. His construction tasks are generally of a temporary rather than a permanent nature. Of course a high standard is required in airfield construction, but the military engineer will construct two temporary, rather than one permanent airstrip. He will carry out maintenance on one whilst the other is in use. The second is that most of the other tasks which fall to him can be carried out by plant suitable for airfield or road construction, even though specialized equipment may be required to operate on the finished facility. So that if a military engineer unit is equipped with an adequate scale of plant necessary to construct roads and airfields he can carry out most of the tasks needed in a limited war operation. There are obviously exceptions to this, and one which comes immediately to mind is water supply, for which well-boring equipment, distillation and purification plant may be required.

Enough has been said to establish the need to develop some equipment for military use. This is necessarily time-consuming because such developments must, if they are to have any value be based on new techniques or materials; otherwise they are obsolete, or at best obsolescent by the time they come into service. Apart from considerations of design, a good deal of development time is spent in technical evaluation, which might include tropical and cold chamber tests, rough country mobility and wading trials, and user trials. In embarking on development of a "military special" one must be as certain as possible that the equipment will be able to do the work required of it, can be made robust and reliable, and will have sufficient service life to justify the costly development programme. A really sound, well tried military developmind may find extensive civil or commercial application. An example which comes readily to mind is the Bailey bridge. Used by all the Allied Armies in World War II, it was subsequently widely used by local authorities in this country, and by a large number of comparitively undeveloped countries overseas. It is still in stock in the British and US Armies, and examples of it, erected during the later stages of the war are still to be seen in Europe, Malaya and elsewhere today, twenty or more years after being built. All this can be achieved only by adequate trials. The main advantages and disadvantages of the "military special" can be summarized as follows:

Advantages

1. Meets the specific military need.
2. Has had thorough military evaluation during development life.
3. Is suitable for exacting needs in both tropical and arctic conditions.
4. It can be designed for airportability.
5. Ease of maintenance and repair has been a design feature.
6. May lead to worthwhile commercial developments of a similar character.

Disadvantages

1. It is a high-cost item, taking into account development costs and relatively small numbers produced.
2. Likely to suffer teething troubles in service, as do all new developments.
3. Spares backing limited to initial service buy.
4. It takes a long time, sometimes up to nine years, from a statement of requirements before the equipment is in the hands of troops.
5. May within a few years be overtaken by later techniques developed commercially.

EXAMPLES OF MILITARY EQUIPMENTS

Space permits mention of only a few recent or current developments and these will be confined to the more interesting which have a bearing on the subject matter of this paper, and may have commercial applications.

*Portable Power Tools.* These are powered by a 5 KVA, 400 cycle/sec, 208 volt, 3 phase alternator with a petrol driven prime mover. The all-up weight is 200 lb and this power pack will replace 100 and 315 cfm air-compressors which weigh 1½ and 3½ tons respectively. The tools consist of rock drill and blower, medium and heavy breaker, circular saws, light hammers, spade and chisels, drills, chain saw and earth augers, all of which have been well reported on in User and Troop trials. They are about the same weight as the pneumatic equivalents and less noisy. This is an equipment we expect to have wide commercial applications in due course. It is of course airportable and airdroppable. (Photo 1.)

*400 cycle/sec generating sets.* A word about 400 cps power would not be out of place. Substantial weight reductions in generating sets can be achieved by adopting high speed prime movers and 400 cps alternators. The 5 KVA, 400 cps generating set at present undergoing troop trials has a prime mover running at only 3,400 rpm, with a belt driven 8,000 rpm alternator, but it is less than half the weight of a conventional 50 cps generating set of the same output. We shall have a range of 400 cps generating sets in service within a few years, the prime movers of which will be "wankel" type or conventional piston engines, with multi-fuel capabilities running at 6,000 rpm and direct coupled to lightweight alternators. The 20 KW generating set from this range will weigh only 472 lb dry and will replace the present 50 cps, 27½ KVA generating set which weighs 2½ tons, in applications where mobility is paramount. This illustrates the attractiveness of utilizing 400 cps generating sets having high speed prime movers.

To obtain the full weight saving benefit however, we hope, in the future to use small gas turbines running at 24,000 rpm, which require only a 2 pole alternator to run at synchronous speed when direct coupled. The problems to be overcome with high speed prime movers in general are the noise levels and ability to give the required life on service fuels. The use of gas turbines add dust ingestion and excessive fuel consumption to these problems, which must all be overcome before such equipments come into general service. When that time comes they may well find commercial applications particularly for site work in the future.

*Light Mobile Digger.* This consists of a coal cutting, chain type head, hydraulically powered and mounted on a 4 × 4 chassis. It operates on a plunge and crowd principle, crowding being achieved by engaging a creep-speed gear. Trials have shown that this equipment can dig trenches 4 ft 6 in deep and 2 ft wide in one pass at speeds of:

| | |
|---|---|
| 30 ft/min in sandy soils | 7 ft/min in clay |
| 20 ft/min in medium soils | 6 ft/min in solid chalk. |

The digging head can be offset, so that it can also dig rectangular holes. It is provided with a conveyor belt and can dispose of spoil to either side of the excavation.

User trials reports have been most satisfactory and troop trials machines are being manufactured now. The equipment on its prime mover will weigh 18,470 lb and will be airportable. This is an equipment which we believe will have commercial applications because of its excellent digging performance. (Photo 2).

*Collapsible Fabric Fuel Tanks.* These have been developed in 10,000 and 30,000 gallon sizes making use of synthetic fibres and rubbers. Empty, they weight 924 and 1,300 lb respectively. They represent not only a great saving in weight and bulk when compared with conventional steel tankage, but also a tremendous saving in construction time. They have only to be unfolded and rolled out on a roughly levelled site and they are ready to be filled. Taken in conjunction with similar developments they enable enormous savings in logistic load and skilled manpower to be made in the construction of a system to provide a bulk fuel supply in an undeveloped country (Photo 3).

*Towed Flexible Barge.* Better known as the DRACONE, these have been developed in 35 and 300 ton sizes. The material again consists of synthetic fibres and rubbers. They are required to offload tankers in deep waters and deliver to beach sites where no port facilities are available. The 300 ton size has been selected for service and trials are still going on. Empty, this dracone weighs less than 5 tons, is airportable and airdroppable. It can be filled with fuel whilst being towed by its parent tanker. (Photo 4.)

*Class 30 Trackway.* A prefabricated light-alloy trackway for rapid surfacing of soft ground and capable of taking wheeled and rubber padded tracked vehicles up to about 30 tons all-up weight. For service use is supplied in 150 ft rolls and laid from a vehicle mounted dispenser. It can also be supplied in the form of planks and assembled by hand. Vehicle mounted, it can be laid at speeds of between quarter and half a mile per hour. Provides an 11 ft roadway. Airportable in rolls in medium range aircraft. It can be recovered and reused. This is an equipment which may well have some commercial applications. (Photo 5.)

*Construction Plant.* There are very few examples of true military specials in this field. Limited military development has been carried out on commercial machines to adapt them for military use. This may take the form of modifying the machine to take a different front-end equipment or operate an additional ancillary, to prepare the machine for deep wading or to fit cold starting aids. But even where none of these is necessary some military modifications are generally essential even if only to ensure that road traffic regulations as regards rear lights and adequate braking are complied with. This is particularly true of towed equipment such as scrapers, which in the commercial field are carried on transporters but in the army are towed on roads. A good deal of development work, particularly on wheeled plant has also been done to improve the breed. Indeed one of the earliest medium wheeled tractors available was one on which a good deal of military development and testing was carried out. Some examples are:

Water proofed Wheeled Tractors.
Airportable, wade in 6 ft water plus 2 ft 6 in wave and spray. For beach work. (Photos 6 and 7.)
Grader 10 ft mould Bd
Airportable, airdroppable. (Photo 8.)
Rough Terrain Crane. For transportation use on beaches. Note small silhouette compared with conventional crane. 10 ton lift at 11 ft 3 in radius, $1\frac{1}{2}$ tons at 31 ft 3 in radius. (Photos 9 and 10).

### Policy with Relation to Engineering Construction Equipment

It will be clear that there will always be military development, either of items which have no commercial application, or those which though commercially available, do not meet the specific military requirements; eg airportability, deep wading, swimming, tropical and arctic operation.

A continuous discussion goes on within the Royal Engineers. On the one hand are those who believe we should purpose-buy commercial construction plant for a particular operation in a particular theatre, and cast or sell it when the operation is complete. On the other hand are those who believe all units should be equipped with a balanced set of plant, the majority of which will work satisfactorily in any theatre.

There are pro's and con's for both systems. For the former the most important advantage is that plant can be bought for the conditions under which it will work, and with a view to the method of transport and difficulties to be encountered in getting it to the work site. Another is that one starts the project with new plant which, initially anyway should be trouble-free. A third is that if it is bought in the theatre in which it is going to work, the manufacturers agent will be near at hand and available to give advice on repair and servicing. Fourthly, it may be possible to buy spares direct from the supplier and thus dispense with the Army system of supplying spares, which is slower and cumbersome in comparison. On the other side of the ledger must be balanced the increased cost of buying for an operation and casting when it is over, the multiplicity of types in service at any one time and the continuous training and retraining this must involve. Most important of all, not all areas in the Middle and Far East can provide a supply direct from the manufacturer, or spares and service to maintain the equipment.

For the latter point of view, the pro's are that all squadrons are interchangeable, all will have some plant which will operate, whether they are employed as combat engineers in the frozen continent of Europe, or on road and airfield construction in the Middle or Far East. The training problem is simplified; only a small number of different types of machines are in service at any one time, and they will be backed by the army spares and repair organizations. As against this they are bound to be less efficient in any given set of circumstances; likewise there are bound to be improved machines available commercially, more powerful, easier to operate, more reliable, perhaps all three.

Again, discussion on wheels versus tracks goes on endlessly. There are those who are convinced that wheeled plant is a waste of time, and that we should devote our efforts to improving the mobility of the tracked machine. Others are equally convinced that with proper study, and training of operators, wheeled plant can be used with advantage on all but the most difficult sites. It is not the purpose of this paper to try to resolve this issue. It may well be that the next improvement in earthmoving and construction plant techniques will be a development less dependent on what type of running gear carries the device.

For the present it is Ministry of Defence policy to retain a balanced set of plant, some wheeled and some tracked, available to each formation throughout the Army. It is also firm policy to try to avoid, as far as is possible a multiplicity of types within each category. There are hopes that a casting policy will be adopted in the near future which will enable the army to reduce its holdings of obsolete plant and thus keep more in step with the latest commercial developments. It is also hoped we will be allowed to develop one piece of plant, mobile, airportable, capable of wading and swimming, and equipped with multi purpose ancillaries. For the rest, it is firm policy to buy the cheapest commercially available machines which will meet the military requirement, and to fit to them only those modifications considered absolutely essential. This will involve a limited amount of technical evaluation and user trial, but should result in the latest commercially available equipment being in the hands of troops more quickly than has been the case in the past.

We realise these will not wade, swim or satisfy any one of a dozen special user requirements. If these prove essential, appropriate steps will be taken to modify a machine for that purpose. However, the biggest common headache is airportability and manufacturers can help us if they keep in mind the aircraft loadings already set out in the paper. This is not to suggest that they should design specifically for the military market; it is too small in terms of numbers to make this worthwhile. But if for example a piece of plant with an all-up weight of 40,000 lb can be broken down to suitable weight and size for air transport our task is simplified. Again, in the lighter classes of plant if an item can be broken down, and as easily reassembled, into 4,000 lb or 8,000 lb lots, it can be prepared for delivery by helicopter to otherwise inaccessible sites. It is a fact that manufacturers of construction plant in the US are already developing along these lines. It is hoped that British manufacturers will follow this lead because of course, we would prefer to buy British manufactured machines whenever it is possible.

Another, perhaps well known, military requirement is that engines for prime movers should be selected from the JESC list, and should if possible have the ability to operate on fuels ranging from diesel to high octane aviation fuels. If, at the same time designers of commercial plant would keep in mind ease of servicing and repair this would help the military engineer. There have been cases in the past of having to remove the engine in order to get at the clutch, which may require only a simple adjustment. This automatically makes what should be a simple field repair, done in an hour or so, into a workshop repair, and involves back-loading to a workshop with consequent loss of valuable working time. It is also worth saying that any equipment which cannot operate on service grades of fuel and lubricants is, generally speaking, more trouble than it is worth. Lastly, the importance of availability of spares, special tools, handbooks and parts lists at the time an equipment is delivered into the hands of troops cannot be over emphasized.

## Conclusion

The writer believes that some equipments must be designed purely to military specifications.

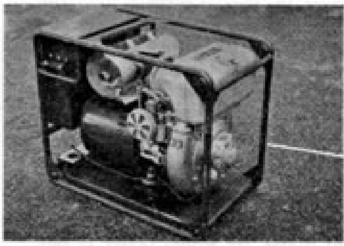
Ministry of Defence policy is to buy commercial equipment with an absolute minimum of modification whenever possible.

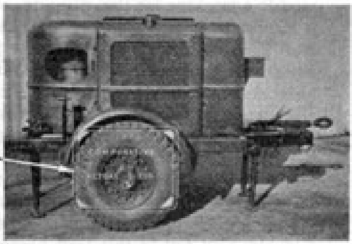
If commercial manufacturers will keep in mind the military requirements and restrictions, it will make this policy more effective.

Lastly, to hope that a wide-spread network of manufacturers agents will cover the more remote parts of the world, particularly the Middle and Far East, so that army units will never be too far from a call on their expert advice for repairs, servicing and emergency supply of parts. In view of the repeated calls for an export drive, is this too much to hope for?

# PORTABLE POWER TOOLS.

## COMPARISON OF WEIGHTS.





| 5KVA 400 cps. GENERATOR. | | 100cfm/100 psi. COMPRESSOR. |
|---|---|---|
| 400 cps. ELECTRIC. (LBS.) | | PNEUMATIC. (LBS.) |
| 200 | POWER UNIT. | 3250 |
| 60 | ROCK DRILL. | 60 |
| 50 | BLOWER UNIT. | — |
| 65 | BREAKER. | 60 |
| 39 | CHAIN SAW. | 31 |
| 22 | DRILL $\frac{3}{4}$" | 20 |
| 8 | DRILL $\frac{3}{8}$" | 6 |
| 22 | DEMOLITION HAMMER. | 20 |
| 17 | GRINDER 6" | 13 |
| 15 | CIRCULAR SAW 8" | 12 |
| 50 | CABLE 200 FT. WITH JUNC. BOX DRUM. | — |
| — | AIR HOSE 200 FT. WITH FITTINGS. | 100 |
| 548 | | 3572 |
| 9HP | ENGINE RATED OUTPUT. | 27HP |
| 1 | FUEL CONSUMPTION (GALL/HR.) | 3. |

Photo 1.

**Requirement and Employment of Equipment 1**

**Photo 2.** Light mobile digger.

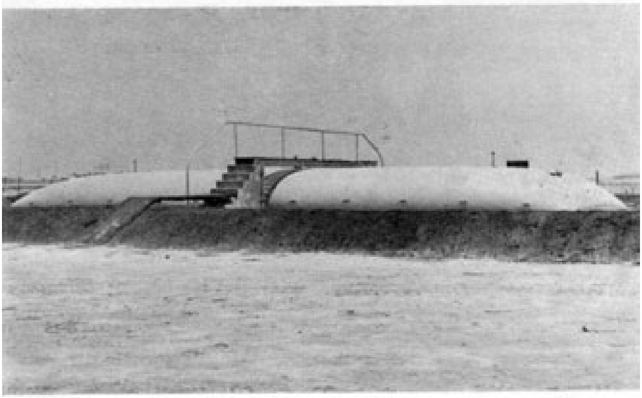


**Photo 3.** Marston Excelsior collapsible fuel tank, filled to 30,000 gallons.

**Requirement and Employment of Equipment 2 & 3**

**Photo 4.** Towed flexible barge—280 tons nominal capacity.

**Photo 5.** Trackway being launched from American truck bridging 5 ton.

**Requirement and Employment of Equipment 4 & 5**

**Photo 6.** Michigan 175 DS rough terrain fork lift truck.

**Photo 7.** Bray 455 M Waterproof light wheeled fork lift truck.

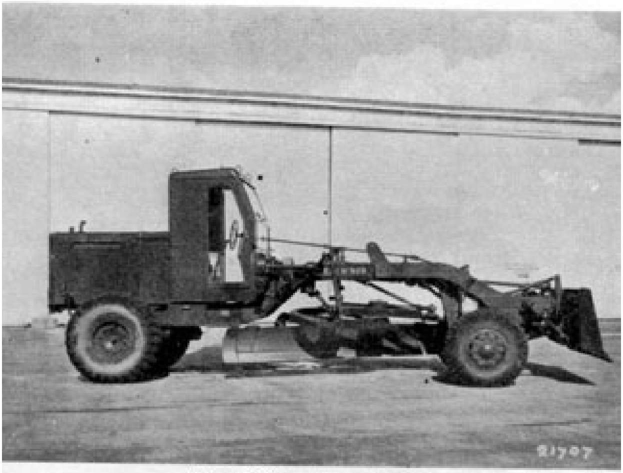


Photo 8. BK 10 airportable grader.

Photo 9. Rough terrain crane.

**Requirement and Employment of Equipment 8 & 9**

Photo 10. Rough terrain crane.

## PART 2 EMPLOYMENT OF ENGINEERING EQUIPMENT

Effective airborne engineer operations are dependent on three things:

1. Good modern engineer equipment matched to the aircraft available.
2. Knowledge of and training with the equipment to be used.
3. Knowledge of the environment in which it is to be used.

The British ArmedForces have the components of an air mobile force in the Strategic Reserve and Transport Command. As engineers we lack the equipment and techniques developed to a high degree by the Americans but this can be remedied. Recent history shows that we do have a requirement for air-mounted operations. Our intervention in Jordan is one example, Suez could have been another, and most recent was the stabilizing operation in East Africa.

*Small Wars and Rebellions.* The salient features of those that the British Army has been involved in since World War II is that they go on for longer than expected (eg Malaya twelve years; Palestine four years; Cyprus three years; Borneo and Aden two years so far) and that movement in the troubled area is difficult. The key to success is the mobility of our troops. For this we need roads, airfields and helicopter landing zones. Many of the airfields and helicopter landing zones have to be constructed by troops and equipment air-lifted to the construction site.

### Engineer Tasks

Engineer tasks in airborne operations are no different in kind from those in ground supported operations, but the technique in carrying them out has to overcome the limitations of the available airlift, which restricts the size of equipment, and denies the engineer the luxury of safety margins.

In the air-mounted operation the accent is on speed to clear a landing zone to enable the main force to land. The instant airfield can only be produced in a desert or salt lake. So the engineer tasks come down to:

Constructing, compacting and dust sealing a new airstrip,
Extending existing airfields and clearing debris, including mines,
Providing parking and unloading areas,
Providing exit routes, including bridging,
Providing fuel distribution systems for aircraft and vehicles,
Water supply.

As operations develop, top priority will be to open up a land line of communication to the nearest seaboard. Camp construction will become necessary as time passes.

Airborne engineer operations will concentrate on providing airstrips for medium and short range aircraft, helicopter bases and landing pads, to provide mobility for our troops in rough country where hostilities usually seem to take place. There will also be a requirement for fortifications in forward positions.

## Equipment

The main requirement is to provide good air portable construction equipment and this is also the most difficult problem. We have plenty of good bridging equipment, both floating and fixed, which can be carried by the aircraft available. Mine clearance and most combat engineer tasks do not produce airlift problems. Hence only construction equipment will be considered in this paper.

In construction work the guiding principle is to apply the greatest possible horse power to the work face. To apply horsepower, traction is required, and this means weight, which is in direct conflict with airportability. The problem is how to get the heavy equipment to the work face. It is wrong to select small, ineffective tractors because they can be parachuted whole, and then take a year to build an airstrip, when tractors the size of a Caterpillar D6 can be lifted in pieces by the same aircraft, and after the necessary assembly time can construct a similar sized airstrip in a short time.

*Limiting Dimensions.* In Airborne Operations the limiting dimension is the size of the aircraft that is going to parachute and airland the engineer loads. With aircraft such as the Hercules C130, which has 10 ft doors, 40 ft cabin and 35,000 lb lift capability, or a heavy drop capability of 24,000 lb this is not much of a problem. However, in difficult country it is more usual to construct short strips for the Twin Pioneer (in Borneo we have thirty-seven such strips). Here the difficulty is to extract the plant after construction of the strip. It can either be helicoptered out in 3,000–4,000 lb pieces, or flown out in 1,000 lb pieces in Twin Pioneers. Experience has shown that although the Twin Pioneer will carry 2,500 lb, it is too difficult to manhandle individual loads greater than 1,000 lb through the door and up the aircraft without damaging it. A third alternative is for plant to walk out, which may take months and is generally not acceptable.

In the Far East our problem has been eased by the introduction of the Caribou aircraft in to both the Australian and Malaysian Air Forces. This provides an 8,000 lb lift, loading through a 6 ft × 6 ft door, landing on Twin Pioneer airstrips. Looking ahead a couple years when the Avro Andover comes into service we should be able to lift from 700 yard airstrips, loads of

6,000 lb providing we can get them through the rear doors (6 ft 10 in wide, 6 ft 2 in high).

*Earth Moving Equipment.* In the section that follows the writer will refer to machines by proprietary names because it is with these machines that he has personal experience and knows that they are first class construction machines which can be used in airborne operations. This is not to say that other machines would not be equally satisfactory. In the United States the Caterpillar Tractor Company has carried out two studies; first the disassembly of the Caterpillar D6C and D4D into under 3,000 lb loads, and second, of segmented versions of the Caterpillar D6C, D4D and 112F, 100 hp motor grader (segmented into two assemblies which can be joined together to make a complete machine by four men in less than an hour). The Allis Chalmers Company employed a similar idea in a special version of their TL 16 wheeled loader for the US Marine Corp. This can be helicoptered in four 6,000 lb modules and assembled by two men in two hours.

### Angledozers

*Airlanding.* Up to 40,000 lb load class we have the choice of both wheeled and tracked dozers. Any weight smaller than 30,000 lb rules out the wheeled dozer, because it has insufficient weight to get traction to apply its horsepower. Operations based on existing airfields, or into deserts generally require engineer support some distance from the airhead. The mobility of wheeled tractors, will be of the greatest importance. Two good machines for airlanded operations are the Caterpillar D7E Angledozer and the Michigan 180 Angledozer. The Caterpillar D7E (160 hp) weighs 39,000 lb all up, of which some 6,500 is in the blade assembly. The bare tractor is 8½ ft wide and with blade removed may fit into Beverley or Hercules. It may be possible to carry the Michigan 180 (170 hp) complete in a similar fashion. Its critical dimensions are weight 34,000 lb, bare tractor width 9 ft 2 in, height 8 ft. Load spreaders for the aircraft floors might be needed.

*Parachutable.* Present limitations are 24,000 lb net on the Heavy Stressed Platform (HSP) and up to 12,000 lb on the Medium Stressed Platform (MSP). The HSP is a bit of a rarity and itself weighs 3,360 lb. The MSP is in common use, two can be dropped out of an Argosy or a Beverley and presumably a Hercules. So it is better to plan on the 12,000 lb figure today. In the Caterpillar range the most powerful machine we can parachute segmented is the D6C (26,700 lb) which might fit on to two MSP's. The D6C is a fast, powerful (120 hp), robust machine with world wide sale. The two segments comprise:

1. Complete tractor power train from radiator to drive sprockets fully serviced with oil and coolant ready to operate;
2. Track roller frames, track, complete angledozer assembly.

The segments should be skid mounted to enable them to be dragged together after landing. Complementing the main work horse (D6C) we need a small utility dozer for other jobs that crop up on a works site; towing wobbly wheel rollers in bad conditions, general clean up, and of course dragging together the segmented pieces of the D6C's. A good machine for this is the Caterpillar D4D Angledozer which could be parachuted on two MSP's. For general purpose work the ratio of D6's and D4's should be five to one.

*Helicopter Transported.* Both the Caterpillar D6C and D4D can be broken down into loads carried by present service helicopters. With the introduction of an 8,000 lb vertical lift the D4D could be lifted in two segments.

*Loaders.* The Army recently bought the Bray 455M, so that settles the $1\frac{1}{2}$ cu yd size of wheeled loader. Its size and weight is such that it could be parachuted on two MSP's from a Hercules. If dropped on to a short airstrip it would have to be dismantled for extraction by helicopter when its task is complete. Its capacity is quite adequate to load all service tippers and dumpers, including the Morewear rear haul dumper. In the ultra light size we have a few Ferguson 203's. This is a useful machine as a power source for a number of ancillaries. Perhaps its greatest use is as a chassis for a back hoe. However, it is not large enough as a production loader. With 8,000 lb vertical lift in 1970 we can go to real construction tools. A machine that is suitable as a general purpose light loader is the Michigan 35A, sometimes known as the Camberley digger. It has a 1 cu yd bucket, a lifting capacity of 3,250 lb, 68 hp and weighs 9,900 lb. The latest version has all wheel steer to give a 27 ft turning circle. It is a single boom design and the bucket and boom assembly can easily be detached to reduce the weight for helicopter transport. The output of this machine working from a stockpile is 3 tons a minute.

A most useful machine, seldom seen in the British Army is the traxcavator. Traxcavators are useful in airborne operations, they can sometimes operate in wet conditions where a wheeled loader cannot. This is particularly true of drainage work and excavating culvert beds. A fringe benefit is that the traxcavator with its smooth tracks and low bottom gear is an ideal machine for towing the 72 ins vibrating roller on newly shaped surfaces (Photo 6). The British made International Harvester BTD 6 has proved to be a robust machine in soldiers' hands and is a good machine for the airborne role. The latest version is the B-100, 50 hp and weighing 15,150 lb. Its overall dimensions are $12\frac{1}{2}$ ft long, 5 ft 8 in wide, 5 ft 2 in high. It can be supplied with a most useful 4 in 1 bucket. It could be parachuted on two MSP's.

*Graders.* The aim should be to bring in full size graders and fortunately this is not difficult. For example the Caterpillar 112F, can be air landed in a Hercules or Beverley, or could be parachuted complete on a HSP (weight 21,200 lb length 24 ft 11 in). There is a segmented design which divides the grader neatly at the cockpit. The rear half, $11\frac{1}{2}$ ft long, 10,200 lb, is the engine and tandem drive, the front half $14\frac{1}{2}$ ft long, 11,000 lb, contains the main girder, blade, steering gear and front wheels. These two pieces could be dropped on two MSP's from the same aircraft.

For helicopter lift there must be considerable disassembly either of a full size grader or of smaller maintenance graders. An example of the latter is the Fordson Transatlas. This grader has been in service with the Malaysian Engineers for two years (Photo 1). It was originally bought to match the lift of the Alouette III helicopter and Twin Pioneer. Although it has been used successfully in Malaysian airborne operations, lifted disassembled by Twin Pioneer and Iroquois helicopters (2,400 lb pay load), (Photo 2) the majority of the machines have been used on the continuous day to day bashing in the Borneo war, building roads and airstrips. In spite of often being misused as construction graders, they stood up to the hard work well. In working rig this machine weighs 9,800 lb, but this includes 600 lb wheel ballast weights and some 800 lb water ballast in the rear tyres.

A most useful ancillary for levelling or planing is the Gurries leveller. This has a 10 ft curved blade mounted on two wheels and tows behind any light tractor, lowered or raised by the tractor hydraulics. Its angle of attack provides its down thrust and a very accurate finish can be obtained with it.

It only weighs 1,180 lb and can be carried by most helicopters or stowed in a Twin Pioneer (Photo 3).

*Scrapers.* To move earth in any quantity scrapers are required and the bigger the one you can get to the site the better. In airborne operations the self loading scrapers offer the great advantage of saving the airlift of pusher dozers. The 10 cu yd self loading scrapers fit into the Hercules and Beverley, both the Le Tourneau-Westinghouse Hancock D and the John Deere 5010 will fit and can be airlanded. But if we are going to airland let us think big, and bring in 20 cu yd motor scrapers in the Belfast when we can.

For parachute operations there are various alternatives. We can segment 10 cu yd motor scrapers and drop them in two pieces. This should be quite simple because this is how they are shipped. They are broken at the swan neck, the wheels put in the bowl, and are shipped in two packages for which a MSP could be substituted. Next there is a range of towed elevating scrapers. They have the advantage that they can be towed by a variety of tractors ranging from agricultural to the majority of wheeled loaders (Photo 4). Only 70 hp is required to tow an 11 cu yd scraper. Tractors should be wheeled to give fast cycle times. The Johnson Manufacturing Co of Texas make 4–8–11 cu yd sizes some of which have been tested by MEXE. There is no point in playing about with anything smaller than the 11 cu yd size, which as far as weight (12,000 lb) and width (8 ft) is concerned might be parachuted on a MSP. It is too long at 22 ft, but the yoke on which the swan neck is mounted appears to be conveniently shaped to slide back along the main longitudinal girder, and it is likely that with front wheels removed and stowed in the bowl, the 11 cu yd scraper could be made to meet the length requirement of the MSP. A third alternative is the Martin Graderscraper GS-55. This is the substitution of a 5½ cu yd scraper bowl and mechanism, for the blade and drawbar of the Caterpillar 112F motor grader. Changeover from grader blade to Graderscraper is claimed to take less than an hour. The grader hydraulics power the ejector and apron, and the grader lift arms power the lifting, tilting, side shifting and down pressure of scraper. The traction of the four grader driven wheels provide the self loading capability. The width is 8 ft and weight only 5,100 lb, so probably two Graderscraper attachments might be fitted on to one MSP. However, it should be remembered that the same scraper capacity could be obtained by dropping one 11 cu yd towed elevating scraper on one MSP and towing it behind one grader if necessary.

For helicopter borne operations the size of scraper we can lift today, sectionalized, is the Johnson 4 cu yd elevating scraper. In 1970 a sectionalized Johnson 11 cu yd will be a possibility.

*Compaction Equipment.* Probably the most versatile and popular piece of compaction equipment with military engineers who have access to a complete range of compaction equipment, is the 72 in, 3¾ ton towed vibrating roller. Its broad roll does not shear the soil like conventional steel wheel rollers. Its compaction in depth through a wide variety of soils has saved many a young officer who has not brushed up his soil mechanics. It can be towed by almost anything, from a couple of oxen, agricultural tractors or crawler tractors (Photo 6). That used by the Malaysian Engineers, and proved most satisfactory is the Stothert and Pitt. Aerial delivery by parachute or helicopter should present few problems. Complementary to the heavy roller is the Stothert and Pitt 32 RD (32 in roll, 2,128 lb weight) which has the great advantage of being self propelled. This is a very popular airportable roller which provides compaction well up to that required by short range aircraft. It can be lifted in whole by helicopter, quickly dismantled into four pieces and extracted by Twin Pioneer if necessary (Photos 7 and 8).

Next on the list must come the towed wobbly wheel roller for initial compaction. Having heard the sad tale of the bowl of a wobbly wheel roller abandoned on a certain airstrip in Borneo because it could not be extracted, the writer quickly modified a commercial wobbly wheel roller to bolted construction, so that it can be dismantled and loaded into a Twin Pioneer. (Photos 9 and 10). Being based on a good commercial design, and using the proprietary wheels and axles, the modified roller can take the full load. Unladen weight is 30 cwt, but ballasted, a compaction force up to 25 tons can be applied through its thirteen wheels. Aerial delivery is no problem. The modification is simple.

For rapid and accurate compaction there is no equal to a self-propelled rubber tyred roller that can vary the tyre pressures on the run from the cockpit. In Britain Aveling Barford make two models, the Pneuma Victa PTR 26 and PTR 30. The empty weights are 10,750 and 15,620 lb respectively to which can be added 16,000 lb of sand ballast. Both models should fit into the Hercules and could be parachuted on MSP's.

Hyster Grid rollers have already been parachuted successfully. This is a big, heavy roller (12,400 lb, two rolls, unballasted; plus 14,300 lb of concrete blocks) and needs a 150 hp tractor to pull it at its correct speed. It is primarily a mobile rock crusher and is probably the fastest and most economical way of producing a running surface from quarry run stone.

*Dump Trucks.* For construction work rugged, purpose designed dump trucks are required. However, proper dump trucks are generally too big for airborne operations. This leaves us with dumpers of various sizes, rear dump haulers such as the Morewear and the Shawnee Poole (Photo 12) or articulated rear dumps such as the Northfield F9 Dump Truck (Photo 13). The principle remains that the biggest capacity that you can introduce is the type to go for. With the limited numbers likely to be available anything much less than 10 ton capacity is not economical.

In the 10 ton class there is the Shawnee Poole and the Northfield F9. The Shawnee Poole has been in service with the Malaysian Engineers in Borneo Operations for two years. It has the great advantage that its prime mover, the Fordson Super Major tractor, is part of the Malaysian Engineers family of air-portable equipment. The tractor can be detached and used for towing vibrating rollers when not required in the dump hauler role. On the flat the Shawnee Poole is a most effective and economical dump truck. With a turning circle of 20 ft it is very manoeuvrable. Capacity is 7 cu yd or 10 tons. When fully laden (16 tons), its power to weight ratio of 3 hp per ton proved insufficient to climb the steep slopes, sometimes 1 in 6, in some of the forward operational areas of Sarawak. Top speed is 14 mph so that the economical radius of action is up to about 4 miles. It can be parachuted on two MSP's from a Beverley or Hercules, and of course air landed.

To cope with gradient problem in Sarawak, the Northfield F9 Dump Truck was bought. It is a more rugged, more powerful and more expensive machine than the Shawnee Poole. It is very reliable and has a most impressive serviceability record in rugged conditions in Malaysia. It is a 96 hp, 12–13 ton capacity, 9 cu yd machine with a turning circle of 19½ ft. Top speed is 28 mph and so its economical radius of action could be up to 8 miles. Unladen weight is 13,500 lb and its dimensions are such that it could be parachuted on two MSP's from Beverley or Hercules.

For helicopter launched operations bulk haulage is best done by the 3 ton Tasker Tipping Trailer drawn by an agricultural tractor. A modified version of this trailer, which can be quickly dismantled and put into a Twin Pioneer has been in everyday service with the Malaysian Engineers over the last two years, and has proved very satisfactory.

*Assembly and Repair Equipment.* It is no good bringing in heavy plant in pieces without bringing in an adequate lifting device with which to assemble it. There is a simple and cheap device with which the writer equipped all his squadrons, and which has given excellent service for field repairs in Borneo operations over the last two years. This is the Atlas Colossus gantry. It can be had in a variety of sizes. The Malaysian Engineers have the 2 ton version, which weighs 870 lb, strips into ten pieces for carriage by the Twin Pioneer (Photo 11). It has proved very versatile, and we have successfully removed and replaced a Caterpillar D7E engine and gearbox (5,000 lb) in the field. However, thinking in terms of the future, a 3 ton version would probably be more suitable.

There will often be a requirement for an airborne crane. For this role we might utilize the Chain Beam Loader, developed in the logging industry in Canada and marketed by Fairey Engineering Ltd in UK under the name of FAIRLIFT. The heart of the device comprises an extensible (up to 14 ft) and retractable beam which rolls into a very compact size. When used as a crane it has the ability to probe directly in and out of confined spaces. The beam can be aimed at a point 14 ft away and can travel directly to that point in a straight line, if necessary passing through a 1 ft square hole. There are attachments for fork lift, power shovel, back hoe, clam grab, personnel lift (2 men 32 ft), earth auger, brush ripper, so it is a pretty versatile power tool system. It could be fitted in place of the back hoe of a Light Wheel Tractor.

For repair, the prime requirement is spare parts and the correct tools with the machine. It is surprising how many machines are dropped blithely into inaccessible places without a spare parts pack. The contents of the spare parts pack must be pretty carefully worked out. When a complete range of new machines, about fifty different types, was introduced into the Malaysian Engineers, the spares scaling problem was tackled as follows. A Royal Engineer Captain toured all the agents and analysed their spares sales over the previous two years against the machine population of the type concerned. The machine population in Malaysia was quite adequate for this study, for example there are in Malaysia 2,550 Caterpillar Tractors, 700 Aveling Barford rollers and 450 Michigan Wheeled Tractors. To commercial usage was added a "soldier factor", and spares scales were calculated. There are two echelons of plant repair in the Malaysian Engineers; Field Repair, anything less than major overhaul, which is carried out by the Field Squadron, and Base Repair, which comprises complete overhauls and may take 5–7,000 hours. This is carried out in the Park Squadron. Spares are also held in only two echelons, a comprehensive spares pack with each machine, topped up by local purchase or the Park Squadron, and a two year back-up held in the Park Squadron. The machine pack is in steel boxes and always moves with the machine. As all machines are standard commercial models in world wide use, there is the flexibility of local purchase of spares as a bonus. The machine sizes are in families, so there is great commonality of spares. In addition rolls of hydraulic hose of the required diameters, to the highest common pressure, together with reusable couplers are held in quantity by all units, so hose specials are not required. This is the type of spares holding required for airborne operations.

Welding is always a requirement. There are light manpack electric welders. The McCulloch 170 Amp Electric Arc Welder which only weighs 55 lb and uses the same engine as one of their chain saws has given excellent service in Borneo Operations over the last two years. It has also the bonus of being able to charge radio batteries through its rectifier.

*Equipment Summary*. The purpose of this review of equipment is to show that airborne specials are not required for airborne operations. Good commercial equipment which is designed for efficient output, if carefully chosen with a view to easy disassembly, and whose overall dimensions will fit within the aircraft available is what is required. It has been shown that a large range of construction equipment can be air transported.

## Training

*Interservice Co-operation*. The Hercules C130 is a heavy aircraft and may land at over 60 tons gross weight. The Engineer and Airman must have a close understanding of each other's problems and methods of functioning. On this teamwork depends success in mounting airborne operations. Unbriefed airmen can easily wreck a temporary airstrip by heavy braking and multiple landings in the same wheel tracks. Faulty construction techniques can equally wreck valuable aircraft. An aircraft using full braking creates a horizontal shearing stress of such magnitude that a relatively high quality base is required to withstand multiple landings. If, however, the aircraft rolls to a stop braked by its flaps and reversible propellers much lighter construction is sufficient, even though the runway must be proportionately longer. The overall saving of engineer work will be considerable, particularly in desert country. Pilots should be briefed to avoid following in previous aircraft's wheel tracks and thus distribute their load laterally across the strip, incidentally aiding its compaction. The landing direction should be reversed wherever the wind permits, to rest the highly stressed area. The area of high stress is not at the point of touchdown, but some 200 yards farther on with the Hercules, where the aircraft loses all airlift.

The ability to assault land even three or four sorties before airstrip construction begins may make an immense difference to the time of completion of an airstrip. Four Hercules sorties could provide two 160 hp dozers, two 100 hp motor graders, a self propelled pnuematic tyred roller, a wobbly wheel roller, or 72 ins vibrating roller ready to work, without all the paraphenalia of parachute delivery. The engineer must make himself familiar with the type of terrain on which Hercules and Beverley can assault land. It is really astonishing what airmen are willing to attempt on a one off basis. This is far different from the requirements for regular operation, which are controlled by safety regulations.

*Air Transport Clearance*. The first requisite is to clear all the equipment that we need for air dropping and air-loading in the aircraft concerned. Time and time again operations in the Far East have been frustrated because equipment has not been cleared for airdropping at AATDC. Construction plant must be given a higher priority in future. The US Corps of Engineers has amassed a great fund of experience in parachuting and transporting engineer equipment in Hercules C130's and we should draw on this. As the data becomes available it should be analysed and relevant parts passed on to our Strategic Reserve engineers so that they have up to date planning information.

Training is required in the breaking down and reassembly of equipment for helicopter transport. This is best achieved by producing a drill for each machine. It should include each stage in the breakdown and reassembly process, the weight and composition of each package, a list of assembly spares i.e. gaskets, nuts and bolts, lubricants, and special tools. The Standing Operating Procedure for each machine should lay down this drill and include an itemized spares pack.

### Conclusions

Airborne engineer operations are no different from normal engineer operations, but the restrictions of aerial delivery mean that the planning must be most accurate, the limited number of construction machines that can be brought in must be the most powerful available, and must be supported by sufficient operators, fitters and spare parts to provide 22 hours output per machine per day.

Drills should be worked out and published for the disassembly of large machines for helicopter lift. The full range of construction machines should be cleared for parachute delivery either whole or segmented.

Royal Engineer officers who are likely to plan or take part in airborne operations must keep abreast of current developments in the field of mechanical equipment, know the machines they are called upon to use, and appreciate their capabilities and limitations. They must also have a knowledge of soil mechanics and the problems associated with the operation of transport aircraft. Finally, they must have a sound background knowledge of mechanical engineering to enable them to improvise and adapt to meet the emergencies which airborne military operations will inevitably impose.

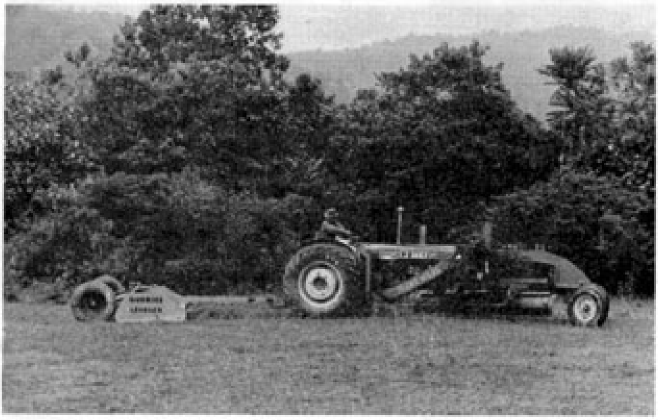


**Photo 1.** Fordson Transatlas Grader towing a Gurries leveller regrading the surface of a jungle fort airstrip. Both have 10 ft mouldboards.

**Photo 2.** DISASSEMBLY. Gear box of Fordson Transatlas grader about to be hecked on to an Iroquois helicopter for extraction from a jungle airstrip. In the background is the grader main girder and a box of spare parts.

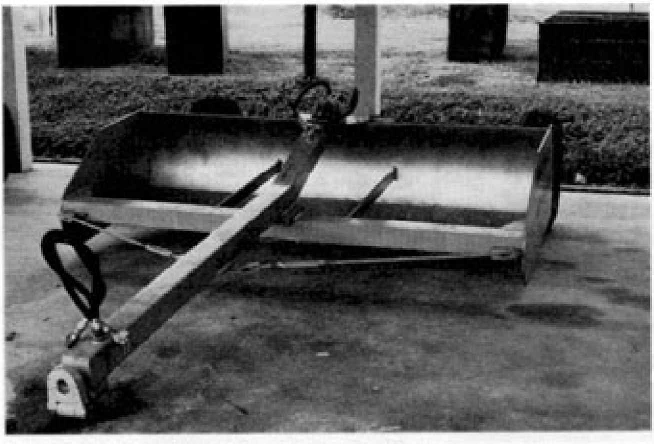


**Photo 3.** GURRIES LEVELLER. This can be drawn by any agricultural tractor. Down-thrust is produced by the blade angle. Width 10 ft, capacity 2½ cu yds.

**Part 2-Requirement and Employment of Equipment 2 & 3**


**Photo 4.** Johnson 40B, 4 cu yd self loading scraper towed by a Fergusson 65 tractor. The 11 cu yd version is similar.

**Photo 5.** SELF LOADING MOTORIZED SCRAPER. Le Tourneau Westinghouse Hancock D 11 cu yd motorized scraper.

**Part 2-Requirement and Employment of Equipment 4 & 5**

**Photo 6.** VIBRATING ROLLERS. Two airportable vibrating rollers compacting a new airstrip on Tioman Island in the China Sea. In the foreground is a 72 in, $3\frac{3}{4}$ ton roller towed by a BTD 6 Traxcavator. In the background is a 54 in, 35 cwt roller towed by a Fordson Super Major.


**Photo 7.** SELF-PROPELLED VIBRATING ROLLER. 32 ins 21 cwt Coates roller—Stothert and Pitt made under licence in Australia.

**Part 2-Requirement and Employment of Equipment 6 & 7**

**Photo 8.** SEGMENTED VIBRATING ROLLER. The same 32 in self propelled vibrating roller segmented for carriage by Twin Pioneer.

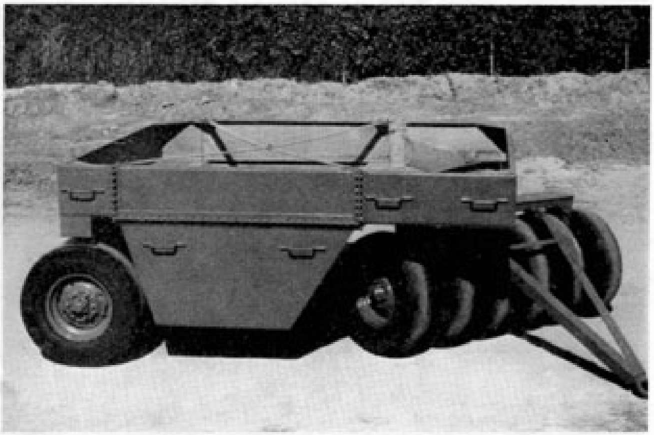


**Photo 9.** BOLTED CONSTRUCTION WOBBLY WHEEL ROLLER. Rolling width 7 ft, thirteen wheels. Weight empty 30 cwt, maximum loaded weight 25 tons, normal operating weight ballasted with wet sand 10–12 tons. Note lifting handles and cross tie bars.

**Part 2-Requirement and Employment of Equipment 8 & 9**

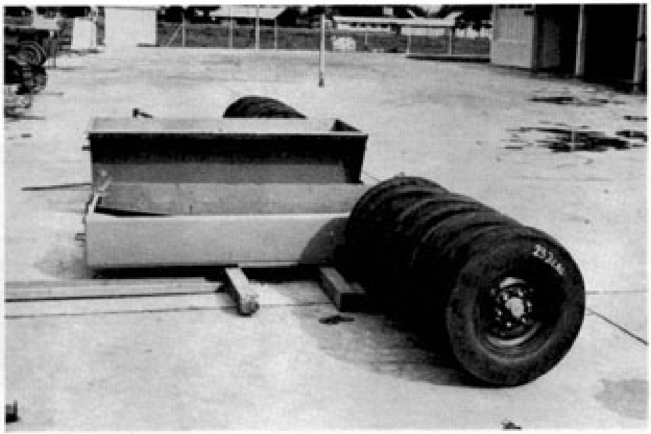


Photo 10. SEGMENTED WOBBLY WHEEL ROLLER. The same roller diamantled for carriage by Twin Pioneer.

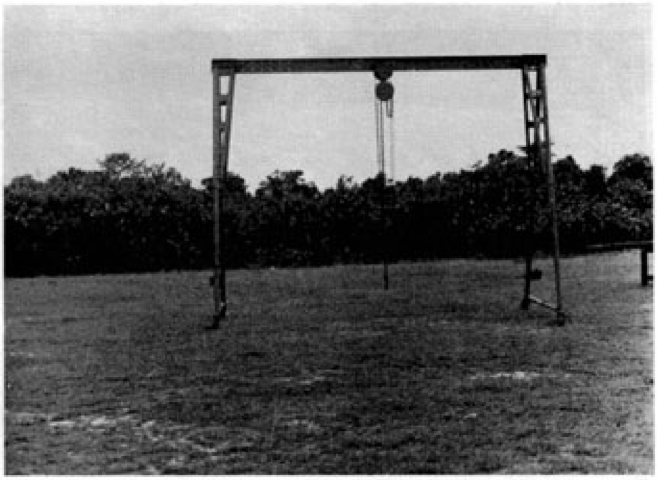


Photo 11. ATLAS COLOSSUS GANTRY. Two ton version. Legs are telescopic and track can be varied, see bolt holes in overhead beam.

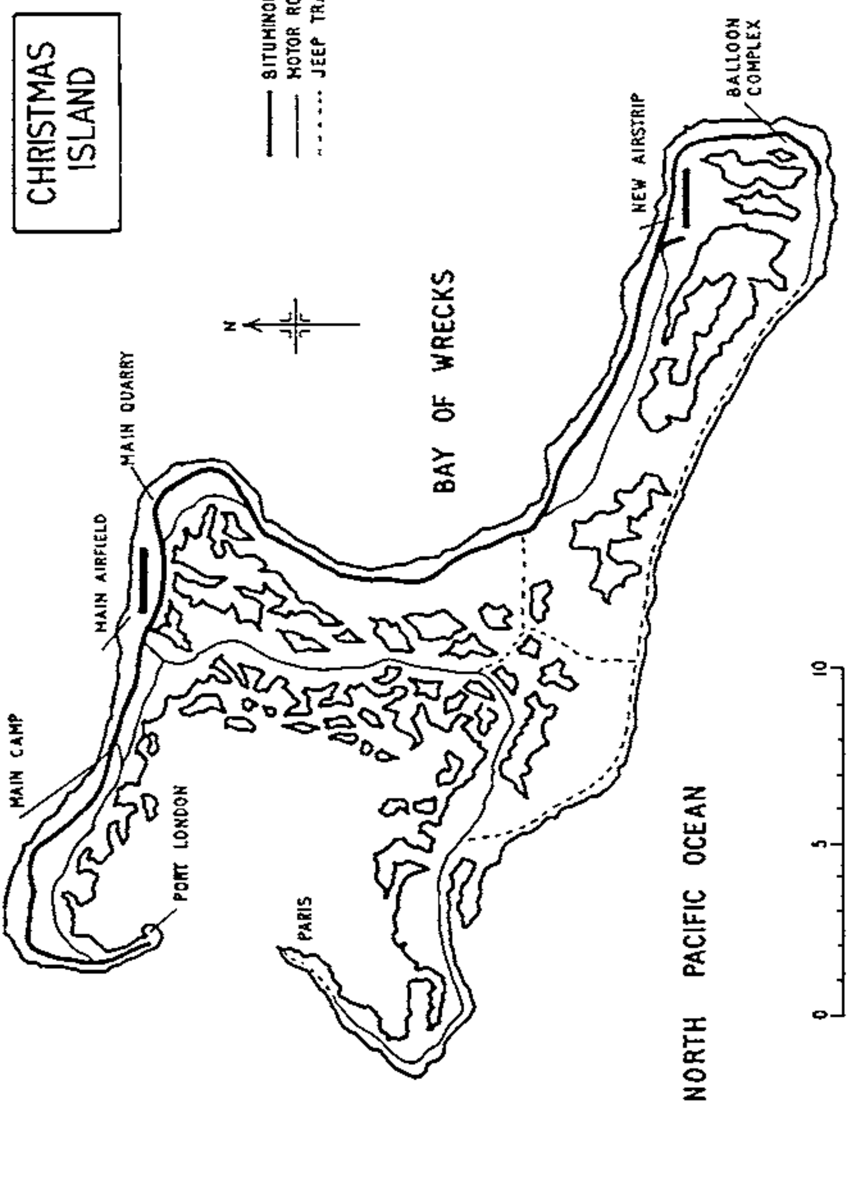
**Part 2-Requirement and Employment of Equipment 10 & 11**

**Photo 12.** REAR DUMP HAULER. Capacity 10 tons or 7 cu yds, unladen weight 12,500 lb. Tractor Fordson Super Major. Maximum speed 14 mph.

**Photo 13.** ARTICULATED DUMP TRUCK. Capacity 13 tons or 9 cu yds, unladen weight 13,500 lb. Maximum speed 28 mph.

**Part 2-Requirement and Employment of Equipment 12 & 13**

FIG. I.


CHRISTMAS ISLAND
BITUMINOUS SURFACING
MOTOR ROAD (CORAL MUD)
JEEP TRACK
N
BAY OF WRECKS
MAIN QUARRY
MAIN AIRFIELD
MAIN CAMP
PORT LONDON
PARIS
NEW AIRSTRIP
BALLOON COMPLEX
NORTH PACIFIC OCEAN
0
5
10
SCALE ~ MILES

# Welded Aluminium Pipelines on Christmas Island

A PAPER PRESENTED FOR DISCUSSION TO THE PIPELINE INDUSTRIE'S GUILD

*By* MAJOR B. P. HOLLOWAY, RE, AMIMECHE, AMIPLANTE

INTRODUCTION

*Background.* A bulk fuel installation was built on Christmas Island by 28 Field Engineer Regiment in 1956 to support the British series of nuclear tests. Thirteen 3,000 barrel (100,000 gallons) bolted steel tanks were erected in the port area. These were built in a hurry for one time use. However, as usual, the installation remained in use for several years. Further tanks and facilities were added but nothing could be done to offset the temporary nature of the installation.

By 1960 the losses by leakage from the tanks had become unacceptable and the maintenance proved beyond the capabilities of the 73 (Christmas Island) Squadron, Royal Engineers.

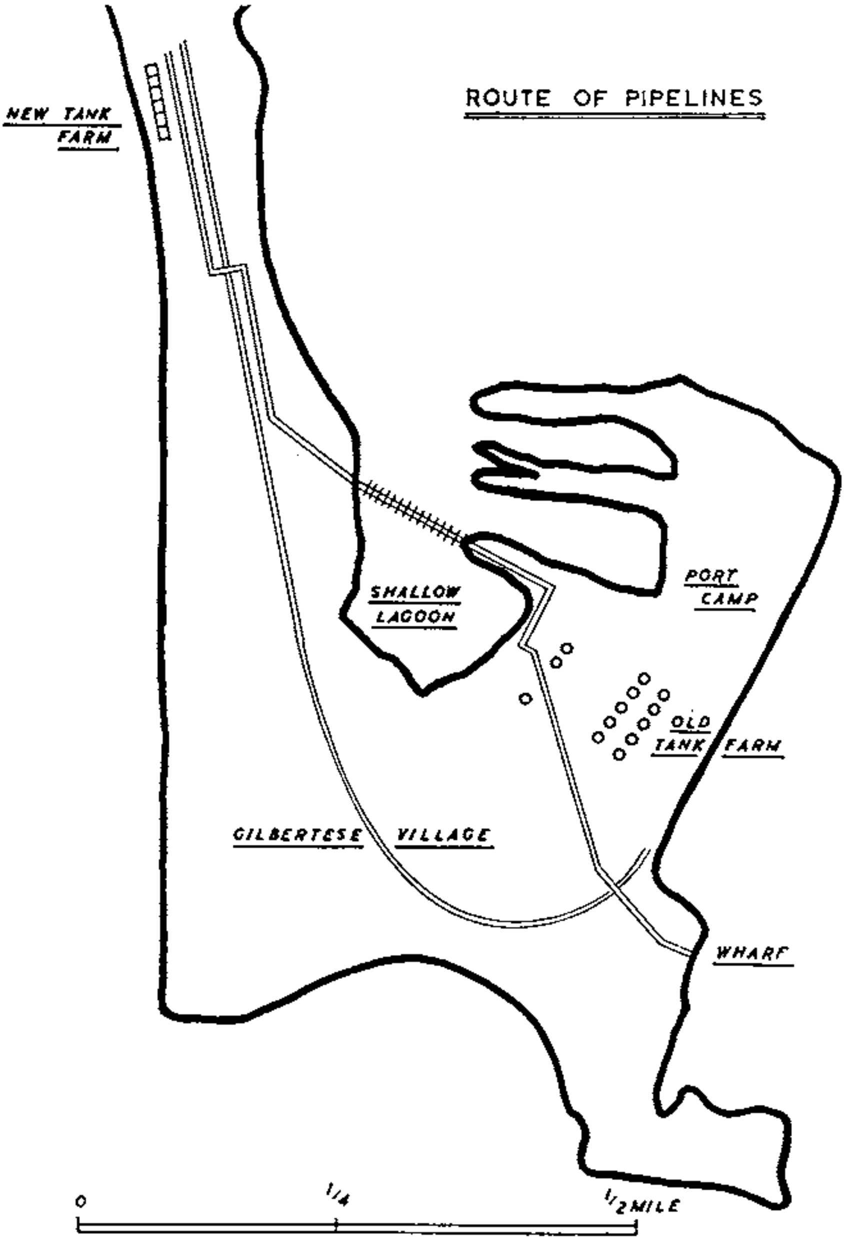
In 1962 it was decided that despite the uncertainty over the future of the Island provision of new storage facilities could be delayed no longer. A scheme was prepared by the Air Ministry to transport to Christmas Island twenty horizontal cylindrical storage tanks dug up from an airfield in East Anglia. These were to be erected on Christmas Island with the necessary pipework, flameproof electric pumps and other facilities to handle four grades of aviation and ground fuel.

*Planning.* The task of planning the work was given to 516 Specialist Team Royal Engineers who prepared a detailed scheme with drawings, stores lists, works tables and a detailed financial estimate.

*Mounting.* After considerable argument and discussion the scheme received Cabinet approval and a financial allotment was made in May 1963. Considerable work had already been done towards the provision of stores but the main contracts could not be let until after the allotment of money. This meant that all the stores could not be available for shipment until November 1963. A directive was given that the work must be complete by 1 May 1964. It was therefore decided that the work should start in November 1963 by which time the first shipment of stores would be available on the Island. The task of construction was given to 20 Field Squadron Royal Engineers who were to work under the direction of 516 Specialist Team; both units together with 73 (Christmas Island) Squadron, being placed under the command of Lieut-Colonel T. Harris, MBE, RE, who was appointed Commander Royal Engineers.

A number of new works services and major maintenance of existing facilities, such as the water mains, were added to the petroleum project to be phased in to absorb the off peak labour pool. The planning and control of these extra tasks were carried out by the CRE's staff and by the officers of 20 Field Squadron RE. The project force of 9 officers and 180 other ranks was flown into the Island between mid-November 1963 and 1 January 1964. Sixty Gilbertese Islanders were recruited to supplement the labour force.

*General description of the Installation.* It was decided that the site of the old tank farm was unsuitable for development because of the hazard of


ROUTE OF PIPELINES
NEW TANK FARM
SHALLOW LAGOON
PORT CAMP
OLD TANK FARM
GILBERTESE VILLAGE
WHARF
0
1/4
1/2 MILE

working in an area soaked with the excessive leakage from the bolted steel tanks, and because both military buildings and the Gilbertese village now closely impinged on it. A site well outside the Gilbertese village and approximately 1 mile from the wharf was selected. The twenty tanks were arranged side by side in six groups not exceeding four tanks per group. The tanks were supported by concrete foundation rafts and each group was enclosed by a concrete bund wall. The line of tanks was parallel to the main road and an access road was constructed in the space between the tanks and the main road. The pumps and pipework were sited in the forecourt between the tanks and the access road.

*Tanks.* The tanks were steel cylinders 30 ft long and 9 ft in diameter. They had been manufactured in about 1942 and buried underground at a Lincolnshire airfield. They differed slightly in length and diameter and were bent and twisted. The contractor who had modified the tanks for installation above ground had not taken much trouble over locating the valve connexions. Consequently there was considerable difficulty in aligning the tanks and manifolds.

The tanks weighed about 6 tons and were transported from the wharf to the site by a home made pole trailer. The RN workshops made up a spreader bar so that the tanks could be lifted on and off the trailer by crane.

Vertical alignment was achieved by including a pull lift jack in one side of each sling around the tank. Tightening or slackening the pull lift jacks caused the tank to rotate.

*Tank Supports.* The tanks were each supported by four saddle blocks themselves supported by a reinforced concrete slab. Had the tanks been fitted with welded-on feet the supporting blocks could have been flat topped. As it was the saddles had to be carefully matched to the shape of each tank. The saddles were precast at a convenient site and when cured were lifted with the aid of a specially made frame on to a lorry for transport to site.

Holes had been left in the saddles to take starter bars which were left protruding from the base slab. The saddles were levelled on to steel wedges and grouted in. Bituminized felt was used to insulate the tanks from the concrete and incidentally to accommodate small variations between the shape of the tank and the saddle. The saddles were higher at one end of the slab so that the tank had a fall of 4 in to enable it to be drained.

## The Welding of Aluminium Pipe

*Advantages.* The advantages of using welded aluminium pipe over steel pipe with victaulic couplings are:—

Lightweight making handling less expensive.

Freedom from corrosion both internally and externally.

No requirement for painting except where necessary for identification.

No maintenance required as with victaulic couplings.

Although capital cost is about 50 per cent higher than steel victaulic piping this is largely offset by lower construction costs and negligible maintenance costs. Capital cost is only 75 per cent of that of victaulic coupled aluminium pipe.

It was therefore, decided to use welded aluminium pipe throughout, both for the pipework around the tank farm and for the four pipelines from the wharf to the tank farm. The pipe was laid on the surface as the cheapest means of construction.

*Specification of Piping*

*Alloy.* The alloy used for the standard alloy victualic ended tubing is BS 1471 HT 30. On advice from Aluminium Laboratories Limited it was decided to use HT 9 WP for the project. This offered better corrosion resistance, especially against salt water, although it is not such a strong alloy.

*Dimensions.* Both 4 in and 6 in tubing were required plus a small amount of 3 in, $2\frac{1}{2}$ in and $1\frac{1}{2}$ in. As there were difficulties in welding by the MIG process if the wall thickness was less than 0.125 in it was decided to use the standard wall thickness of 0.160. As this provided a burst strength of about 1,700 lb/sq in across welds it had a rather excessive factor of safety at 100 lb/sq in working pressure of the line. However, a thinner pipe would have been too vulnerable to mechanical damage. The pipe was ordered in 20 ft lengths to ease handling problems.

*Welding Rods and Wires.* Standard 5 per cent magnesium rods were used for the hand welding. The pipewelding machine required 2 lb spools of 0.035 in diameter 5 per cent magnesium wire.

*Welders.* All the welding was done by the two Sergeant Welders of 516 Specialist Team. They were both Army Class A1 Welders who received special courses of instruction at both the British Oxygen Company's training school and at Aluminium Laboratories Limited. To assist in maintenance of the equipment the Sergeant Electrician of the specialist team attended a short maintenance course with the British Oxygen Company.

*Processes Available*

*MIG.* The bulk of the welding was done by a semi-automatic pipewelding machine developed in Canada by Aluminium Laboratories Limited, the production unit being designed by the Linde Company. This works on the expendable fine electrode wire, argon shielded (MIG) process. The welds are completed very rapidly to a high degree of consistency. In conjunction with the machine not only is a special end preparation required but a special combined alignment and backing up tool must be used. This can only be used with straight tubing.

*TIG.* To weld on fittings or to join two long lengths of pipe where no backing up tool can be used the welding has to be done by hand using the Tungsten Arc process with argon shielding (TIG).

*End Preparation.* To produce the required end preparation a special machine was purchased. This clamped to the inside of the pipe and cut the specified J preparation. To cut the pipes to length a power driven hacksaw was purchased.

*MIG Welding.* The pipeline welding machine consists of a MIG spool on a gun welding torch which is rotated around a saddle clamped on to the pipe. Also clamped to the saddle is the control panel which has controls governing the speed of wire feed, the speed and direction of rotation of the torch around the pipe and the main argon control. The argon tube and electric cables are wound up on a reel which rotates with the torch. These are taken to a separate control box which houses the control relays and the arc ammeter and voltmeter. The saddle is clamped to the pipe by a spring loaded chain and is centred on the various sizes of pipe by means of changeable studs.

*Power Supply.* The power supply must be of 300 amp DC capacity and in this case a drooping characteristic welding generator was satisfactorily used. A stud welding machine was obtained from British Oxygen Company and mounted on a trailer. The control circuits require a 115V AC 60 cycle supply, and to provide this an alternator was mounted onto the shaft of the welding generator. A 300 amp welding current contactor with 115 volt operating coils was also mounted on the trailer. The end preparation machine was fitted with a 240V 50 cycle motor so that it could be used away from the welding set.

*End Preparation.* The end preparation was detailed by Aluminium Laboratories. The object was to get an internal register, standard root depth and a wide U shaped groove. The internal register was necessary due to the ovality of the pipe. The end preparation machine cut the full preparation in one operation. However, it was quite impossible to achieve in the field the strict tolerance laid down by Aluminium Laboratories Limited. Although this may have affected the proof strength of the welds it did not have any practical effect within the test limits imposed.

The pipe was bought plain ended since an end preparation machine was required for closures etc, and it was cheaper to prepare the pipe in the field. It also avoided any possibility of damage in transit. The bulk of the end preparation was done on the wharf before moving the pipes to site.

When the pipes were aligned the ends were brushed clean with mild steel brushes, polished with wire wool and washed with white spirit. Stainless steel brushes might have been better but this did not cause any apparent problems.

*Backing up Tool.* The pipes were aligned and pulled together by the expanding backing up tool. This was fitted with a 20 ft length of aluminium tube as a handle so that it would be operated from the end of the pipe. The outward pressure of the tool tends to round out any ovality.

*Welding Controls.* The Pipe Welding machine reduces the time taken to train a welder to produce consistently good welds. However, considerable skill and care on the part of the welder are necessary to ensure consistently good welding results. These are the following variables which must be concontrolled by the welder:—

(1) Argon Flow, controlled by nozzle diameter and gas regulator.
(2) Distance of nozzle from pipe.
(3) Distance of guide tube from pipe.
(4) Speed of rotation, normally 100 in/min.
(5) Speed of wire feed controlled by drum brake, drive roller tension and feed motor control.
(6) Open circuit and arc voltages.
(7) Welding current.
(8) Cross feed, controlled manually.

The following also appear to affect the welding conditions: wind, humidity and the amount of salt in the atmosphere. The material of the pipe and welding wire have a marked effect.

The welder has to set up the machine to standard settings and then adjust by trial and error to establish the right conditions for welding in the local situation. Once these have been established the welder must still make adjustments during welding to effect small changes in the variables. Considerably more automation of the machine could be carried out with advantage.

*Weld Quality.* The welds achieved are of a consistently high quality. They do have an amount of scattered porosity but this does not affect the weld strength when the full five or more passes are put down. For this operation a full strength weld was not required and only three passes were put down. As a result a few cases of porosity were found on testing but these were easily rectified with the use of the hand torch.

Tests in England on HT 30 pipe with a burst pressure of 2,800 lb/sq in gave welds with a burst pressure between 2,400 and 2,600 lb/sq in. With HT 9 WP alloy the figures are about 75 per cent of the HT 30 results.

*Spatter.* Considerable trouble was experienced with small globules of molten alloy being thrown out by the intensity of the arc and building up on the nozzle and guide tube. The build up reduces the flow of argon and eventually causes burn back of the electrode wire.

Although the use of an anti-spatter silicone paste had been considered it was not advised by Aluminium Laboratories and tests in UK had indicated that it was unnecessary. When the trouble with spatter was discovered a request to have some flown out from England failed to produce it in time. Some success was achieved using plumbers' black on the guide tube.

When the weather broke and heavy rain continued for some weeks it was expected that trouble would be experienced due to damp. However the welding troubles virtually ceased. It is thought that the heavy rain may have leached out the salt from the atmosphere.

*Fixed Station Technique.* Instead of the pipe being strung out along the right of way and the welding machine moving from joint to joint the fixed station technique was employed. The welding machine was set up at a change of direction, and the pipe stockpiled there. The first two pipes were fed in on a roller conveyor and clamped together with the backing up tool. The first weld was made and the backing up tool withdrawn. The pipes were pulled forward 20 ft so that the second joint came under the machine and the third pipe clamped on and welded. The pipe was thus pulled out 20 ft at a time until the required length or up to ¼ mile of pipe was pulled out. As the length increased it was necessary to provide a vehicle to tow the pipe. The longest length welded on Christmas Island was 1,100 ft.

The four pipes were pulled out and then the station turned to weld in the other direction. In some cases the station welded pipe was then towed or carried round the next change of direction.

The pipe is extremely flexible and bends to suit the ground thus necessitating the minimum number of set bends. The fitting of bends and joining lengths of pipe must be done by hand as the backing up tool cannot be used.

*Speed of Welding.* Owing to the short time which was available between the arrival of the machine in England and its shipment to Christmas Island there had been very little time for the welders to gain the necessary experience. This slowed down the progress in the initial stages of the project. It was difficult to judge whether failures were due to operator error or machine fault. After this initial shaking down period eighty welds a day were being achieved consistently. With 20 ft lengths of pipe this meant that the welder and his team of six were welding and pulling out 1,600 ft of pipe in an 8-hour day. If 40 ft lengths of pipe had been used the output would have doubled.

*TIG Welding*

*TIG Process.* The arc is struck between a Tungsten electrode and the pipe and a welding rod is fed into the arc and molten pool by hand. The process

**Photo 1.** Three-tonner towing pipe.

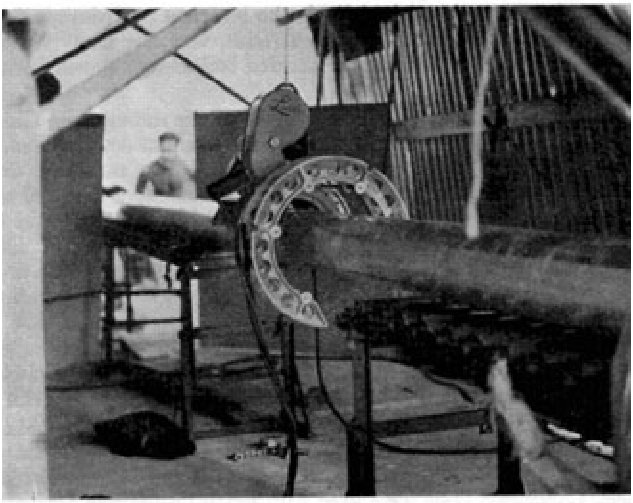


**Photo 2.** Semi-automatic pipeline welding machine.

**Welded Aluminium pipelines on Christmas Island 1,2**

is not unlike oxy-acetylene welding. The welding current is AC and is supplied by a welding transformer connected to a generating set. A high frequency current is super-imposed to initiate and control the arc. The Tungsten electrode is supported in a ceramic or water cooled nozzle, depending on the welding current, through which the shielding argon flows.

*End Preparation.* For non-positional welds a simple vee preparation may be used but for positional welds a similar preparation to that for the MIG welder is desirable.

*Welding Set.* The machine used was a Saturn Hi-volt welding set which takes about 15 kVA at 400 volts. This set is a standard workshop machine and for site welding was mounted in a 1 ton truck. As the current required made the use of the water cooled torch necessary a water tank and electric circulating pump were fitted in the truck. By adding ice to the water tank adequate cooling was achieved. The power was supplied by a trailer mounted 27½ kVA three phase generating set with the welding set connected between two phases. This somewhat cumbersome arrangement could be reduced to one small high frequency generating set which can be towed behind a land rover. However it was cheaper to use standard army equipment than to buy another special.

*Welding Speed.* Initially the machine was set up in a workshop area to prefabricate parts. Forty 6 in welds could be completed in a day.

Positional welds on the site were much slower and about twenty-five 4 in welds were completed in a day.

About ten 6 in pipeline closing welds could be completed in one shift.

*Weld Quality.* A very high quality of weld was achieved. Test results in England showed that due to the wider heat-affected zone the weld was slightly weaker than that obtained by the MIG machine. Test pieces burst in the range 1850 to 2100 lb/sq in using HT 30 pipe. Again the results with HT 9 WP would be about 75 per cent of those with HT 30.

Some defects were found initially due to incorrect procedure in finishing the weld. This was remedied and, as a result, very few faulty welds were found. This defect would not have occurred had the equipment been fitted with automatic crater suppression.

*Lagoon Crossing.* To avoid taking the pipelines through the Gilbertese village it was necessary to cross a shallow lagoon about 600 ft wide. A pipe bridge was designed as this was more economical than anchoring the pipe on the bottom. H frames were welded up from aluminium pipe and set into concrete blocks. The complete frame was carried into position in the lagoon by a dozer with a crane attachment. The frames were set at 40 ft intervals and levelled in by hand. The pipes were welded up complete on dry land and carried into position by the entire squadron plus about sixty Gilbertese labourers.

*Road Crossings.* Twenty-four inch Armco culverts were put in to carry the pipes under the roads. The lower pair of pipes were encased in pitch fibre pipes and these supported the upper pair of pipes clear of the culvert sides.

*Valves.* The majority of valves were bolted directly on to the tanks or on to steel filter bodies, loading arms or pumps. Standard cast steel valves were used for this purpose. The aluminium pipe flange was fully insulated from the steel. Galvanized bolts were used with nylon bushes and Densochrome paste and tape were used to exclude moisture.

Where valves were required in the pipeline, aluminium bodies with stainless steel spindles and gates were used.

*Pumps.* Standard Air Ministry electrically driven screw displacement pumps were installed. The electrical work had to conform to flameproof regulations and MICC cable was used extensively. The pumps were provided with remote control so that the operator could start and stop them from the vehicle loading points.

One pump was mounted on a trailer so that it could provide a useful transfer pump both during the project and for normal use afterwards.

A Sykes Univac pump, which is a centrifugal pump provided with a vacuum pump connected to the suction, driven by a diesel engine and trailer mounted was provided for transfer purposes, pumping sludge during tank cleaning and even pumping water out of pipe and cable trenches. It did stalwart service.

*Filter and Water Separators.* To ensure that the fuel dispensed into aircraft was fully up to the rigid quality control standards set up by the RAF a fairly lavish scale of filters was provided. The fuel was filtered before going into the storage tanks, before the pumps, and in the case of aviation fuels was filtered and water separated out before loading into the bridging vehicles for transport to the airfield. At the airfield the fuel was filtered before the pumps and passed through filter water separators before loading into the refuellers.

*Electrical work.* A high voltage feeder cable was laid along the pipe from the Port power station to the tank farm site. A 50 kVA sub-station was constructed and electric lighting was provided for the area.

*Airfield.* In addition to providing the new fuel installation at the Port, rehabilitation was carried out to the airfield tank farm. The bolted steel tanks were found to be in good condition and were merely cleaned, tested for leaks and painted. Flameproof electric pumps were installed and all the pipework replaced with welded aluminium pipe.

*Completion of Project.* Rehabilitation of the airfield installation was completed and the tanks brought back into service. However, the main tank farm was being finished just as the decision was made to abandon the Island. It was therefore completed but not commissioned. All possible steps were taken to put it into a state of preservation.

The whole project was completed three weeks before the target date and within 3 per cent variation of the original estimate of cost.

## Conclusions

The construction was carried out to a high standard of workmanship, on time and within the estimate. It had provided valuable training for all the tradesmen of 20 Field Squadron. The standard of proficiency of the tradesmen was greatly enhanced by their experience on the project.

The welding of the aluminium pipe was highly successful. The MIG pipe welding machine enables long lengths of pipeline to be constructed at high speed by a small labour force.

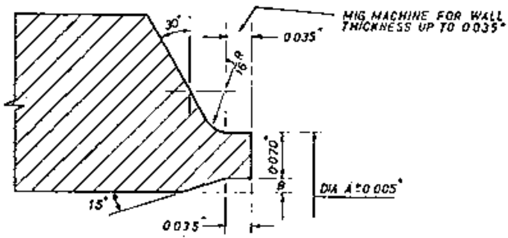
The validity of the arguments in favour of the use of aluminium pipe to save maintenance can only be proven by time. However there is no reason to doubt the success of this method.

Although the pipewelding machine assists the operator to produce consistently good welds, a very high standard of training and experience is necessary.

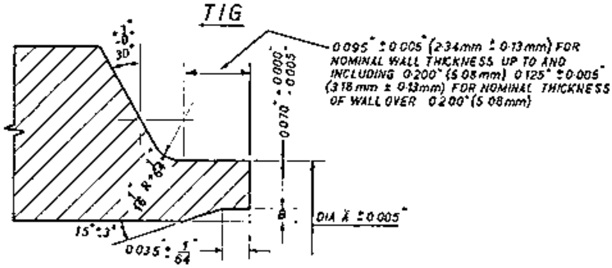
ANNEX C

## PROFILE OF END PREPARATION

### MIG

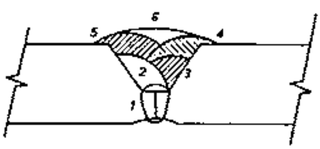



### TIG




ALL CORNERS TO BE FREE FROM BURRS

## WELDING SEQUENCE




DIA Ā = MAXIMUM MEAN I.D. PLUS 0·010" (0·25mm) PLUS 0·140" (0·36mm) MAXIMUM MEAN I.D. TO BE DETERMINED FOR EACH SIZE BY MEASURING BOTH ENDS OF A REPRESENTATIVE SAMPLING OF THE PIPE. Ā MUST BE THE CONSTANT FOR ALL PIPE ENDS IN ANY ONE SIZE. THE DIFFERENCE BETWEEN THE MAXIMUM DIMENSION 'B' AND THE MINIMUM DIMENSION 'B' FOR ANY ONE PIPE END MUST NOT EXCEED 10% OF THE NOMINAL WALL THICKNESS.

TOLERANCES ON SQUARENESS OF PIPE ENDS ACROSS DIAMETER:

0·022" (0·56mm) FOR 10" (254·0mm) PIPE.
0·018" (0·46mm) FOR 8" (203·2mm) PIPE
0·015" (0·38mm) FOR 6" (152·4mm) PIPE
0·012" (0·31mm) FOR 4" (101·6mm) PIPE
0·010" (0·25mm) FOR 3" (76·2 mm) PIPE
0·008" (0·20mm) FOR 2" (50·8 mm) PIPE

# Towards a Better Plant Policy

*By* Major J. C. Hunt, MBE, RE

*The subject matter of this article is at present undergoing investigation with a view to determining Corps policy. The views expressed in this article do not necessarily represent the likely outcome of these studies.*

## Introduction

When the fallout has settled, historians could well regard the nineteen-sixties as a watershed in the affairs of the Corps. Coupled with the loss of TN, Movements, and Works responsibility in peace, plus the possible loss of Resources and a mechanical repair capability, they may well see the amputee, with little left but his teeth, busily regenerating new and ultra-powerful plant limbs with which to do engineering.

Only a few years ago, the combat engineering side of the Corps was largely a body of manual workers, but it is now moving towards being an assembly of advanced plant handling teams. There can hardly be an aspect of the role left to the Corps in which machine power cannot be employed with advantage. The pace of advance is tied largely to that of the international construction plant manufacturing industry, which has made giant strides in the last decade and is still accelerating.

## Aim

This paper seeks to look at some aspects of the plant and plant training policy which the Corps will need in the future. The writer claims no special expertise, other than that of one who has been concerned with plant from time to time during his service.

## What is Meant Here by "Plant"

By military definition, "Plant" is a generic term covering all prime-mover, driven, or towed vehicles, machinery or equipments which are serviced on an hours-run basis as opposed to mileage. But even this catch-all classification becomes tenuous in such items as a truck mounted excavator, where one engine is serviced by mileage and the other by hours. For the purpose of this paper, "Plant" is taken to be principally those equipments which are the province of plant and construction plant trades.

## Why Plant is Needed

There would seem to be four main reasons for the employment of plant, as follows:—

(*a*) To enable one operator to do the work of many men working by hand.

(*b*) To enable work to be done in a fraction of the time needed by hand methods.

(*c*) To achieve results impossible by other means.

(*d*) In hazardous circumstances, to reduce the number of men exposed to risk.

Thus, it can be said that plant may be used to save cost, labour, time or lives. This may seem obvious, but it is basic to the employment of plant.

## Personnel Policy

Clearly, no plant can be better than the men who control it, and any plant policy must start at this point. Important progress has been made in this area by the recent introduction of the "A" trade of Plant Operator Mechanic. The title is self-explanatory, and at A1 level the POM will be capable of operating and carrying out running repairs on all plant in the Service. There can be no doubt that a machine costing £20,000 or more should be operated by the best man available, and the POM trade will go far towards achieving this. The initials should amuse Australian Sappers a good deal! The build up of the Military Plant Foreman Roster, from its inception in 1959, is also a significant milestone. Further benefit will follow as the best of these achieve Quartermaster rank year by year. Some no doubt will achieve other types of commission.

The matter of the continuation plant training of middle-piece combatant officers is by no means so satisfactory. It is no secret that the level of plant management in the Corps is capable of improvement. This is unlikely to be put right until it is generally appreciated that machines are already in service which perform singly the work formerly done by a whole troop, or even squadron, and that in most engineer operational work practically all else is subordinate to the need to keep plant working effectively. Perhaps, like British industry has just done, the Army will decide that its leaders must be taught the management skills developed recently in the USA.

Much depends on the future of Engine Fitters (Plant) now that the POM trade is in being. One side aspect of this is that EFPs have provided half of the military plant foremen to date.

At present, there are too few appointments in the trade of Construction Plant Operator to provide a worth-while promotion structure. The solution would seem to lie in amalgamation with an analogous trade. There is little doubt, however, that the kind of plant involved will increase in importance as the Army's need for air movement increases, and this is coming on a flood tide. The recent raising by the Corps of four Field Squadrons (Airfields) will help to create an outlet for CPOs. The most promising trade with which CPOs might amalgamate would seem to be Fitter IC & P. Concretor is another possible.

## Which Plant

Most Sapper officers responsible for plant would agree that two factors largely beyond their control provide the major difficulty. These are that much of the plant held is not the most suitable for its purpose, and that "down-time" lost while awaiting spares is unduly high. This paragraph will concentrate on the first of these factors. At the present time, the holding of a plant-user unit may suffer from some or all of the following shortcomings.

(*a*) A high proportion of old, under-developed, and unreliable early Marks, but only a few modern and thus usually more efficient Marks.

(*b*) A multiplicity of makes of the same type of machine, eg there are five makes of light crawler tractor in Army service, each with its own spares backing.

(*c*) Major holdings of machines which have failed commercially, and gone out of production.

(*d*) Considerable holdings of "military special" machines, for which spares are almost unobtainable on the civil market overseas.

(*e*) A grave shortage of machines capable of movement to the work site by the means available. This is particularly so in operations in FARELF.

As usual, it is easier to criticize than to suggest valid remedies. The following are, however, proposed as being the lines on which a future plant procurement policy could be framed with advantage.

(*a*) The Sapper aim in procurement of plant should be "to select the best machines for the task, *capable of being moved to the various types of work site by the means available*". The civil plant operators' aim is generally only to pick the best and most economical machine for the task. To take a common military case, if a hasty TT (SR) strip is to be built outside helicopter range, and only air movement is possible, the Sapper must first discard all plan incapable of air-drop on the type of platform available. Only then can the pros and cons be evaluated of wheels *v.* tracks, petrol *v.* diesel or cable *v.* hydraulics, and so on. To take a further example, the first LWT, the Michigan 75, can almost certainly be dropped on two MSPs. The latest buy, of Bray 455's, was retrograde because it weighs more and cannot be air-dropped on two MSPs. It follows that study of plant needs cannot be divorced from study of plant carriers, for air, sea and land movement.

(*b*) The very basis of a viable plant policy is the operation of an active casting policy for "C" vehicles and engineer plant. The Army cannot keep abreast of civil development without one, any more than a major contractor can.

(*c*) It is also surely essential that no plant is even considered for purchase until the civil version is a proved commercial success, both on the home and export markets, and has run through at least two Marks to "iron out the bugs". Having learned to live with it, we should then stay with it *until it is technically superceded*, as dual steer has by pivot steer, for example.

(*d*) All our history since the Crimean War illustrates that the "internal" system for the development and selection of military hardware produces nine geese for every swan, and plant is no exception. What we want are the Volkswagens and Land Rovers of the plant world; what we get are often the Champs and Ford Edsels. The case for the employment of an independant advisory and selection agency for plant, on the lines of the Rand Corporation (in miniature) seems overwhelming. So far as can be seen, the present system ignores the most important selection tools; that is of commercial and economic intelligence, and statistical method. The trouble with technicians is that left alone, nearly all are figuratively capable of saying with the fin-de-siécle Chief Engineer of the General Post Office that there can be no future for the telephone in the UK. But this is not to say that we can do without technocrats.

(*e*) Cost effectiveness is even more important to us than to the Americans.

## The Movement of Plant

At present, plant thinking among many sapper officers is along one of three lines. There is the UK/BAOR School, who have learned the hard way that in NE Europe even the heaviest tracked machine may be grounded by weather for up to 30 per cent of the year. They have also found that land and sea movement of heavy plant presents few problems in highly developed countries. They also know that wheeled plant can do little but re-handling when the ground is frozen, and that its uses are limited at other times.

The second or Strategic Reserve/MELF School tend to think in terms of plant capable of carriage by Inter-Theatre aircraft landing on Class 1 and firmly held airfields. They have found wheeled plant very useful in hot, dry countries, and have found hasty, unsurfaced airstrips easy to build in deserts and valleys.

The third School is of course the FARELF one, where standard thinking is that whole brigades must be at constant readiness to emplane at Class 6 air-portable scales. This places engineer emphasis on the better power/weight ratio of (ultra light) wheeled plant, and the fact that it is likely to be able to operate except in the monsoon. They also know the air movement difficulties in getting plant to the site of even an TT (SR) airstrip when the whole terrain consists of mountain, jungle or paddy. Further, in a complex of under-developed countries, they are accustomed to think almost exclusively in terms of air movement.

All three views of plant utilization are of course equally valid, and based on long experience. It follows that the Corps must possess families of plant to match all three requirements. There is also the point that they overlap in that, for example, heavy tracked plant is often needed in FARELF, particularly during the monsoon, and light wheeled plant, which may be a squadron tool in FARELF, can often be useful as a troop tool in Europe.

One way of viewing the problem is that the selection of plant for Corps use depends very largely on the types of aircraft available to the RAF. At the present stage of aircraft development, the following seem to be the paramount needs to enable efficient short range air movement to take place.

(*a*) A VTOL lift of 12,000 to 15,000 lb over a radius of 100 miles.

(*b*) A STOL aircraft with a 75 × 75-in rear door, capable of carrying plant loads of say 10,000 lb over 500 miles radius, and landing or taking off in 300 metres—beyond this there is of course already a whole family of TT(MR) aircraft available for airdrop and heavier plant lifts on to rough airfields.

## The Absence of Spares

This is the Achilles Heel of plant operation within the Corps. Whether a machine is the best of its type which can be got to a site, or not, matters little if it cannot be worked for lack of spares, and much of the Corps plant spends much of its life in this condition. The spares supply situation is complex, and radical improvement depends largely on major changes in equipment policy. Some suggestions follow.

The absence of a casting policy has a major effect on the need for spares. Not only do old machines need frequent replacement of components, but various Marks of a machine often have little commonality of spares, eg there is only about 5 per cent commonality of spares between Mk 2 and 3 Fowler MCTs.

The system of having an Ordnance Stores Section as an organic part of each REME workshop has resulted in a highly efficient system for the supply of "A" and "B" vehicle spares. The Corps on the other hand seems to have made little use of RAOC expertize at unit workshop level, and this would seem to offer the prospect of rapid improvement in a vexed situation. Nor is it generally appreciated that FAMTO scales may be adjusted by unit commanders in the light of experience.

If we could move away from the situation of having two or more makes of most types of plant, spares scalings could be reduced drastically, with a consequent increase in efficiency of supply.

Lip service is often paid to the need for simple, reliable and robust machines, but the Corps is often obliged to try to cope with major assemblies, such as turbo chargers, transmission systems, and hydraulic mechanisms, which prove prone to failure, and have an egregious appetite for spares. It appears likely that commercial intelligence would do more to pinpoint such weaknesses, before purchase, than technical assessment has done in the past.

Present powers of local purchase for spares are very limited, and generally involve going cap in hand to RAOC. Liberalization of these powers is a further area in which the possibility of real improvement would seem to lie.

## Crystal Ball Gazing

The would-be seer must take his chance of being proved ridiculous if his stuff is re-read ten years later. This, however, is the way one man sees some aspects of the possible future for plant in the Corps.

Ultra-light wheeled industrial tractors such as the Ferguson 203 are likely to be used on a much larger scale. There are already tens of useful matched ancillaries available, and road speeds of 20 mph have been obtained. This type of machine *costs little more than £2,000* and could provide each section in the field troop with a reliable and versatile piece of plant. Among the many advantages foreseen are:—

(*a*) Movement without stripping by STOL and VTOL aircraft and over Class 6 routes, plus easy air drop.

(*b*) Immense value by making virtually every man not only plant minded, but a minor plant operator. The gain in plant management skills by section and troop commanders will be large.

(*c*) An enormous increase in field squadron digging capacity. The Ferguson 203 backhoe already out-performs that of the LWT.

(*d*) With a matched tipping trailer, they provide a personnel, stores, ancillaries, or earth carrier.

(*e*) Spares are available in the most remote areas of the world, and *the basic design has been refined by thirty years of mass production.*

Better tyre design and more driving wheels are likely to result in a higher proportion of wheeled to tracked machines. Conversely, plastic or synthetic rubber track plates may well permit fast movement by tracks over public roads. "Brimec-type" loader-equipped trucks are likely to replace low loaders almost completely.

Pure winch and cable operated machines are likely to be relegated to only the very largest sizes of plant. The Army will require a hydraulically operated excavator/crane range capable of all digging, piling, loading and cranage tasks. All will have one engine to provide both power and road movement. There will probably need to be one type capable of 40 mph on its own wheels, and a tracked version capable of self loading on to a bogey-type trailer.

Most machines are likely to have life-sealed cooling systems, life-lubricated bearings, and be designed to almost eliminate the need for servicing. The engine may be of the Wankel or V8 type, but will have a much improved power/weight ratio. The transmission system may develop in one of several ways, but will certainly be much more foolproof and reliable than any in use now.

The operator will have infra-red heating if his driving position must be exposed, and air conditioning to cope with both arctic and tropical conditions will be fitted in cabs.

Movement of plant by ground effect vehicles is obviously already practicable, but expensive. It may well be that special purpose vehicles will be developed which use the main engine for ground effect movement over say swamp and, having reached the site, revert to conventional muck shifting, and so on.

### Conclusion

As the writer sees it, the wheel has swung almost full circle since the Corps started to operate road and rail traction engines in the nineteenth century. It took a further great lurch when horse-transport was finally eliminated in the nineteen-thirties. The next stage is surely to become a Corps which functions largely by manipulating engine power to perform engineering tasks—and does it better than most.

---

# Get in the "Q"

*By* Major G. P. J. Armstrong, RE

### Background

I was sheltering from the rain under a rather inefficient fir tree waiting for the CO to return from a recce of Poole Harbour. My discomfort was slightly more bearable in the knowledge that in two months time I would be taking up my first Grade II staff appointment in Germany. The fresh air and fun of regimental life was all very well but . . . "Ah, there you are, jump in, we must go and see X Squadron". With a bump and a splash we set off across the heath. "By the way", the Colonel shouted over his shoulder, "Call from War Office, your posting's been changed, going to Quartering at Chessington".

### Introduction

Chessington was shrouded in fog as I was directed down the long concrete passage. Ears seemed to flap awkwardly under the new bowler. Here was a door labelled "Works Services—Southern & N. Ireland Commands". This was it. Rapid introductions followed, "Poor Mike has another four months to do, he'll show you the form. Come and meet the others". The fellowship of the prison camp was much in evidence. "Never mind old chap, it's only two years". From a jumble of first impressions a basic pattern emerged—kindness, sympathy and condolence. "If you can stick two years here you can stick anything." Only one dissenting voice, that of my AQMG, who described the job as one of the most responsible and rewarding Grade II appointments in the Army. A little far fetched I thought; and the fog grew thicker.

### Aim

This is not a horror story. My aim is to shed a little light on the dark labyrinths of power, and to reveal that Quartering is not synonymous with astrology or black magic—though there are superficial similarities. The jargon alone may induce a state of mental paralysis, but I hope to show that such witchcraft can be overcome.

### Initiation

It is a strange enough experience to be posted to the MOD (A)—at that time still known as the War Office—for the first time, without the added complications of Quartering. One notices a subtle difference from the Regimental Orderly Room. "I'm sorry Major, the typing pool won't accept pencil drafts. No, the clerical staff are not supposed to type. I could ask the Director's PA as a special favour. Of course it won't go out tomorrow if you want THAT many copies. With all those bits at the back it will have to go to the Long Job Pool at Wandsworth. Get the Colonel to sign an immediate label, then it might be back before the week-end."

The week of handover passed all too quickly. I was left with a notebook full of people, places and problems. I had an acute feeling of mental indigestion as I stood alone in the office after the last farewell and the last pint in the local in honour of my predecessor. Two thoughts struck me very forcibly; how ignorant I was of the Quartering business compared with everyone else, and the awful realization that no one had really told me what a DAQMG in Q2 actually had to do. Now that I know that nobody else knows either I feel much better. The following paragraphs tell of some of my more interesting discoveries during the months which followed.

### The Programme

At least one thing was clear. Some four or five years previously the Army had initiated a comprehensive rebuilding programme designed to rebuild or modernize the accommodation of every unit in the United Kingdom. As there were few permanent barracks less than twenty years old in existence, and a good many units were still in wartime hutting from one or other of the previous three wars, the task was one of considerable magnitude. Our programme envisaged an expenditure of about £153,000,000 over a period of fifteen to twenty years. This huge sum was the forecast for major projects at the time of my arrival in December 1962. Since then the programme has undergone various squeezing and stretching exercises as a result of financial and other pressures but mercifully the future was well hidden at the time. A rough guide to the pattern of annual expenditure on "Works" may be of interest—

| Class of Expenditure | *Cost in £m* |
|---|---|
| Major new projects (Part I services) | |
| At home | 17 |
| Overseas | 9 |
| Minor new works (Part II) | 2 |
| Maintenance (Part III) | 30 |
| Total | 58 |

(These figures exclude married quarters which are accounted for separately.)

Of the £17m on Part I services in the UK about £7m were being spent in Southern Command and rather less than £1m in Northern Ireland. This was the share of the programme for which I was apparently responsible in some mysterious way not yet understood.

### Why "Q"?

Obviously a building operation demands close understanding and teamwork between the architect or engineer and his client. The latter must say what he wants, agree the design and pay the bill. The designer must translate the client's ideas into practical terms within a given cost ceiling and supervise the contractor on site. I think I knew that much even before coming to Chessington. In a small operation there is a face-to-face relationship and no need for a Quartering Directorate. But as time passed I discovered how a change in scale altered the character of this relationship.

### Soldiers (and Others)

Any big Army project includes living accommodation, offices, stores, dining and kitchen facilities, NAAFI premises, technical accommodation, classrooms, workshops, armouries, gymnasia and sportsfields—occasionally civilian canteens, and even cinemas and churches. Each part of the project is the concern of some different specialist or adviser, frequently far removed from the building site. A single project therefore involves a dozen or more "clients" each interested in a different aspect of the work. Each is prone to changes of policy, changes of mind, and the inevitable "new brooming" when officers change appointment. Small wonder that the architect views such a client as a many headed monster of nightmare proportions.

### Financiers

Even this is not the end of the story. No soldier in the client organization can say what he wants without fear of possible contradiction by the Army's financiers. Although all too often, and occasionally with reason, the soldier regards him as an enemy rather than an ally, the financier has to tread a thorny path between military requirements and financial prudence. He is an essential member of the team in preparing the detailed statement of requirement—the "Q" Brief—managing the financial aspects of the project, and—the most delicate and important task of all—obtaining Treasury approval for all the larger projects which are usually outside any delegated powers of approval.

### Architects

The architect was a professional civil servant in the Directorate General of Works (DGW)—this was in 1962—or a member of a civil firm commissioned by DGW to plan a project as external consultants. Some of the Works Directorate architects were old hands with years of experience from DFW days, and knew more about building for the Army than any soldier could tell them. Others had joined comparatively recently after the civilianization in 1957, and though relatively inexperienced in dealing with the Army, had ready access to the accumulated experience within the Directorate. The civil firms had been commissioned both to provide the extra professional effort needed to handle the enormous programme, and also perhaps to add a little extra spice to military architecture of the mid-twentieth century. More often than not such firms had little or no previous knowledge of their client and needed very close military support and liaison in order to avoid unintentional errors through ignorance of the client's attitudes, methods, organization and system of financial control. At worst the diehard soldier might have regarded the architect (unjustly) as an ignorant scatterbrain with Bohemian tastes in dress and an excessive love of glass.

### The "Q" Role

These then, are the three stars in the drama of a great building programme. In spite of themselves and each other they often work in harmony with satisfying results. Sometimes they do not. Sometimes their joint efforts are brought to nothing by some external influence—political, economic or operational. Hence the need for someone to foster harmony within the team, to spot and if possible to eliminate disturbing influences from within or without in order to maintain that harmony. This service is provided by the Quartering Directorate.

### "Q" Organization

The Quartering Directorate is wholly concerned with building and accommodation matters but of course there is much more to it than the UK Barrack Rebuilding Programme. The Directorate contains branches dealing with policy, accommodation scales, estimates, building overseas, married quarters, hospitals, depots and workshops, deployment and lands aspects as well as the sections of Q2 immediately concerned with the Barrack Rebuilding Programme. These sections also serve as the eyes and ears within the MOD of the Q (Quartering) staffs of the home commands. Members of the Directorate are part of the military "Q" Staff of MOD (Army) and are not in technical or "works" appointments save only a single SORE I appointed since MPBW took over the Works Organization. Nevertheless some prior knowledge of the planning procedures involved in a major building project is certainly helpful.

### Requirements Change

In any five year period nearly all the military officers concerned with a project will change at lease once, more often twice. This can be an exceedingly disruptive influence unless each newcomer is given very firm instructions before he starts to "improve" upon his predecessor's ideas. Numerous committees within MOD are constantly evolving new policy on manpower, training, equipment, deployment and rationalization most of which have a significant effect on at least one major project in the pipeline. Whether the policy alters the project or vice versa ultimately depends on whether site work has actually started. For example one major project was recently abandoned when ready to go out to tender owing to a change in equipment policy. Another new barracks will soon be completed while doubts have arisen about who should live in it.

### —But Projects don't

Few people seem to realize how long it takes to plan and build a barracks. About six months are needed to prepare the "Q" Brief which forms the basis of the instructions given to the architect. For a £1m project the architect needs nine months or more to complete sketch plans for formal approval, and a further twelve months to produce the hundreds of working drawings needed by the contractor. Tender and contract action may take another three or four months and the actual building period over two years. At any time during this five year period the requirement may change unavoidably (or even disappear!). Ideally there should be no change once the brief is in the architect's hands. In practice this ideal is seldom achieved. The later the change, the more costly it becomes in terms of time and money. An apparently trivial change after working drawings have been prepared may easily cause a delay of two or three months. After the contract has been let the cost is out of all proportion to the work involved and quickly consumes the architect's slender financial reserve to the detriment of the finished project. There is, therefore, no such thing as a "new" barracks. Every barracks is in fact three years old in design before the Army occupies it—a point seldom understood by experts at handover boards whose minds are full of the latest ideas on the design of armouries, kitchens, surgeries or whatever else they fancy.

### "Q" in Action

Without some resistance to change nothing would be built at all. The Directorate is engaged in a constant struggle to educate the "user" and sponsor branches to prevent the Army from sabotaging its own programme.

Of course major policy changes imposed from above have to be accepted, and periodically the programme is delayed or reshuffled as a result. Recent examples are the T. A. Review and the Chancellor's measures to reduce public expenditure. On the other hand much has been done to forestall minor local difficulties by improving and modifying the machinery for consultation and specialist advice. Military Project Liaison Officers are appointed for each major project to bridge the gap between the architect and the various military officers interested in the project, and each has now been given a comprehensive instruction leaflet to define his duties.

## MPBW

The most important and far-reaching decision to strike the Quartering Directorate in the past three years was the announcement by Mr Harold Macmillan in December 1962 to transfer responsibility for all service building to the Ministry of Public Building and Works as from April 1963. The short notice and the size of the organizational problem resulted in more than a fair share of teething troubles, but luckily there was reasonable continuity of staff at Chessington and much goodwill and determination to get on with the job among MPBW staff drafted into Army Works for the first time. There have been plenty of problems to iron out between Commands and MPBW Regions, but at Chessington the main problem has been to maintain contact and to keep the work going during a period in which the work of the old Works Directorate has been distributed among four different directorates of MPBW only one of which is still located at Chessington. Each separate professional department—Army Works, Research & Development, Housing and Maintenance is supported by a different finance Secretariat, while within MOD our own finance branch continues to "vet" Army requirements before passing them to MPBW. This "double banking" of financiers has undoubtedly increased the time and effort needed to convey a requirement from "Q" to architect as well as leading to a number of demarkation disputes. Perhaps one good thing has come out of it from the architect's point of view —official notification of changes in requirement may take so long in transit that the project has been started before they arrive!

## Conclusion

At the time of writing there are in the two commands handled by my section eighteen major projects under construction and about thirty more in the planning stage. They all involve close collaboration with command and sub-district staffs, commanding officers, liaison officers, architects in MPBW and sometimes in civil firms, officers and civil servants in a dozen different branches of MOD, representatives of NAFFI, AKC, voluntary welfare organizations and occasionally of other ministries and members of the public. Frequent site visits and the occasional expense account lunch help to lighten the routine and prevent one from becoming office-bound. I am sure the pessimists I met on first arrival were wrong. Of course the job is not without frustrations, yet it would be difficult to find one more interesting and rewarding. A worthwhile posting for anyone, I feel that for me at least it has provided an invaluable experience in a field now unfamiliar to many Sapper officers.

# Movers Lane Flyover Competition

*By* Lieut-Colonel J. D. Townsend-Rose, MC, BSc, AMICE, RE

On 18 August 1964, the *Daily Telegraph* announced outline details of a Public Competition for the design of a "portable" Flyover, with prizes to the value of £3,000.

The detailed specification and site drawings were obtained from the Ministry of Transport against a deposit, and by September, I was working with Officers of the Engineer Planning School of the RSME on the design.

The site was on the A13 London–Tilbury Road where it is intersected by a minor road at a roundabout which causes traffic jams at the rush hour. The Flyover was to carry one lane of traffic in each direction over the roundabout, giving clear through passage for the major road; among the items of the specification were:—

Minimum lane width 11 ft, minimum clearance 13 ft.

Maximum gradient 1 in 15, minimum vertical curve radius 2,000 ft.

Maximum overall width of structure 34 ft.

Minimum clearance over roundabout 16 ft 6 in.

Modified HA loading, roughly equal to Class 60 (Wheeled).

Provision to be made for lighting, road heating and drainage.

Minimum disturbance to underground services, including a 72 in sewer which ran the length of the centreline.

Among the conditions of entry was a clause which read:—

"In arriving at their decision, matters to which the Judges will give due consideration will include:—

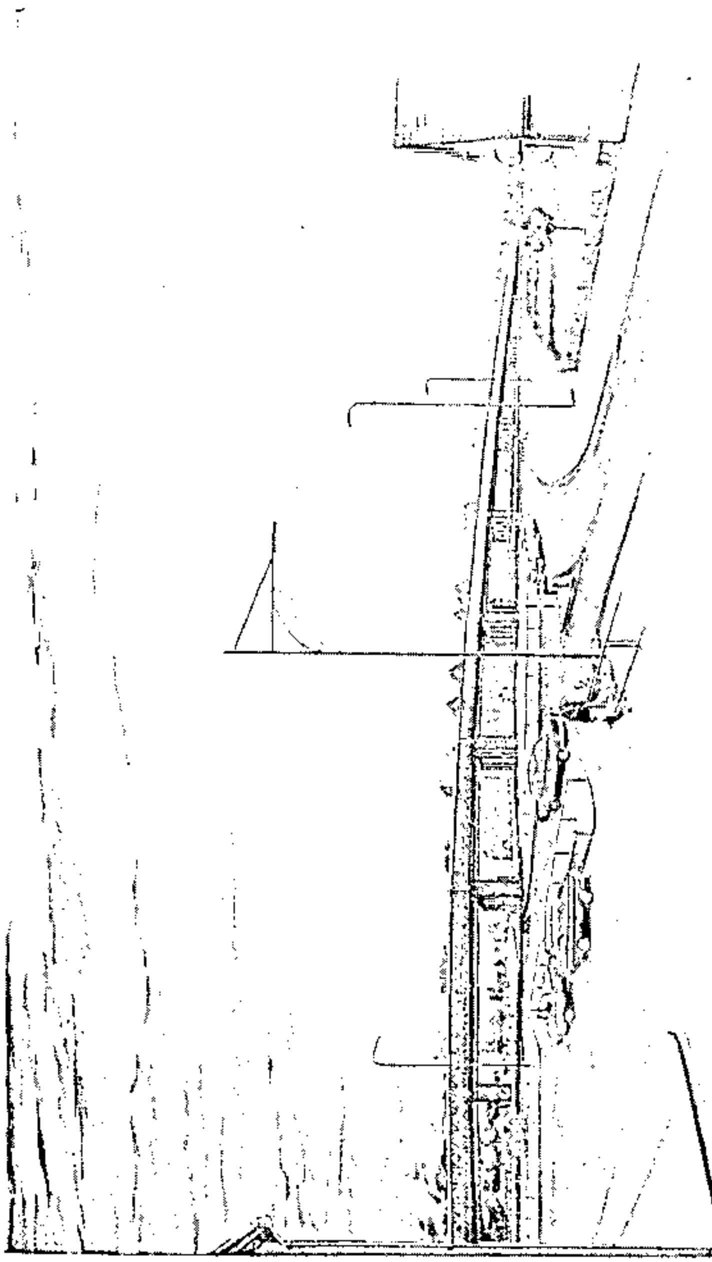
(1) Probable cost; (2) Method and speed of erection; (3) Appearance; (4) Speed of dismantling and removal; (5) Suitability of the component parts for re-erection elsewhere without undue alterations or repairs and replacements; (6) Anticipated cost of maintenance over a period of 5–6 years service; (7) Quietness of operation of deck under traffic."

It was clear that the problem could be solved by a Military treatment, and our design was based on double single Bailey Bridge for the superstructure, with eleven L-trestle piers at 60 ft centres. The ruling dimensions were such that most of the Bailey parts had to be re-designed, including transoms, bracing frames and rakers; steel decking already produced by Messrs Thos Storey was incorporated, topped by a mastic asphalt.

The four approach spans at each end were continuous at a slope of 1 in 16 and the four middle spans across the roundabout, in DSR construction, were simply supported, using span junction posts, so that each end of each span was on the profile line; by using transoms of differing depths, the vertical curve was achieved giving the required sight distance of 250 ft.

Each of the two carriageways was to be constructed working from each end, winching forward as building progressed; this involved winches of 20 ton capacity. The launching noses, of one panel each, with launching links were to be removed as the two structures met, and the two parts pinned at the bottom chord before jacking down—links at the other span junctions being removed during jacking.

The piers were to a standard L-trestle design, founded on the existing road slab and capped with standard section BSBs; to achieve the exact height



PROPOSED TEMPORARY FLYOVER AT ALFREDS WAY, BARKING, ESSEX.

required, and to correct the crossfall at the road slab, each had a concrete raft of thickness up to 1 ft.

The closing date for the competition was 19 March 1965; all entries were anonymous, and ours was the combined work, mostly spare-time, of five officers and two Warrant Officers. Documents submitted to the judges were a 20 page report, which included a priced Bill of Quantities, lists of Bailey and trestle parts, surfacing specification and lighting recommendations; and seven drawings, which included the perspective view reproduced on page 375, and a Critical Path Network analysis of the construction programme, involving over 200 activities.

The results of the competition were announced to competitors on 19 June 1965; there had been fifty entries, including twenty-three by established firms of Consultants and Contractors, and the prizes were awarded as follows:—

First J. G. L. Poulson Associates, Consulting Engineers.

Second Braithwaite and Company, Structural, Ltd.

Third Braithwaite and Company, Structural, Ltd, in association with the British Iron & Steel Research Association.

Bearing in mind the formidable opposition, the failure to achieve either financial benefit or martial glory came as no surprise to us; we had selected a Military equipment and modified it to suit the project, and efficient though the Bailey Bridge may be, it has the look and cachet of the early 'forties; L-trestling, too, although still in use by British Rail, and by a number of contractors (indeed, this fact encouraged its selection) is not as clean of line and economical of steel as the structures of the 'sixties.

However, the degree to which our design met the Judges' criteria mentioned above was obviously inadequate, though the following points may be of interest:—

*Cost.* Our design came out as £113,000; other entries ranged from £45,000 to £203,000, the winning design was estimated at £94,000.

*Speed of Erection.* Including all sitework, our entry allowed an overall time of 7 weeks; the winning design needed only 15 days, but this time excludes foundation work.

*Appearance.* Here we were at a severe disadvantage, as other perspective drawings at the exhibition showed.

*Speed of dismantling.* As with most other designs, this was comparable with speed of erection.

*Suitability for re-erection.* The winning design made provision for a degree of horizontal curvature, a great advantage for many potential sites.

*Cost of maintenance.* If repainting was necessary during the life of the Flyover on one site, our design would have been more expensive than some of the others.

*Quietness of deck.* The Storey steel deck system is rattle-proof.

Had resources been available for an official Corps entry, with time and design staff sufficient to prepare a design from scratch, there would have been more chance of success; but there is no doubt that the Officers and Warrant Officers concerned in the exercise have derived valuable experience, which may one day be put to the test.

# The Special Brigade RE

## 50TH ANNIVERSARY REUNION DINNER

*By* MARTIN S. FOX, BSC

25 SEPTEMBER 1965, was a memorable date in the annals of the Special Brigade RE, as former members assembled to celebrate the 50th Anniversary of its formation, and also to commemorate the Battle of Loos which began on that date exactly fifty years ago when the original companies of the Brigade first went into action in support of British infantry attacks against strongly entrenched German forces. The Brigade's task was to discharge chlorine gas from the Front line trenches, as a retaliatory measure for the employment of poison gas by the enemy earlier in the year.

The anniversary celebrations took the form of a dinner at the Cavendish Hotel, Eastbourne, which was attended by no less than 134 former comrades. They were of all ranks. Major-General C. H. Foulkes, CB, CMG, DSO, who commanded the Brigade throughout the whole of its wartime operations, presided at the assembly, being supported by several distinguished members, including Major-General T. M. Foulkes, CB, OBE, son of the President. The Guest of Honour was Brigadier-General Sir Harold Hartley, GCVO, CBE, MC, FRS. Lieut-Colonel A. E. Kent, DSO, MC, carried out the duties of MC.

The gathering was truly a remarkable and inspiring one. That spirit which had permeated all ranks in the far-off days of wartime stress and strain was in evidence from the first moments of the reunion. It was realized by everyone as they met in great cordiality, rejoicing with each other in a friendly fraternity once more, and sharing a genuine enthusiasm of comradeship which rose above the passing of the years.

A highlight of the evening was the reading of a telegram from the Queen, who thanked the Brigade for its loyal message to her. Messages from the United States Army and from the Mayor of Helfaut in France conveyed their greetings and congratulations. The toast to the Special Brigade was proposed by Lieut-Colonel S. W. Bunker, DSO, MC, in which he referred to the remarkable achievements of the Brigade under the brilliant leadership of its Commander. General Foulkes was given a standing ovation, following which he replied by extending a warm welcome to all members, and expressed his delight at witnesssing such a remarkable rally; it was indeed a memorable occasion. "Most of you", he said, "I cannot have seen for nearly fifty years; few of you can be under seventy, so that, like myself, you are approaching middle age". (The General is remarkably fit at the age of ninety.) He mentioned that three members had flown from overseas for this reunion, one from Canada, another from South Africa, and a third from Australia. Welcoming the Guest of Honour, he reminded them that, although General Hartley was not a member of the Brigade, yet he had been closely connected with its activities in the field of chemical warfare, and was regarded as one of the brotherhood. Since the war he had held with distinction several important Government appointments, had been elected a Fellow of the Royal Society, and awarded the GCVO by the Queen. Thanking the organizers of this reunion, he praised the members of M Company who had done Trojan work for it over a long period, under the direction of the organizing secretary, Mr L. Clements. He was sure that they must be highly gratified that their efforts had resulted in such a fine achievement. In giving a brief summary of the Brigade's history, the President emphasised the great success of its operations, which resulted in the establishing of a fine reputation in the BEF. A few years ago he had been awarded the Gold Medal of the Institution of Royal Engineers, a rare award, since only three are in existence. He claimed it to be a distinction which all present were entitled to share for their services in the Brigade. He was proud to have led them during those eventful years.

After the dinner, slides showing scenes connected with the Brigade's wartime operations were shown. They were a portion of a collection formed by C Company some years ago, and portrayed many Front line scenes, taken at the actual time of gas attacks. Such realistic views certainly stirred many memories of those far-off days.

As the hours of the memorable evening came to an end with the singing of Auld Lang Syne, everyone privileged to be present knew that he would carry its happy and poignant memories in his heart throughout the days to come.

The menu card for the dinner will be prized as a rare souvenir of the occasion. It very appropriately depicted a plan of the Loos Battle, indicating the extent of the advances made by the British Forces in the early stages which were largely due to the success of the Special Brigade's first offensive operation with poison gas.

The history of the Special Brigade RE which began in May 1915, though brief, was unique in the annals of British warfare. During the previous month the second Battle of Ypres had raged, where in furtherance of their desperate efforts to break through the Allied lines, the Germans had resorted to the use of poison gas. It caused heavy casualties among the British and French troops, and for a short period there was a serious shaking of morale. Fortunately for us, the attacks failed, and the lines were held. This deliberate employment of gas was a violation of the existing conventions of war, and there was a public outcry for reprisals. The British authorities, for the sake of the safety and morale of our troops, decided to retaliate in like kind.

The War Office made an urgent appeal for men with a knowledge of chemistry to volunteer for a special duty, and there was an immediate response by students, graduates, and schoolmasters. Many of these held science degrees, some of the highest distinction. The remainder of the personnel assembled consisted of men already serving in the army, most of whom had seen some service in the line. They were included with the idea of help in subsequent training, and for imparting the necessary morale. Because of the secret nature of the new work contemplated, no information could be divulged about it.

Recruits were speedily dispatched to France, often within a few days of enlisting, to swell the ranks of the first three companies which were being rapidly organized; a fourth company was formed later. All were allotted to the Royal Engineers, and placed under the command of Major C. H. Foulkes, a regular RE officer who had been serving in France from the first days of the war. For various reasons, not always understood, all the rank and file were enlisted as full corporals. Their training in preparation for a Front Line operation with chlorine gas was carried out in secrecy, and in far too limited time. At any cost they had to be ready to go into action as soon as other preparations for the forthcoming battle were completed. Thus, on the

*Photograph by kind permission of the Editor, Eastbourne Gazette*

**Photo 1.** *Left to right.* Colonel J. L. Dawson, VC, Lieut-Colonel A. E. Kent, DSO, MC, Major-General T. H. Foulkes, CB, OBE, Brig-General Sir H. Hartley, GCVO, CBE, MC, FRS, Major-General C. H. Foulkes, CB, CMG, DSO, Lieut-Colonel S. W. Bunker, DSO, MC, Lieut-Colonel W. Campbell-Smith, CBE, MC, TD, Lieut-Colonel E. Gold, CB, DSO, OBE. *Standing.* L. Clements, Organizing Secretary.

**The Special Brigade RE  Photo 1**

*Photograph by kind permission of the Editor, Eastbourne Gazette*

**Photo 2.** Veterans of the Battle of Loos, studying a plan of the Battle depicted on the menu card.

**The Special Brigade RE Photo 2**

morning of 25 September, 1915, the new companies went into battle at Loos, and heralded its start by discharging gas from cylinders manipulated in the Front Line trenches. In spite of vagaries of the wind, the direction of which was so vital in gas attacks, this first discharge of cloud gas by a British unit was a pronounced success. The enemy suffered heavy casualties, being caught by surprise, so that our infantry were enabled to make considerable advances through the German trench system at comparatively little loss, though they lost much ground later due to various causes. The RE companies carried out their unaccustomed task with thoroughness and remarkable coolness, under the hazardous conditions prevailing. Their losses were severe.

Further successful gas attacks were operated during the final months of the year, and the future importance of this new weapon was realized. Early in 1916, reorganization took place, by which the four original companies were expanded into a Brigade of about 6,000 officers and men, comprising twenty-one companies. Some companies were to continue with cylinder discharges, while others were to employ Stokes mortars for firing gas bombs. One Special Section devoted its energies to flame-throwers and other frightfulness. When the Battle of the Somme opened on 1 July 1916, every Special Company was ready and eager to play its part in the great offensive. Extended over many miles of the British front, and operating from the Front Line under the heaviest artillery fire, the Special Brigade stuck to its task, and carried on unswervingly throughout the ensuing months of the struggle. At times it suffered grievously, but won through, proving convincingly the great value of its work.

Developments in the use of gas took place. Chlorine was soon superseded by various gaseous mixtures, and phosgene came into prominent use. One of the most deadly weapons of the war was invented by Captain W. H. Livens, DSO, MC, of the Brigade. This was the Livens' projector, an amazingly simple gun device, which could fire a gas bomb up to a range of about a mile with reasonable accuracy. When employed in batteries of several hundred it had a devastating effect upon the enemy positions, and it could be used for delivering smoke, burning oil, high explosive, and thermit. Projector attacks took place without any warning, and the concentration of gas upon any target was so intense that protection was unavailing. The effect of this weapon upon the morale of enemy troops in the line was probably greater than that caused by any other weapon throughout the war.

As the campaign continued, the operations of the Special Brigade were extended to meet the increased demands for its services. Gas attacks of every nature which could be devised became frequent on all sectors of the British front. During the final German onslaughts in the Spring of 1918, several Special Companies acted as infantry and helped to check the enemy's advance. Later in the same year when the Germans were retreating, Brigade units assisted in following-up the enemy, carrying out gas operations whenever possible. At the time of the Armistice, no less than nine companies were already aligned in preparation to assist the 1st United States Army at Verdun and the 2nd facing Metz, in yet another great offensive.

By the end of the war, the Brigade had suffered over 5,000 casualties. In recognition of their services, no fewer than 557 decorations were bestowed, of which 494, including one Victoria Cross, were immediate awards for gallantry in the field. In the war of attrition to which both opponents were committed, the Special Brigade succeeded to a far greater extent than any other branch of the British Army. For whereas the losses of our infantry and artillery were comparable with those of the enemy, man to man, the casualties suffered by the Special Brigade were calculated to have been only about one-fortieth of the number inflicted on the Germans by our gas attacks. The records proved unquestionably that this Brigade played a worthy part in the great struggle, and fully justified its existence.

The Special Brigade was disbanded towards the end of 1919. No account of its wartime accomplishments, however brief, could be allowed to conclude without reference to its brilliant Commander. When the choice for this post fell upon Major C. H. Foulkes, no one could have commenced such a formidable task with more enthusiasm and optimism than he applied. This optimism, often threatened during the early days, was fully justified. He rose to the rank of Major-General, respected by everyone for his unswerving confidence, his unremitting application to his onerous and unprecedented responsibilities, and for his sympathetic consideration for every Sapper under his command. His awards included the CB, CMG, and DSO, while in addition he received many decorations from the Allied Armies for the magnificent services which his Brigade had rendered. He became a Colonel Commandant Royal Engineers and was awarded the Institution of Royal Engineers' Gold Medal in 1964.

# For Valour—A New Zealand Sapper VC

*By* LIEUT-COLONEL K. C. FENTON, BE(CIV), MNZIE
Royal New Zealand Engineers

THE article in the June 1965 *Royal Engineers Journal* entitled "For Valour—Two Sapper VCs" reminded the writer in New Zealand that the deeds of 4/400 Sergeant S. Forsyth, NZE, would also merit an account in the *RE Journal*.

Samuel Forsyth was born at Wellington, New Zealand, on 3 April 1891, and enlisted for overseas service on 13 August 1914. Prior to enlistment, he was employed as an amalgamator with a gold mining company at Thames, New Zealand. He embarked for Egypt with the main body of New Zealand Expeditionary Force in October 1914 and was posted to the Field Troop, New Zealand Engineers in the rank of Sapper.

Under the system for allocating personal numbers to New Zealand Expeditionary Force soldiers at that time, the prefix 4 denoted Engineers while the number after the oblique stroke illustrated the order of the enlistment.

4/400 Sapper Forsyth landed at Gallipoli in May 1915 and was evacuated to Egypt in July through sickness. He returned to Gallipoli and was wounded in action in August, but he remained on duty until November when evacuated sick to Mudros and later to England. He was discharged from hospital in April 1916 and joined 3 Field Company New Zealand Engineers in France. He was promoted Lance-Corporal in December 1916, Corporal in

Sergeant S. Forsyth VC, New Zealand Engineers attached to 2nd Battalion Auckland Infantry Regiment

## Sergeant S Forsyth VC

October 1917 and Sergeant in May 1918. In August 1918 he was attached to 2nd Battalion, Auckland Infantry Regiment of the 1st New Zealand Infantry Brigade, for preliminary infantry experience prior to being recommended for an engineer commission. This was apparently the normal practice at that time.

In August 1918 the 1st New Zealand Infantry Brigade was held in readiness to exploit success on any part of the IV Corps front, being part of the Allied offensive following the costly failure of the Germans in the 2nd Battle of the Marne. On the morning of 24 August at 0130 hrs the 1st Brigade comprising the 1st and 2nd Battalions Wellington Regiment, and the 2nd Battalion Auckland Regiment, with the 1st Battalion Auckland Regiment in reserve, was brought in to exploit the New Zealand Division success in the direction of Bapaume. It was during this day that Forsyth won his VC and was killed.

The troops assembled east of the Albert-Arras Railway. Three hours later, they went into the attack with the Rifle Brigade without artillery support because there was no time to arrange for such support. This gave the attacking infantry the advantage of surprise, but left the many German machine gun nests untouched. It took eight hours of fighting to advance about 2,000 yards and capture Grevillers. Throughout this day long fighting Sergeant Forsyth did conspicuously good work and showed a high degree of leadership.

In the 2,000 yard advance he was instrumental in disposing of three machine guns. To quote from the official citation "On nearing the objective, his company came under heavy machine-gun fire. Through Sergeant Forsyth's dashing leadership and total disregard of danger three machine-gun positions were rushed and the crews taken prisoner before they could inflict many casualties on our troops. . . ."

The advance continued toward the Grevillers sector of the formidable Transloy-Loupart system defending Bapaume. The 1st Brigade met intense fire from advanced posts hidden in pits and sunken roads. Tanks were sent for to help the Aucklanders beat down the Germans. The narrative of the citation continued thus:—

"During the subsequent advance his company came under heavy fire from several machine-guns, two of which he located by a daring reconnaisance. In his endeavour to gain support from a tank he was wounded, but after having the wound bandaged he again got into touch with the tank, which, in the face of very heavy fire from machine-guns and anti-tank guns, he endeavoured to lead, with magnificent coolness, to a favourable position. The tank, however, was put out of action. Sergeant Forsyth then organised the tank crew and several of his men into a section, and led them to a position where the machine-guns could be outflanked. Always under heavy fire, he directed them into positions which brought about the retirement of the enemy and enabled the advance to continue. This gallant NCO was at that moment killed by a sniper. From the moment of the attack to the time of his death, Sergeant Forsyth's courage and coolness, combined with great power of initiative, proved an invaluable incentive to all who were with him, and he undoubtedly saved many casualties among his comrades."

The official history of the Auckland Regiment was written by a soldier, later commissioned, who on the day was scouting near Sergeant Forsyth. The following extract from it gives the unit's view of his award.

"Forsyth . . . moved freely around a bare and exposed slope organising the new run. Enemy snipers not a hundred yards away were very busy and one of them shot Sergeant Forsyth dead. He had been in front from the moment the advance started and had acted throughout with the most cool and desperate daring. It was quite certain that he would be killed. He had as fine a fighting service as any man in the Division. Enlisting with the main body of Engineers he was one of the few who went right through Gallipoli. In France he had been through every engagement in which New Zealand troops had fought in addition to which he had been in two fights with Australian and one with British troops. His was a wonderful record crowned by a day of glorious deeds. . . . All were agreed that he was worthy of it and that there was no one who could be named in any way equal to him."

# The Salvage of HM Submarine Talent

*By* Major P. H. Brazier, RE

In the early 1950s I was serving at the Royal School of Military Engineering at Chatham. One of my responsibilities was the maintenance of the wet bridging "hard" at Upnor which was on the opposite bank of the river Medway to HM Dockyard. In the river we kept a variety of craft which meant maintaining a small permanent staff to keep constant watch over the premises and particularly the boats on moorings in the river.

One evening I had returned to Chatham from London and was dining with friends at Veglios; a restaurant well known to all serving officers who have been stationed at Chatham. We were on the point of leaving for the Theatre Royal when I was called to the telephone. One of the duty watch on the hard told me that there was a submarine sunk off the hard and help was required. I apologized to the party and set off for the hard in my London clothes, complete with bowler hat and rolled umbrella. I had noticed on my return journey from London that fog was increasing and by now it had deteriorated into one of the winter's worst "pea soup" fogs; visibility was nil. It took me some time to make my way to the hard. Once there, I saw the familiar figure of the Assistant Queen's Harbour Master (AQHM) with whom we were on excellent terms. He was responsible for those parts of the river which were under Admiralty control. In addition, there was the Chief of the Kent Fire Brigade and a civilian naval salvage expert who had been hurriedly sent up from Dover. The AQHM took me aside and told me briefly what had happened.

Opposite our hard at Upnor were a number of pens or dry docks which opened directly into the river, unlike most of the others which opened into the main dockyard basins. They were sealed by a caisson which is simply a floating, hollow shutter. When in position they were flooded and sank into place, blocking the entrance. To remove them, they were pumped out and then towed away. In one of these pens lay, high and dry, HM Submarine *Talent* undergoing a major refit. All the hatches on the submarine, or what submariners prefer to call a boat, were open and some tubular scaffolding had been erected along the casing to allow men to work on the sloping sides. On this particular afternoon there had been, as predicted, a high spring tide but this had been increased by easterly gales in the North Sea. Quite suddenly and without a moment's warning, the caisson lifted and river water poured into the dock. A simple phenomenon then took place which I can well remember from childhood days. If you slid rapidly down your bath towards the plug, a wall of water hit the end of the bath and then rebounded back past each side of you with great velocity and probably much of it went on to the floor at the back of the bath. I always found this experiment intriguing but it was unpopular with Nanny who was old fashioned enough to still believe in corporal punishment! This is almost exactly what happened to the ill-fated *Talent*. When the water poured into the dock the boat became buoyant. On her casing were thirty or forty terrified dockyard maties. When the water rebounded *Talent* shot out of the dock like a cork out of a champagne bottle. As the submarine crossed the river she lost momentum, filling up rapidly as she went, and eventually sank just short of the far bank near our hard. When all the dockyard maties who were visible had been picked up, it was found that a number of men, about ten if I remember correctly, were missing from the working party.

Obviously the first task was to recover the missing bodies and the AQHM then asked if we would provide a number of motor boats. These were to ferry our firemen and portable pumps to *Talent* whose conning tower was now presumed to be above the surface but was completely invisible because of the fog. When we set off from the bank we groped our way through unseen buoys and piles in the eerie darkness. I found to my disgust that there was no boat hook aboard. Here my training and initiative as a Sapper came to the rescue as I remembered my umbrella still clutched in my hand. It served as a most useful alternative and I remember musing that it would have had an added advantage if it had started to rain. We eventually identified the conning tower of the submarine and were then able to start ferrying men and equipment out from the shore. Progress went forward rapidly and soon several pumps were hard at work.

It was a macabre scene; thick fog, the noise of the pumps in the dark and the casing slowly uncovering as the tide took off. Others on the submarine, like myself I suspect, were preparing themselves for the unpleasant moment, rapidly approaching, when we would have to go below and remove the poor souls who had been trapped inside. Imagine our consternation and complete bewilderment when not one body was found inside. This caused the dockyard authorities considerable embarrassment for the next twenty-four hours as apparently ten men, dead or alive, had vanished. The next day the terribly crushed remains of two men were unhappily found near the entrance to the dock. The remaining eight had an undeserved escape. Apparently they had been dodging off from work early and getting their friends to punch their time cards. In fact they had not witnessed the tragedy at all but had been safely at home.

It was possible at low water to complete the pumping, close all the hatches and make the boat reasonably tight. A fleet auxiliary, the Boom Defence

Vessel *Swin*, was now standing off in deep water and had floated grass warps down to the stricken boat. As the tide rose the two vessels drew closer together until the submarine was moored alongside. At this stage the two experts, the AQHM and the salvage men transferred themselves aboard the *Swin*. By now I could well have returned home but the thought of missing the final phase of a salvage operation was too much for me and so I boarded the *Swin* as well.

A conference was held on the bridge of the *Swin* between her master, the salvage expert and the AQHM. All agreed that to move the vessels was going to be what might be described in soldiers' language as "pretty dodgy". Visibility was nil, the river narrow and crowded with laid-up warships and the current swift. Eventually it was decided to try radar and the set was switched on. There was so much clutter on the screen, as she lay on a congested river in the middle of a built-up area that even to my untrained eyes it was useless. However it was some time before the experts were prepared to concede this and switch it off. As we lay across the fairway some effort had to be made to move the vessels. I realized this must be a highly complicated manoeuvre requiring the most delicate handling. It appeared simpler to try and beat the flying mile record down Piccadilly in the rush hour than to move from our present position, but after all this was the Senior Service.

I have always had firmly fixed in my mind one of the cardinal principles of control of a ship is that one man and one man only is in charge on the bridge. Little did I realize what was going to happen. Warps were cast off and anchors weighed. I suppose because it was still part of the salvage operation the civilian expert, feeling responsible, went to the engine room telegraph and rang through instructions for each engine. As it was hard to see inside the bridge he ran outside to the port wing of the bridge to watch for any progress. No sooner had he gone than the AQHM informed the remainder on the bridge that from his personal knowledge, the ship was standing into danger and immediately rang through a different order to the engine room. He then dodged outside the bridge on the opposite side to our civilian friend to avoid any embarrassment. Immediately a frantic ships master ran forward gasping "My God, my ship" and stopped all engines. He then retreated into the darkness at the back of the bridge. This extraordinary scene, reminiscent of a Gilbert and Sullivan opera, must have gone on for ten or fifteen minutes with each expert rushing to the telegraph in turn, and ringing through fresh orders to the engine room. Once, as I peered through the glass of the bridge into the opaque gloom, the dockyard wall reared high above us and the lights, diffused by the fog, slid by eeriely and disappeared as we recrossed the river. Then the inevitable happened, we ran hard aground on the opposite bank. The "soviet" on the bridge then unanimously agreed that they had better remain where they were until daylight came and the fog lifted.

This episode considerably increased my morale as a soldier. It was good to realize that such things could happen in any service, even the Royal Navy! The lessons to be noted by all sailors are that umbrellas can be invaluable at sea and that you should always make your ship fast even on dry land.

# Hill 60 and the Mines at Messines

*Brigadier J. A. C. Pennycuick has commented as follows on the article in the September 1965* RE Journal *by Captain E. Mullins of the United States Army, first published in the April 1965 issue of the (United States)* Military Review:—

"THE article reads curiously, the author puts all the First War mines—Hill 60 and Messines together as one operation, and seems somewhat mesmerized by the "blue" clay. The Hill 60 mines were fired in April 1915, the Messines mines were a totally different project fired two years later in 1917, though they may have been inspired by the pioneer Ypres battle.

The secret of the so-called "blue clay" was no longer a secret after Hill 60 although, of course, the necessity to conceal the spoil from any mining operation anywhere remained just as strong from 1915 to the end of the war. At Hill 60, in April 1915, there were mines, each of about one ton of explosive, four of them charged with gunpowder and one, I believe, with gun cotton. They were fired in pairs on the evening of 17 April, the first pair at 7 pm the other pairs after intervals of 10 seconds. Surprise was complete and by the time the last mine was fired the Germans were leaving their trenches well to the flank of Hill 60. The operation to take the high ground was, however, too rigidly planned and no advantage was derived from this.

I was then serving as a subaltern in a field company at Ypres. We were given a night off from our trench work and watched the mines go up from the ramparts of the town. German reaction was violent and fairly prompt, within 24 hours the enemy had a hundred batteries shelling the hill.

Our company was at work on the hill on the night of 18 April. That night I found a German counter mine in a captured trench. It went down, by stages, 30 to 40 ft (not as deep as our mines) and was very wet at the bottom. A gallery about 25 ft down had a charged mine and a German hurricane lamp, still burning, in it. I cut the wires leading to the explosive which was then removed.

The successful Hill 60 mining operation was in charge of Major D. M. Griffith, who commanded 171 Tunnelling Company, RE. There are no doubt still survivors alive from that company. Griffith had to go up to his mine galleries at all hours, though we went only at night to the trenches, so he worked out a route along the railway to the hill for use by day, there were not many communication trenches then.

His mines were kept very secret, but occasionally privileged officers were invited to accompany him personally. On one occasion, Major J. R. White, who commanded my field company, and I went with him; the expedition was something of an ordeal, as Griffith was very deaf. At one point he announced that we must all run for about 80 yds because of German snipers. He then shambled off to lead the way, with White and I following at suitable intervals. At the end of the run Griffith sat down and the conversation went:—

Griffith: "Did you hear many bullets past you?"

White (rather hot, tired and irritated): "No, none."

Griffith: "Not many did you say?"

White (fortissimo): "No Griffith, none."

Griffith: "Ah, not very many today."

We went on to his mine shafts.

171 Tunnelling Company had been specially raised and had recruited "clay kickers"—a new RE trade. The "clay kicker" lay on his back at the head of the mine gallery, with a sandbag behind his shoulders. He worked a spade with a long narrow blade, with his feet and hands, to bring down the spoil from the face of the gallery. Two other miners removed the spoil and a small team brought up and fitted the close timbering. As the galleries were only 5 by 4 ft (sometimes 3 by 2 ft) the work was exacting and skilled.

After the Hill 60 battle died down Griffith, whose health had deteriorated, went home and in June 1915 F. G. Hyland took over command of the Tunnelling Company. He found that he had to cope with great administrative difficulties and asked for a regular RE officer to be attached to his company for a fortnight to run the mines, while he straightened out his command. As a result I was attached to the Tunnellers. The job was not difficult though it involved being on call day and night. I was allotted a Douglas motor bicycle and quickly learnt to ride it, more or less across country, to the vicinity of Hill 60. Daily I crept round the galleries to join in the listening. Our listeners were equipped with apparatus which consisted of an elaboration of the doctor's stethescope. We could hear the Germans working and guess fairly accurately the distance away and direction of the noise. Presumably they heard us although the clay kickers worked silently as well as quickly.

The character of the mining had already changed contrary to what Captain Mullins implied—both sides were down in the clay and each side tried to stop the other with camouflet mines, ie small mines that did not break the surface. During my brief tour of duty my diary shows that we fired three camouflets and the enemy one. The German camouflet killed the miner working on the face of a gallery and buried the team behind him. These latter were, however, very promptly dug out by a gallant rescue party and were, miraculously, found to be alive.

Captain Mullins quotes the sad tale of the unfortunate canary that became the target of a trench mortar bomb. E. M. F. Momber who, like Hyland, was one of the younger RE officers to be given command of a tunnelling company (he was killed in 1917) used to tell how he was summoned urgently to a front line dug-out where the point of a German mining drill had been seen to break through a wall. On arrival he noticed a slight movement at the hole made by the alleged drill, so he borrowed a bayonet from a sentry and crawled into the dug-out to emerge a moment or two later with a large rat transfixed on his bayonet. Its vibrating nose had been taken for the point of an enemy drill!

I had no personal experience of the 1917 Messines mines, a stupendous undertaking, but I have never before heard that mines were left charged for over a year. In 1917 the field company that I was then commanding took its turn on the construction of the new trench system forward of Wytechaete, conditions were very different to those of 1915. Messines might almost have been a different war."

As Brigadier Pennycuick says there was a great difference between the shallow mining operations against Hill 60 in the Ypres Salient in April 1915 and the deep mine galleries at Messines, blown two years later.

### Hill 60, April 1915

In describing this operation *Corps History*, Volume V says that:

"Early in April 1915, an extension of the British front relieved more French troops. The new extension carried the British line round the Ypres salient once more, as far as the Ypres-Poelcapelle road, and from then until the end of the war, the famous 'Salient' was held by British troops.

The trenches taken over were in poor condition, and very insanitary. The French, relying upon their famous artillery to smother any attack, had neglected their earthworks, and even the dead of the first battle of Ypres still lay unburied in the Langemarck area. There was thus much work to be done and, as it so happened, very little time to do it in, for the Germans were about to launch their first gas attack on the north-east shoulder of the salient.

Before this attack, the British II Corps had been making preparations to drive the Germans off Hill 60, an artificial mound adjoining the Ypres-Comines railway, about two and a half miles south of Ypres, giving the enemy a full view over that part of the Salient right up to the ramparts of the town. The 28th Division had begun the preparations by mining towards the hill. A mining section had been formed of Welsh miners from the 1st and 3rd Battalions of the Monmouthshire Regiment (28th Division) and attached to the 1st Northumbrian Field Company. These men worked under the direction of Major D. M. Griffith. When the division was relieved by the 5th Division, the miners were left and were reinforced by the newly-formed 171 Tunnelling Company. The 13th Brigade was ordered to carry out the attack, which came as a complete surprise to the enemy. In the middle of a quiet evening, on 17 April, six mines were exploded, a bombardment by twelve batteries immediately burst out, and the storming party—a company of the 1st Royal West Kent Regiment and a section of the 1st/2nd Home Counties Field Company—dashed out to seize the craters. It was the first example of mining and crater-seizing on our front. The attack was completely successful and consolidation began at once. The inevitable counter-attacks, however, followed early next morning and throughout the period 18 to 21 April the Hill was subjected to terrific bombardments and infantry attacks, and was finally lost on 5 May."

The publication *Work of the RE in the European War 1914–1919—Military Mining* gives considerable detail about this shallow system of mining which was the first of any magnitude used in conjunction with infantry operations on the Western Front, but small of course compared with later mining projects.

Two shafts, M1 and M2, were sunk close behind our front line trenches to a depth of about 12 ft and 4 ft 6 in square in section. An old French shaft, M3, was also used. From these galleries, about 100 yds long, were driven forward and, although the ground was good and hard, they were shored with frames and sheeting for protection against shake from shell fire. Ventilation was difficult and blacksmiths' bellows, fitted with rubber hosepipe, were used. Lighting was by candle. Spoil was removed on specially made silent trolleys running on wooden rails. The earth was filled into sandbags which were later built into breastworks. Two chambers were excavated at the head of each gallery in which the following charges were placed: M1 2,700 lb gunpowder, M2 2,000 lb gunpowder, M3 500 lb gun-cotton. The charges in

M1 and M2 were tamped with three 10 ft thick sandbag walls with a 10 ft air space between each. Both electrical and instantaneous fuze method of firing were duplicated. The enemy was heard working close to M3 on 2 April and it was feared that he might break into our gallery at any time. Work on the gallery was, therefore, suspended and a charge of 250 lb (later increased to 500 lb) of untamped gun-cotton was laid as silently as possible. The mines were fired on 17 April.

Debris flew 300 ft high and up to 300 yds away. It looked as though the inside of the hill was literally torn out. In view of later blows this description may seem exaggerated; it accurately represents, however, the impression formed at the time. The chambers of M1 were about 90 ft apart and when fired they formed an enormous pit about 90 ft wide, 180 ft long and 30 ft deep. The craters formed by the charges in each of the two chambers of M2 and M3 were about 30 ft across. No one was allowed to enter the galleries after the blow until reported free of gas and the infantry were warned not to go down into the craters for at least half-an-hour after capture. Two Sappers who entered M3 shaft without orders 36 hrs after the explosion were killed by gas due to the large amount of gun-cotton used. The success of the mines was unquestionable but, from a tactical point of view, the attack was on too limited a scale and the captured positions were rendered untenable by enemy artillery fire. But this did not end mining operations against Hill 60 which culminated in the deep, low level, mining offensive against the Messines–Wytschaete area when nineteen mines, containing 1 million lb of explosive, were fired on 7 June 1917.

## MESSINES—7 JUNE 1917

The background to this operation is described in Volume V of *Corps History:* "The Battle of Messines formed a stage in the larger operations which Sir Douglas Haig planned with a view to driving the Germans from their dominating position round Ypres and to securing the Belgian coast. The whole plan had been maturing in 1916, but the German offensive at Verdun and Nivelle's plans for 1917 had interfered. When Nivelle's plans had failed and the French army had become perilously involved in large-scale mutinies, it became imperative for the British Commander-in-Chief to relieve the French.

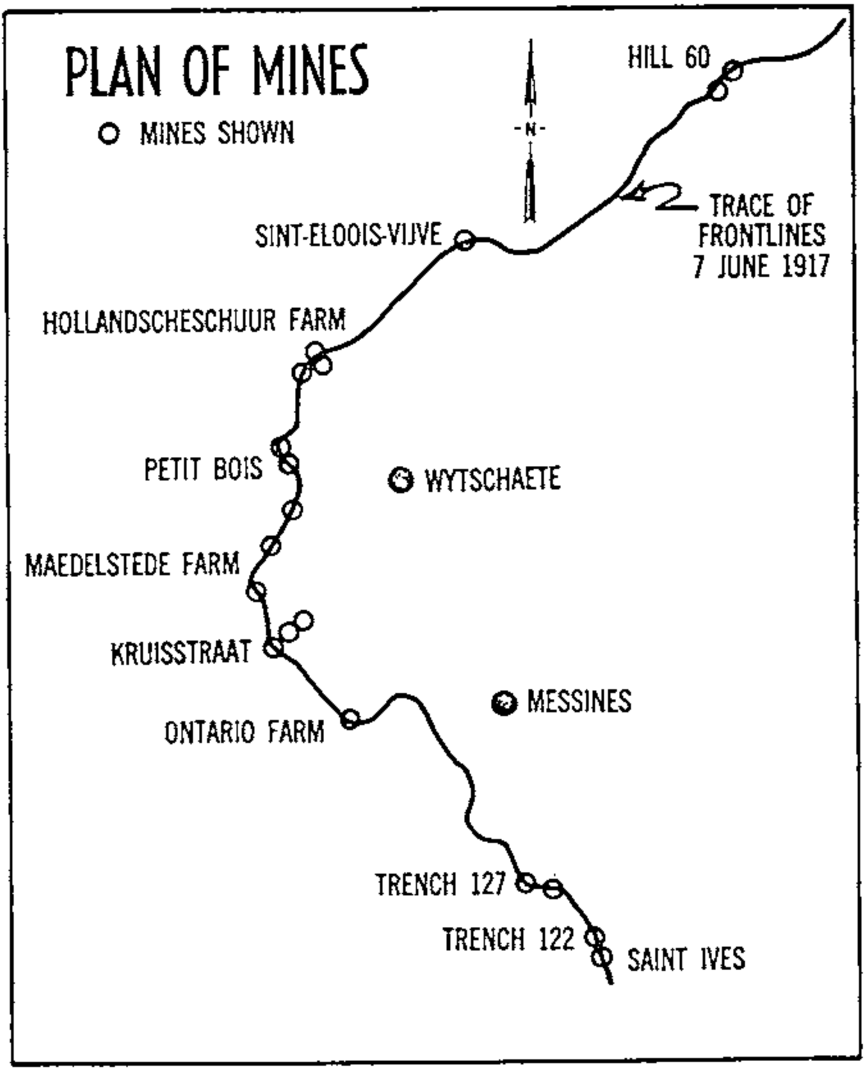
"The Second Army was to assault the Messines-Wytschaete ridge on a frontage of three corps, the II Anzac Corps on the right, the IX Corps in the centre, and the X Corps on the left, with the XIV Corps in GHQ reserve. The preparations for the battle had been begun long before the date fixed for the assault—7 June 1917. The battle was to be opened by the explosion of nineteen gigantic mines which were designed to destroy the enemy's front-line defences on a wide sector, and to demoralize his front-line garrisons. These mines had been systematically prepared, and were carried to completion on a carefully thought-out scheme by the Controller of Mines, Brigadier-General R. N. Harvey. The arduous and gallant work of the tunnelling companies through the whole of 1916 and the first half of 1917 was rewarded by the successful explosion of the largest mines ever used in warfare. So thorough had been the work of these companies that the charges, some of which had been laid and tamped for a year, exploded without a hitch."

The work connected with this operation has been admirably described in

Captain Mullin's article. Preparations were lengthy and accurate survey was essential. In the case of the 1915 Hill 60 blow crude preparatory survey had to be carried out by means of an Abney level, used through a steel loophole plate in the parapet of a front line trench. In the case of the Messines operation, covering a wide front it was of first importance that the mines should destroy the strongpoints on which the enemy's defensive positions were based, and the direction of the mine galleries, some of which were 700 yds long, had to be determined very accurately. This was made possible by using an excellent series of aerial photographs specially taken for the purpose. Thus we see military aviation and photographic reconnaissance, both Sapper developments, assisting the RE Miner in his traditional and historic role.

Considerable previous training and experiment had been carried out in England by the Fortification School of the SME in the Darland area, now forming part of Gordon Barracks. A replica of the Hill 60 trench complex was reconstructed and a deep mined charge of 5,000 lb of ammonal was fired on 15 February 1917 to determine the exactness of the British and French demolition formulae then in use, the size and depth of the crater actually formed and the damage caused to trenches, breastworks and dugouts at specific distances from the charge, the area affected by the gases produced by the firing of such a large charge, how far debris would be thrown and how long to allow for the debris to fall. One of the salient points of the demolition formula was the "soil factor". This factor was, however, rather upset because on the day the charge was fired, due to a sudden, very heavy frost, the top soil had frozen solid to a depth of 15 in. The results, however, far exceeded those which both the British and French formulae would have led one to expect. Darland Banks in 1917, unlike today, was a fairly sparsely populated area. Nevertheless it was essential to warn the surrounding neighbourhood of such a monumental bang. This was done by stationing a large number of RE Bugler Boys in a wide circle around the mine who, at a given zero hour, sounded a G on their bugles to warn the residents of Rainham that the explosion was imminent.

The claustrophobic, uncomfortable and often terrifying task of driving the galleries forward to the Messines Ridge was not accomplished in a day, nor without incident. A camouflet, blown by the Germans immediately above the Petit Bois gallery in the spring of 1916, damaged nearly a hundred yards of its length and entombed twelve tunnellers, only one of whom survived. In August 1915 a mined charge had been placed under La Petite Douve Farm and a branch gallery which was being driven from it broke into a German working. The enemy blew a camouflet which cut the leads to the charge and flooded the gallery which had to be abandoned. We might easily have blown first, but at a great risk of betraying the extent of our deep system. This was the only mine lost during the operation. In September 1916 the Germans were heard working so close to our Hill 60 gallery that it was almost decided to fire this mine in conjunction with a minor infantry operation. The danger was, however, gradually averted by skilful counter-mining and the operation did not become necessary. The Berlin Tunnel, leading to Hill 60, became completely flooded in September and the charges, just placed at the head of the gallery, were temporarily lost and only recovered intact after several weeks of strenuous pumping. In early February 1917 a heavy camouflet was fired in the Hollandscheschuur Farm area. The earth tremors were felt on a 3-mile front and throughout the entire deep mine system and


PLAN OF MINES
MINES SHOWN
N
HILL 60
TRACE OF FRONTLINES 7 JUNE 1917
SINT-ELOOIS-VIJVE
HOLLANDSCHESCHUUR FARM
PETIT BOIS
WYTSCHAETE
MAEDELSTEDE FARM
KRUISSTRAAT
ONTARIO FARM
MESSINES
TRENCH 127
TRENCH 122
SAINT IVES

considerable damage was done, all fortunately repairable. Towards the end of the month there were several severe blows near Kruisstraat. The main gallery at Spanbrockmolen was wrecked, the leads cut and the charge lost. This was an important mine and three month's intensive efforts were needed to by-pass the damaged gallery with another. The chamber containing the charge was only recovered on 3 June. Fortunately the charge was found to be in good order and it was made ready for firing, the work being completed only the day before zero hour. Finally in the middle of May the German tunnellers were heard working close to our Hill 60 mine. By careful calculation it was estimated that their gallery would pass just clear over ours and they were allowed to proceed undisturbed. By zero hour on 7 June 1917 the following mined charges were ready for firing:—

*Hill 60*

Work started in August 1915.

Gallery driven forward 450 yds to two chambers, each about 100 ft below ground surface. A charge of 45,700 lb ammonal plus, 7,800 lb gun-cotton was placed in one chamber and 70,000 lb ammonal in second; charging completed September/October 1916.

*Sint-Eloois-Vijve*

Work started August 1916.

Gallery driven forward 550 yds to one chamber 125 ft below ground surface in which 95,600 lb ammonal was placed; charging completed May 1917.

*Hollandscheschuur Farm*

Work started December 1915.

Gallery driven forward 300 yds to three chambers about 60 ft below ground surface in which charges of 30,000 lb ammonal plus, 4,200 lb blasting gelatine, 12,500 lb ammonal plus 2,400 lb blasting gelatine and 15,000 ammonal plus 2,500 lb blasting gelatine were placed; charging completed June/August 1916.

*Petit Bois*

Work started December 1915.

Gallery driven forward 700 yds to two chambers about 65 ft below ground level in which charges of 21,000 lb ammonal plus 9,000 lb blasting gelatine were placed in each chamber; charging completed August/September 1916.

*Maedelstede Farm*

Work started September 1916.

Gallery driven forward 550 yds to one chamber about 100 ft below ground level in which charge of 90,000 lb ammonal plus 4,000 lb gun-cotton was placed; charging completed 6 June 1917, one day before zero hour.

*Peckham*

Work started December 1916.

Gallery driven forward 400 yds to one chamber 70 ft below ground level in which a charge of 65,000 lb ammonal plus 15,000 lb blasting gelatine, plus 7,000 lb gun cotton was placed; charging completed July 1916.

*Spanbroekmolen*

Work started January 1916.

Gallery driven forward 600 yds to one chamber 90 ft below ground level in which 91,000 lb ammonal was placed. Charging was completed in June

1916 but the gallery was lost due to enemy action. The charge was not recovered and connected up for firing until 6 June 1917, one day before zero hour.

*Kruisstraat*

Work started January 1916.

Gallery driven forward 750 yds to four chambers. Charges of 30,000 lb ammonal were placed in three of them and a charge of 18,500 lb ammonal plus 1,000 lb gun-cotton in the fourth. The chambers were about 60 ft below ground level. The charging of the chambers was completed in August 1916.

*Ontario Farm*

Work started January 1917.

Gallery driven forward 450 yds to one chamber 103 ft below ground level in which 60,000 lb ammonal was placed; charging completed 5 June 1917, two days before zero hour.

*Trench 127*

Work started December 1915.

Gallery driven forward 460 yds to two chambers 75 ft below ground level in which charges of 36,000 lb ammonal and 50,000 lb ammonal were placed; charging completed March 1916.

*Trench 122*

Work started February 1916.

Gallery driven forward 350 yds to two chambers 60 ft and 75 ft below ground level in which charges of 20,000 lb ammonal and 40,000 lb ammonal were placed; charging completed June 1916.

Any mining operation, even a small protective system of galleries, requires most careful planning. The Messines operation on which over 6,000 British, Canadian and Australian tunnellers and attached infantry were employed over a long period called for foresight and direction of the highest order. Mention has already been made of the use of aerial photographs for the accurate siting and direction of the galleries and Captain Mullins in his article described the several methods used to conceal from enemy ground and air observation tell-tale indications of the presence of vast quantities of the excavated blue clay sub-soil through which the galleries were driven.The design and construction of underground chambers to hold up to 100,000 lb of explosive and arrangements to ensure its efficient complete detonation also provided technical problems which were successfully solved.

The major administrative problem was to avoid having at any time large quantities of high explosive exposed to enemy shell fire close behind the front line trenches. Bulk consignments of explosives had to be brought up by lorry from the rear and carried forward from an ammunition point by horse transport or trench tramway. From forward dumps the explosive was lifted by infantry carrying parties to the head of the shafts. From there it was taken by the tunnellers along the galleries, placed in the demolition chambers, connected up for firing and tamped. The insurance of an even flow of supply, thus avoiding an accretion of explosives at any point in the chain, demanded most careful co-ordination and timing. In some instances large mined charges were placed successfully in one night.

The best testimony to the engineering skill of the whole operation was that, when fired, each mine destroyed its planned target.

The explosion of the mines at 0310 hrs on 7 June 1917 was watched by Brigadier-General Harvey, Inspector of Mines, from a dug-out at Kemmel. He described the scene in his diary in the following words: "3.10 am. A violent earth tremor, then a gorgeous sheet of flame from Spanbroekmolen, and at the same moment every gun opened fire. At short intervals of seconds the mines continued to explode; period which elapsed between first and last mine, about 30 seconds. I found it difficult to concentrate on looking for the mines, there was so much going on, and the scene, which baffles description, developed so quickly that my attention was distracted. The majority of the mines showed up well with a fine flame. Others merely showed a red glow; this may have been due to their being blotted out by the smoke of the bombardment. The earth shake was remarkable, and was felt as far as Cassel."

As seen through German eyes, General Ludendorff wrote in his memoirs: "We should have succeeded in retaining the position but for the exceptionally powerful mines used by the British, which paved the way for their attack, consisting, as usual, of fierce artillery fire supporting a closely massed infantry advance. The result of these successful mining operations was that the enemy broke through on 7 June.

"The heights of Wytschaete and Messines had been the site of active mine warfare in the early days of the war. For a long time past, however, both sides had ceased to use such tactics; all had been quiet, and no sound of underground work on the part of the enemy could be heard at our listening posts. The mines must, therefore, have been in position long before. The moral effect of the explosions was simply staggering; at several points our troops fell back before the onslaught of the enemy Infantry. * *"

The Messines operation was tactically a complete success. The stupendous artificial earthquake enabled the assaulting infantry to walk to the top of the ridge in comparative safety. Follow-up divisions advanced as far as the Oosthaverne Line, the furthest objective of the plan. Field companies quickly consolidated ground won and constructed communication trenches, trench tramlines and tracks for the field guns to advance and tracks for pack and wheeled transport. The enemy was so shaken that they were unable to mount any counter attack.

Messines was, however, the last large-scale mining operation of the war on the Western Front. With the continual growth of armaments and the resulting defence in greater depth the main centres of resistance became sited beyond the range of trench mortars and incidentally that of underground attack. 7 June 1917 marked the culmination of the siege warfare art of the Sapper and Miner. Fletcher's sappers of the Peninsular War and Harry Jones' sappers before Sebastopol would have given much to have witnessed the scene that baffled description at 0310 hrs on that day.

Immediately after the battle every tunnelling company made a careful reconnaissance of our own craters and what remained of the enemy mining system. The outstanding features of our offensive were:—

(*a*) The depth of the shafts, although none of them approached the depth credited to us by the enemy, and the great lengths of the individual galleries.

(*b*) The size of the individual charges placed and the enormous aggregate amount used, the highest concentration being almost half a million pounds on the quarter mile front between Hollandscheschuur-Ontario Farm.

(*c*) The length of time that had elapsed between the loading and firing of the majority of the mines.

(*d*) The absence of precedent in military history, or civilian practice, from which the surface and underground effects of earth waves, resulting from simultaneous firing of a number of concentrated mines could be even approximated.

There were many freak results which did not conform to those expected from the formulae then in use. For instance 70,000 lb of ammonal in a 100 ft deep chamber in one of the Hill 60 mines produced a crater 50 ft deep and 260 ft in diameter with a rim 60 ft across and 17 ft high and complete obliteration over an area 380 ft in diameter; yet 60,000 lb of ammonal, buried 103 ft deep in the Ontario Farm mine, caused a practically negligible crater 200 ft in diameter with a rim only 10 ft across and 4 ft high, and an area of complete obliteration 220 ft in diameter. This mine had only been loaded the day before it was fired whereas the Hill 60 mine had laid dormant, although not unexposed to enemy interference, for eight months. The greatest yield was produced by one of the Petit Bois mines where 30,000 lb of ammonal and blasting gelatine, loaded in a chamber 57 ft deep produced a crater 46 ft deep and 217 ft across with a lip 100 ft across and 4 ft high and an area of complete obliteration 420 ft in diameter. This charge had been laid and fuzed ten months before it was fired.

It would be interesting to know whether underground nuclear explosions produce such varied results. In his article "Engineering with Nuclear Explosives", published in the June 1965 issue of the *RE Journal*, Major D. R. Whitaker stated the following rule of thumb "a kiloton device buried 100 ft deep will produce a crater 300 ft in diameter and 80 ft deep. A megaton device 1,000 ft deep will produce a crater 3,000 ft in diameter and 800 ft deep". From this it would appear that the yield of a kiloton device buried 100 ft deep does not greatly differ from that of the Hill 60 mine, quoted above, where a crater 260 ft in diameter and 50 ft deep resulted from the detonation of a charge of only 0.031 kilotons of ammonal buried 100 ft deep. This of course may not be a fair comparison. The simultaneous detonation of mines close by may have affected the yield of the Hill 60 mine, but on the fact of it comparisons seem odious. No doubt the nuclear experts in the Corps may be able to tell us the reason why.

# Correspondence

Headquarters,
Middle East Command,
BFPO 69

The Editor,
*RE Journal*

11 August 1965

Dear Sir,

In the *Journal* of June 1965 you published an article by Major King titled "Eighty minutes to spare". I found it most interesting but there are two points on which I would like to comment.

On the subject of tippers Major King states that the 10 ton Leyland was the only type to really stand up to the task. He goes on to say that ". . . this was principally because the body was of sufficient strength to withstand the effect of being knocked by the arms of Michigans and Gainsboroughs, or being hit by a swinging bucket". Obviously a tipper body must be robust but in my opinion this is dangerous talk and I hope doesn't reflect PRA School teaching. A tipper is not designed to be hit by the loading machine, and if it ever is hit it can only be due to careless or badly trained operators.

In view of Major King's comments on the 10 ton AEC, which turned out to be the weakest of the five types used, it seems unfortunate that this, and not the Leyland, is the Army's 10 ton tipper. I quite agree with Major King that a threeway tip is quite unnecessary. It is of interest that in this Command the 10 ton AEC is having to be modified before issue. The modification consists of strengthening the body and also prevents threeway tipping.

The other point on which I would like to comment is that Major King states on the subject of oil spraying that ". . . it not only controlled the dust, but also added considerably to the strength of the surface". If this is true it seems odd that it was only considered necessary to mark out the centre line with an oil stripe! The first part of the quoted remark is true as oiling is undoubtedly a good method of dust prevention but it does not, I believe, add anything much to the strength of the surface. Oil sprayed on the surface will only penetrate about ½ in thick and the resulting stabilized soil crust has in itself little inherent strength. If the soil does require stabilizing then the bitumen (oil) must be properly mixed with the soil; usually in 4-in layers using a dry or wet soil process. Even this has "little or no inherent strength" (Soil Mechanics for Road Engineers).

As can be imagined there is quite a lot of oil spraying carried out in this Command. For interest the normal rate of spread used is ½ to 1 gallon per square yard of fuel oil: dieso mixture (2 : 1 ratio); the dieso increases penetration. It is a good dust preventative, is reasonably cheap and easy to put down, but suffers the disadvantage of having to be renewed at intervals.

Yours faithfully,

M. G. Hunter, Major, RE

---

Headquarters
The Gurkha Engineers
Johore, Malaysia
14 October 1965

The Editor,
*RE Journal*

## SAPPERS INACCESSIBLE

Dear Sir,

I was interested to read the article by Lieut-Colonel F. W. E. Fursdon in your September edition, as Gurkha Sappers in varying numbers have been "inaccessible" in parts of Borneo for nearly three years. Several airstrips have been built and many other tasks have been carried out by troops maintained entirely by air. However I would like ensure that those who have not yet had any experience of air dropping get the impression that this activity is well provided for and straightforward.

In Borneo a quantity of plant has been supplied to forward troops but never on a Heavy Stressed Platform because none have been available. Even if one were available its use would be strictly limited as it has to be recovered and is too large and heavy for existing helicopters. However, elderly D4s have been put each on two MSPs and successfully dropped several times. Other lighter plant has been carried in under helicopters. Of course because of the lack of MSPs it has not been possible to drop graders or Michigans.

Yours faithfully,

M. J. A. Campbell, Lieut-Colonel, RE
Commandant, The Gurkha Engineers.

# Memoirs

## MAJOR-GENERAL D. McA. HOGG, CBE, MC

DOUGLAS MCARTHUR HOGG, who died on 11 September 1965 after a long illness, was born on 23 September 1888, the youngest son of Major-General George Crawford Hogg, CB. He was educated at Cheltenham College and the Royal Military Academy, Woolwich, and commissioned into the Royal Engineers on 20 December 1906.

After his young officer training at Chatham he spent two years with 7 Field Company, then stationed at Shorncliffe. In 1911 he was posted to India where, after a tour as Garrison Engineer at Rawalpindi, he joined the QVO (Madras) Sappers and Miners, serving consecutively with the 2nd and 14th Field Companies.

On the outbreak of war in 1914 he was sent to Bombay and employed with the Royal Indian Marine in preparing ships as transports for personnel, horses and stores. At the end of the year he went with 10 Field Company, Madras Sappers & Miners to Egypt where the unit was engaged in an active role on the Suez Canal defences. In May 1916 he was sent to Basra where he joined 13 Field Company, Madras Sappers and Miners and took part in the first unsuccessful operation to relieve Kut. In October he was given command of 2 Field Troop Madras Sappers and Miners which had recently arrived in Mesopotamia from France. His troop took part in the Battle of Ramadi, in the cavalry operations during the winter 1916/17 and in the final advance to Kirkut in 1918 when Hogg became the "Squadron Commander" of the 2nd and 7th Field Troops. In a night approach march of 24 miles across the desert in December 1917 Hogg and Squires, commanding 7 Field Troop, successfully navigated a column of cavalry by compass bearing which arrived exactly on the objective by dawn. In December 1918 he was posted to the staff of the Engineer-in-Chief, Mesopotamian Expeditionary Force. For his wartime services he was awarded the Military Cross in 1917 and mentioned in despatches three times.

In 1921, after leave at home, he was posted back to the Madras Sappers and Miners and given command of 3 Field Troop at Sialkot. Two years later he qualified for the Staff College, Quetta and on graduating from there he took up his first staff appointment as DAAG at Army Headquarters. In 1926 he became Brigade Major, 3 Indian Infantry Brigade at Peshawar, which appointment he held until his tour of duty in India expired towards the end of 1927.

On returning home he spent a year as DCRE Woolwich followed by three years as DAA & QMG Headquarters East Anglian Area receiving a brevet lieutenant colonelcy in 1931. He then attended a course at the London School of Economics and in 1933 he was given command of the Depot Battalion RE. In 1935 he was promoted Colonel, with seniority back-dated a year, and attended a Senior Officers War Course at the Royal Naval College, Greenwich. After a tour as AQMG at Headquarters Eastern Command he was promoted Brigadier in September 1938 to become DA & QMG, 1st Anti-Aircraft Corps, at that time being rapidly expanding to meet the need of the air defence of Great Britain.

In April 1940 he was made DA & QMG, V Corps which was sent hurriedly to Norway after the German invasion of that country. He was in charge of the Corps Administrative Headquarters which, after all communications with the rest of the Corps had broken down he was able successfully to evacuate back to England. For his services in Norway he was created CBE and mentioned in despatches. In January 1941 he was made Major-General i/c Administration Northern Command and a Member of the Transport Board. He retired in July 1942.

After retirement he joined John Lewis Partnership Limited and was General Manager of Peter Jones from 1943 to 1945. He was a frequent contributor of articles on military and economic subjects in service and professional journals and he was a member of the Ski Club of Great Britain.

In 1921 he married Eithne Geraldine, daughter of R. W. W. Liddledale Esq, KC of Dublin. They had one daughter. His widow and daughter survive him.

---

## BRIGADIER J. V. DAVIDSON-HOUSTON, MBE, O ST J

JAMES VIVIAN DAVIDSON-HOUSTON was born on 20 November 1901, the son of James Davidson-Houston of Conneywarren House, co Tyrone. He was educated at Lancing and the Royal Military Academy Woolwich, and commissioned into the Royal Engineers on 22 December 1921.

His remarkable flair for languages and his thirst for adventure and the unorthodox, together with his wonderful capacity for making friends and achieving the confidence of people of all classes and nationalities greatly influenced his military career which was almost unique for a Sapper officer of his generation.

After his young officer training at Chatham he was posted to India in 1924 where he spent a short time with the Bombay Sappers & Miners. Returning home he served in the 38 Field Company at Aldershot and then in a Works appointment at Catterick.

In 1927 he sailed with the Shanghai Defence Force, sent to the city during an outbreak of Chinese "anti-foreignism". Whilst there he began his study of the Chinese language and qualified as an interpreter in Russia—a remarkable achievement. When the crisis in Shanghai had passed he spent some leave in Japan before returning in 1928 to his Works appointment at Catterick.

In 1930 he was sent to China on a long language course. He spent two years in Pekin from where he travelled widely through the country and qualified as an interpreter in Chinese. After a short attachment to the Military Intelligence Branch at the War Office in 1933 he returned to Shanghai as a GSO3 in Headquarters China Command. During the Japanese-Chinese hostilities he acted as an unofficial observer, studying in particular the military engineering aspects of the fighting. He was then, in 1938, employed for a short while on barrack construction at Wei-Hai-Wa and later as a GSO2 in Headquarters Shanghai Area. For his services in China he was awarded the MBE.

In February 1939 he was posted to command 55 Field Company at Catterick, a field company of the 55 (West Lancashire) motorized Division. He did not, however, stay long with the company and in July he joined a

British Military Mission in Bucharest, his task being to teach the Rumanian Sappers demolition techniques for use if their country were over-run by German forces. The fall of France in May/June 1940 led to the expulsion of the Mission and Davidson-Houston made his way to Egypt where he was employed on the staff of the Engineer-in-Chief, Middle East in Cairo. From there he went to Khartoum to join the General Staff of Headquarters British Troops Sudan. In July he was recalled to Cairo and sent on a mission to the Iraq/Iran border. Rashid Ali's revolt had been put down, but there was still a risk of a German invasion and the mission's task was to organize clandestine operations in rear of any invading army should one materialize. The requirement for these operations did not arise and Davidson-Houston was put in command of a small British column, sent from Mosul, to keep contact with the Soviet forces in Norther Kurdistan. Later he was sent to Baghdad and to Teheran. The Russian victory at Stalingrad removed the threat of any German invasion of the Iran oilfields, and a sequence of events took Davidson-Houston to GHQ New Delhi in 1942 from where he flew to contact the Military Mission at Chungking. From there he flew to Maymyo where he met the American General Stilwell with whom he established a most cordial relationship. The Japanese successes in April 1943 necessitated his move through the jungle and the Chin Hills to Imphal. From there he returned to report to the War Office. Shortly afterwards he became SO1 RE Operations and Training South Eastern Command. Whilst in that appointment he was asked by Wingate, whom he had known in the Sudan, to join his force of Long Range Penetration Troops organized to operate behind the Japanese forward positions in Burma, and he left with Wingate for India. He was first made Second in Command of 111 Indian Brigade (Chindits) but, due to his knowledge of Chinese and his previous happy acquaintance with General Stilwell, he was made Wingate's special liaison officer in the American-Chinese sector where Brigadier Bernard Fergusson's 16th (Chindit) Brigade was also operating. He accompanied Wingate on his visit to Chungking, and later became Colonel GS at Advanced Headquarters, Special Forces at Imphal.

Returning home in April 1945, he was employed in AR3 Branch of the War Office and completed a Staff College Course. In 1947 he was posted to Egypt as a CRE Works. In 1950 he went to Australia as Area Specialist, Joint Intelligence Bureau and the following year he returned home to become a GSOI in the Military Intelligence Branch of the War Office.

In September 1955 he was appointed Military Attaché Moscow, with the rank of Brigadier. Whilst in Russia he managed, by means which only he could have achieved, to travel literally the length and breadth of the country. He retired in February 1958. In 1962 he took up an appointment with the Ministry of Defence.

Davidson-Houston was a well known writer, *The Japanese Engineer* (1945), *Armed Pilgrimage* (1949), *Armed Diplomacy* (1959) and *Russia and China* (1960) were among his best known books. He contributed frequently to the *RE Journal* and to *Blackwoods.* He was a devoteé of all field sports and many articles by him have appeared in *The Field.* Only recently an article by him on Draghunting was published in *Country Life.* He did great service for the St John's Ambulance Brigade and was their Deputy Commissioner for Kent. He was honoured with the Order of St John of Jerusalem.

In 1930 he married Cecily, Alice, Ayscough, daughter of the Rev E. A. Stockdale of Middleton Tyas, Yorkshire. They had three sons.

He died on 25 October 1965 at Pembury, Kent, aged 63 years. A memorial service was held for him at Speldhurst Parish Church on 30 October. It was conducted by the Rev G. W. Nightingale and the lesson was read by Colonel Mervyn Crawford. Among those present in the large congregation were:—

Mrs Davidson-Houston (widow), Mr and Mrs Geoffrey Davidson-Houston (son and daughter-in law). Mr Ronald Davidson-Houston and Mr Michael Davidson-Houston (sons), Mrs Stephanie Greenwood (sister), Mrs J. H. Davidson-Houston (step-mother), Colonel Sir Thomas Butler and Lady Butler (half sister), Colonel W. C. Davidson-Houston, Mr and Mrs Jeremy Greenwood, Mrs Gay Greenwood, Mrs Basil Seager, Mr and Mrs Hugo Fletury.

Rear-Admiral Royer Dick (Commissioner-in-Chief) with other senior members of St John Ambulance Brigade, including the Countess of Guilford (Kent County president), Lady Denning (County vice-president), Major S. W. Barrow (deputy County Commissioner), Lady Cumberbatch (County Superintendent N), Mrs I. Houchin (County Staff officer), Mr B. T. Beaumont (County secretary), Commander C. R. Burgess (Area Commissioner) and Mrs Burgess, Mr R. H. Percival (County surgeon), Dr J. A. Carman (Deputy County surgeon), Dr J. Piper (Area Surgeon) and Surgeon Commander R. Erskine-Gray (Divisional surgeon).

Lieut-General Sir Reginald Denning, Lady Longmore, Mr T. R. Kennedy (representing Ministry of Defence), Brigadier Charles Turner, Captain Eric Bush, RN, Colonel C. G. Stainer (representing British Red Cross Society), Colonel L. H. F. Sanderson, Lieut-Colonel H. A. W. Allan, Mr C. Hall (representing Eridge Horse Trials Committee), Mr K. M. Payne (representing Speldhurst Conservative branch), Mr and Mrs John R. Gibbs, Mr J. H. Girling, Mrs Lofts-Constable, Mrs A. R. Kelsey, and Captain J. M. Rymer-Jones.

---

## COLONEL R. E. GORDON, MC

Ronald Eagleson Gordon, second son of Dr Robert Gordon, of Stragallan, Northern Ireland, was born at Uniondale, South Africa on 17 January 1889. He was educated at Berkhamsted School and at the RMA Woolwich where he won the King's Medal. On 23 December 1909 he was commissioned in the Royal Engineers and was posted to India in 1912 where he served with the Military Engineer Services in the Rawalpindi-Murree area. Throughout the 1914–18 War he was with Railway Sappers and Miners in East Africa, starting with the attempted landing at Tanga in 1914 and then with 25 Company on the construction of the new Voi-Moshi line connecting the Kenyan and German East African railways. This line traversed the wild bush country of the Tsavo game reserve. Local hazards included continual mining of the line by German raiding parties, and rhinos who charged both the engines and the construction camps. This task was followed by the repair of the Tanga-Moshi line after the German withdrawal. As OC 27 Company he was then employed on the repair of the central railway from Dar-Es-Salaam and the construction of a narrow gauge line near the Mozambique border. He was awarded the Military Cross and was mentioned in dispatches.

On returning to India he served with Sappers and Miners in the Khyber Pass during the Afghan war of 1919–20 and was then seconded to the Indian Railways with whom he remained until 1940. Most of the time was spent as Divisional Engineer with the North Western Railway in Lahore and Karachi. He carried out special studies of grain elevators for Sind and Punjab, the electrification of suburban railways in Bombay and Calcutta and the designing of large modern marshalling yards. From 1937–40 he was Senior Government Inspector of Railways for South India, with headquarters at Bangalore and later at Wellington, Nilgiris.

After a short tour as commander of a railway group at Basra in 1940 he commanded the Transportation Training Centre at Jullundur, where he remained until 1945 and was responsible for the raising and training of railway companies to a total strength of 75,000.

Colonel R. E. Gordon, MC

After serving as Commander of a railway group at Hamburg he retired in 1947 and lived for some years at The Old Vicarage, Bekesbourne, moving later to the Precincts, Canterbury.

On 13 July 1918 at St George's Cathedral, Cape Town, he married Vera Newcomb who survives him, with one son and two daughters. He died peacefully in Canterbury on 4 August 1965.

**Colonel RE Gordon MC.**

# Book Reviews

## MEMOIRS OF LIDDELL HART—VOLUME II

*By* CAPTAIN B. H. LIDDELL HART

(Published by Cassells. Price £2 2*s*)

This second volume of Captain Liddell Hart's Memoirs spans a period of three years, from the appointment by Mr Chamberlain of Mr Hore-Belisha as War Minister in May 1937, to the German offensive through the Low Countries in May 1940. The book's six chapters are headed: Adviser to a Reforming War Minister, The Struggle for Reform, Race against Time, The Slide, The Brink and The Crash.

The early chapters of the Memoir cover the pre-war period when Liddell Hart was an intimate adviser to the War Minister intent on reforming the Army with a ruthlessness of a Lady Macbeth driven on by his coadjutor. The Hore-Belisha/Liddell Hart "partnership" developed to such a pitch that the latter became the "Captain General in the Wings" and practically usurped the duties of the Military Secretary and the Chief of the Imperial General Staff, advising the Minister on every military subject and on promotions and appointments of officers to the highest position in the Army. Normal security conventions were openly flouted and highly classified and confidential papers on political and military matters were sent by the Minister by the most insecure means for comment to the forty years old military correspondent of *The Times*.

The dissolution of the "partnership" was inevitable; and Hore-Belisha's final downfall resulted from his clash with both Generals Ironside and Gort resulting from the infamous "Pill-Box Row" and his criticism of the Sappers' work on the defences in continuation of the Maginot Line in the sector of the French frontier held by the BEF during the Phoney War period 1939/40. A very full account of this unfortunate and often inaccurately reported incident, written by Major-General R. P. Pakenham-Walsh, The Engineer in Chief of the BEF at the time of the "row", was published in the December 1960 issue of the *RE Journal* as a rejoinder to "The Private Papers of Hore-Belisha" published about that time by R. J. Minney.

The Crash carried into oblivion both War Minister and his erstwhile collaborator and Winston Churchill from then on held the stage.

---

## THE ST VALERY STORY

*By* ERNEST REOCH

(Published by Highland Printers Ltd. Price 12*s*)

The author of this splendid story of the last stand of the 51st Highland Division at St Valery-en-Caux in June 1940 served on Major-General Fortune's staff and writes with authority and personal knowledge of the Division that bore the famous HD sign.

The book covers briefly the early history of this illustrious Territorial Division, how it was recruited from the sparsely populated Highlands and Isles and the difficulties that entailed, its achievements in the First World War, when it was colloquially known as "Harpers' Duds" after their GOC Major-General (later Lieut-General Sir George) Harper, KCB, DSO, a distinguished Sapper officer. After its gallantry, dash and success in spite of terrible casualties suffered in the 1916 Battle of the Somme, one Jock was heard to exclaim: "They winna ca' us Hairpers' Duds noo", and nor were they ever again.

No book on the Highland Division would be complete without a reference to the heated and long drawnout controversies about wearing the kilt on active service, and this one is no exception.

The greater part of the book, however, is devoted to the epic story of St Valery, the Division's movement across France from the Maginot Line, the steadfast refusal of the Divisional Commander to make a run for an evacuation port or beach, which could easily have been done, and his staunch support of the French formations still vainly trying to hold the advancing German armour even though the major part of the BEF was being evacuated from France, then the final withdrawal to the coast, the ships to save them, hampered by fog, that never came, the last heroic, agonizing moments at St Valery before the inevitable surrender to Rommel, and not least the fortitude displayed during long years in prison camps by the General Officer Commanding and all ranks.

It is a story all should read.

From the few who did get away, known as Ark Force, another Highland Division was formed which carried on the battle in North Africa, Italy and Normandy. The Division under Major-General T. G. Rennie, who had escaped after capture at St Valery, re-entered the Croix de Guerre town of St Valery on 2 September 1944, whilst Rommel, recovering from wounds and under house arrest, committed suicide rather than face trial on his Fuhrer's orders.

Nemo me impune lacessit!

## THE ART OF VICTORY

*By* Philip Longworth

(Published by Constable. Price 50*s* net.)

This book tells the story of the Russian military hero Generalissimo Alexander Suvorov, born in 1729 the son of a Russian Army officer and after his death in 1800 practically canonized as a warrior-saint in Russian folk-myth. His ghostly image appeared behind the picture of Stalin on war-time posters and Stalin even instituted a new decoration for valour which he named the *Order of Suvorov*. He awarded himself the decoration and adopted the title only one other Russian—Suvorov himself—had ever held before, the supreme rank of "Generalissimo". Anothèr Soviet propaganda poster of 1942 depicted Suvorov, mounted on a white charger, urging Russian tanks, infantrymen and aircraft into battle, like the legendary figure of Saint James of Compostela on his white horse charging at the head of the Spanish knights against the invading infidel many centuries before.

Suvorov fought victorious campaigns against the Poles, the Turks, dissident tribesmen of central and south Russia and the Armies of Revolutionary France. It was never in his day a case of the "Russian Steamroller" overwhelming all opposition by sheer weight of numbers, he generally had to fight when his forces was numerically weaker than those of his adversary. He was never defeated in battle, nor by the most adverse conditions of climate and terrain he encountered.

In the days of Imperial Russia Suvorov surprisingly rose to fame without influence at Court. He suffered from recurring ill-health, his married life was an unhappy one and he was constantly the victim of intrigue on the part of jealous brother officers, politicians and allies and finally his Imperial Master, Tsar Paul.

Like a famous British commander of later years Suvorov was a great believer in physical fitness, the inculcation of initiative into junior commanders, and explaining simply and in no uncertain terms exactly what had to be achieved, the reason for it and how to the last detail the affair was to be carried out. He produced a text book entitled *The Science of Victory*, a large section of which had to be learned by heart by every man under his command. Its staccato sentences reflected the author's brisk and direct personality. He would make sudden, unexpected visitations on formations under his command and woe betide any commander whose unit was found lacking in alertness or any individual officer or man who failed to answer correctly catechismal questions on the *Science of Victory*. He was pragmatic and not doctrinaire. His aim was always the total destruction of the enemy's forces in the field but his methods of achieving this often varied. Like his contemporary Napoleon, whom he never faced in battle, he brought mobility into warfare and imbued into his conscripted peasant serfs an impetuous élan equal to that of the finest of the Little Corporal's soldiers of Revolutionary France.

According to the book Suvorov lacked the personal qualities normally associated with a great leader. He was vain, rude, impatient and not always self-disciplined. He often displayed contempt for his senior officers, a thing he would not have tolerated for a moment from those serving under him; he was moody, temperamental, jealous and resentful. He often dressed like a tramp and seemed on occasions to behave like a madman. He has been accused of many atrocities; a Gillray cartoon of 1795 pictured him presenting basket loads of decapitated Polish women's heads to his Tsarina after the capture of Warsaw and receiving her approbation. Gillray also pictured him as a monstrous Gulliver eating the Lilliputian French soldiers defeated by him in Italy. Yet despite all this Suvorov commanded the absolute devotion of his men.

A form of madness, besides chronic ill-health, affected him during the last days of his life. His new Imperial Sovereign, Tsar Paul, for whom he had won such glory, in a fit of pique expunged his name from public prayers and deprived him of his titles. Nor did he see fit to accord him a state funeral when he died. A friend, however, supplied money for the ceremony. Behind his coffin his orders were carried on velvet cushions in a seemingly endless stream. All the soldiers in the funeral procession appeared grief-stricken and the streets were lined with people of all classes, many of whom sank on their knees as Russia's greatest soldier passed to his grave. Even *The Times* of the day wrote that the world had never lost a great captain.

Later memories of his achievements were dimmed by those of Napoleon's victories. His methods and his *Science of Victory* were almost forgotten by the Staff Colleges of the world, only to be revived during the Second World War. The Suvorovian legend played a large part in maintaining the morale of the Soviet Army in its darkest days and his extortation "Hit, stab, give chase, take prisoners", learned by rote from his famous handbook, spurred the Russian soldier forward to final Victory.

---

## "SURVEYING"

*By* Bouchard and Moffitt

(Published by the International Textbook Company (USA). Price $9.50)

The late H. Bouchard was Professor of Geodesy and Surveying at the University of Michigan. F. H. Moffitt is Professor of Civil Engineering at the University of California.

The edition under review is the fifth edition. The book was originally published in 1935 and the fourth edition was printed in 1959. Among the new features of the fifth edition are a much fuller treatment of least square methods and tacheometry, more astronomy and description of some stereoscopic plotting machines. The measurement of stereoscopic models by automatic devices to obtain earthwork data is discussed.

The book is written primarily for engineers and is consistent in its aim. Brief mention is made, however, of more sophisticated instruments and techniques. It is a large book consisting of over 750 pages. This total includes 480 pages on field survey, 40 pages on air survey, 40 pages on earthworks, a 30 page Appendix on least square adjustments and 100 pages of survey tables. At the end of most chapters there is a selection of numerical problems and where appropriate a Bibliography.

The chapter on measurement of horizontal distances mentions methods varying from pacing to the geodimeter and tellurometer but only fully describes taping methods. Much more should have been included on the tellurometer.

Levelling is dealt with thoroughly and both old and new types of level are described. Brief mention is made of theodolite heighting and altimetry. Altimetry deserves more attention as only the double base heighting method is described and very little is written about types and construction of altimeters.

Astronomy is restricted to an elementary study and is well described. However, the War Office publication *Textbook of Field Astronomy* is better.

Chapters on traversing, horizontal and vertical curves, earthworks, random errors and an Appendix on least square adjustments are all very comprehensive and well explained. Chapters on angular measurements and triangulation are slightly disappointing. Optical theodolites are not fully described nor are the techniques of taking rounds of angles. The orders of triangulation described are applicable only in the United States. The chapters on State plane co-ordinate systems and the United States Public Land Surveys are of little interest outside the United States.

Air survey is dealt with thoroughly as one would expect from an author who has written a separate text book on photogrammetry. Elementary air survey from cameras, mosaics and radial line work to optical projection plotters and one mechanical plotting machine are well described. Surprisingly, however, no mention is made of the cheap approximate restitution plotting machines like the Stereotope.

The book is well produced using a clear bold type on good quality paper. The text is well illustrated with photographs and line diagrams. Generally the book is very good and with the exceptions I have mentioned, up to date and comprehensive. A good buy for a civil engineer. T.A.L.

# Technical Notes

## CIVIL ENGINEERING

Notes from *Civil Engineering and Public Works Review*, August 1965

CONCRETE TECHNOLOGY. The August edition contains three articles of interest to those concerned with the behaviour of concrete. The first is entitled "Tensile Splitting Tests on Concrete Cubes and Beams" and describes a new cube splitting test used to determine the tensile strength of concrete. Applied to a wide range of concretes and mortars the tests gave markedly consistent results, and would appear to provide an improved method of determining the indirect tensile strength of a concrete. Interesting correlations were also found between these tensile strengths and the compressive strength of similar concrete of varying ages. The second article is on the "Early-age cracking of concrete". Much study has been made of the cracking of mature concrete (shrinkage, creep etc) but little is known of the cracking which sometimes accompanies the actual setting process of a concrete. Whilst few conclusions are drawn, the author draws attention to the importance of such cracking in water-retaining structures. The third article is short, and describes the use of Thermistors for temperature measurement in concrete. Thermistors have large negative temperature coefficients of resistance (about ten times that of the platinum resistance thermometers used commonly in this country) and are robust. The article describes how they have been used successfully in Sweden for temperature measurement inside concrete dams and the like.

CANTILEVER RETAINING WALLS. The first part of this article appeared in the July issue and was described in the September *RE Journal*. The present article reproduces design tables which give the most economic toe and heel lengths of cantilever retaining walls for a wide variety of height, soil and stress conditions. Use of the tables is illustrated by two worked examples, which show that the principal dimensions of a retaining wall can be established in a matter of minutes with no calculation. These two articles should provide a most useful short-cut to anyone involved in the design of a reinforced concrete retaining wall.

ROADS AND MOTORWAYS. *Civil Engineering* has in the past featured an excellent series of Data Sheets on a variety of subjects. The most recent have been on Soil Mechanics and Rock Mechanics, and these are followed by a new series starting in this issue on Roads and Motorways. The first sheet deals with reconnaissance and soil investigation and is a useful summary of the factors involved.

EXTENDING THE LIFE OF TIMBER BRIDGES. A short article describes practical measures which can be taken during design and construction to extend the life of timber bridges, piling etc.

C.F.R.

Notes from *Civil Engineering and Public Works Review*, September 1965

FAILURE OF REINFORCED CONCRETE DUE TO THE BRITTLE FRACTURE OF THE REINFORCEMENT. This article at first appears of academic interest only, but has, in fact, a practical point to pass on to the engineer. The failure of a reinforced concrete portal frame with a span of 104 ft in use as part of a farm building is fully investigated. After checking all design stresses and the conditions applying at failure the author was able to rule out any mistake in this direction having been made. The steel recovered from the failed portal was subjected to various mechanical tests to ensure that it was in accordance with the applicable BSS. Square twisted steel was used with an allowable stress of 30,000 lb/sq in. While the steel came within the specification given in the BSS it was found that it had a lower impact value than ordinary mild steel, particularly so at ambient temperatures just below 0°C. The portal frame failed under similar temperature conditions. The conclusion reached was that there was a slight original crack in the concrete at the point of failure. This allowed the square twisted steel to drop to the critical temperature at which a small hairline crack on the surface of the steel, self-arresting in a more ductile steel, spread in the more brittle steel rapidly through the whole section causing failure.

WINTER BUILDING FEATURE. A series of eleven articles covering nearly every possible aspect of civil engineering under winter conditions make up this very interesting feature.

The first two articles set the theme for the remainder. This is that winter working is an attitude of mind and the attitudes of various countries including Sweden and Canada are compared. Many countries, where the climate is colder than in this country, expect and cater for the onset of inclement weather whereas the British are surprised by winter every year. Criticism is not only levelled at the often inadequate and invariably late precautions taken on sites in this country but at specifications of the type "when the temperature drops to 34°F on a falling thermometer concreting will not be started". Surely the specification should read, "As soon as the site temperature drops to 41°F the contractor must be equipped to hold this temperature by heating to allow concreting work to continue".

Comparisons are always odious, but it is obvious that there are many aspects of our present attitude to winter working which when compared with that of certain other countries show where changes must be made.

The Canadian "indoor" method, ie: all construction carried out within a big plastic envelope is discussed and compared with the Swedish System of open sites with individual structural members protected. Both systems try to take account of the human factor, but in different ways.

Following the two introductory articles is a paper on winter concreting which gives a worthwhile guide to the time and type of protection required for concrete placed in cold weather. Taken into account are the initial temperature of the mixed concrete, the strength and water cement ratio of the concrete together with the type of shutters in use. This article together with one describing the use of steam for concrete products and a shorter article covering the winning and storing of concreting aggregates in winter make a very useful reference for anybody engaged in winter concreting.

A further article deals with the problems of the Site Agent in winter conditions, who must weigh the economics of providing for winter conditions against the possibility of these provisions being required. In addition he should consider whether the expensive precautions he takes will allow him to continue working in all conditions or will some factor beyond his control stop the work anyway. For instance it is of little use to arrange for the water required for concreting to be heated, if during freezing conditions the quarry supplying the aggregate will be closed. The maintenance of construction plant in winter is also mentioned in the article, but in addition this subject is fully covered by some notes supplied by the Caterpillar Tractor Co Ltd.

Cold weather is not the only factor which has to be considered when carrying out construction work in winter, the restricted hours of daylight must also be taken into account. Site lighting must be installed if full advantage is to be taken of the working day. A short article giving some useful references on this subject is included in the feature.

Finally this feature is concluded with a paper showing how the consultant can help the solution of the problems to a great extent by considering them fully at the design and planning stage. The avoidance of restrictive specifications, the use of prefabrication, the choice of the date for starting work, and the provision of provisional sums in bills of quantities can all make vital contributions to overcome the problems.

B.O.B.

## THE MILITARY ENGINEER

### July–August 1965

Engineers in Air Assault II by Lieut-Colonel R. J. Malley, Corps of Engineers. Exercise Air Assault II in October and November 1964 was the second major exercise to test the new air mobility concept of the army and was carried out on a divisional scale to test the Air Assault Division and the Air Transport Brigade. This article describes the exercise from the point of view of the Engineer Battalion in the Air Assault Division. A great deal of detail is given, helped by excellent photographs and the article is of the greatest interest to anyone wanting information on the technical problems of engineer air mobility and their solution.

The Mohole Project by Gordon G. Lill. Early in 1961 Project Mohole was initiated to prove that it was possible to drill into the deep sea floor with a view to discovering more about the composition of the centre of the earth. The first core of oceanic basalt was procured by the drilling ship *Cuss-I* and its composition disturbed the current theories of the earth's structure. This article describes the steps that are being taken to extend the investigations by borings at a point North of Hawaii. There is a description and illustration of the floating drilling platform which has been designed for the purpose and the technical difficulties of allowing for movement in rough weather are considered. It has proved to be feasible to hold erect and maintain 12,000 ft of 11 in steel pipe in sea water.

Relocatable Military Housing by Lieut-Colonel Clark H. Gerry, United States Air Force. In a unique military family housing project for the Clark Air Base in the Philippines 270 three-bedroom houses were completely manufactured in the United States, each folded up into a single package and shipped to the site for unfolding and erection. In this article details of the design of the houses and the method of packing and transportation and erection on site are given with illustrations.

Army Nuclear Power Plant Operators by Captain Garrett V. Sidler, Corps of Engineers. This is a description of the organization and work of the United States Army Engineer Reactors Group at Fort Belvoir which is responsible for the selection and training of personnel required for the operation and maintenance of military nuclear plant. The standard demanded is exceedingly high.

Aircraft Hangar at Brienne-le-Chateau by Captain Robert R. Connolly, Captain Homer Johnstone, and Captain Horace Schow, II, Corps of Engineers. An interesting well-illustrated account of the erection of a prefabricated hangar 58 metres long by 60 metres wide with all auxiliary services. There are good illustrations.

HYDROGEN FOR AN ENERGY DEPOT by David D. Reiff. Field army energy requirements are relatively small and too widely dispersed to benefit from a direct application of nuclear power. Hydrogen, however, can be produced from a mobile nuclear reactor and can either be used as such or combined with nitrogen to form ammonia for use in a fuel cell or in an internal combustion engine. This article describes the design and construction of the containers used for the storing and distribution of liquid hydrogen and the safety factors involved. The article is in considerable detail and is well-illustrated.

LIGHT VEHICLE RIVER-CROSSING EXPEDIENT by Lieut-Colonel William G. Stewart. A well-illustrated article describing a method of using the pneumatic rollers, which form part of the M4T6 bridge launching equipment, to make flotation expedients for various vehicles.

HIGH LIFT WATER SUPPLY PROJECT by David B. Benham. A description of the Oklahoma City–Atoka water supply system which is an open system of six pipelines in series with each station pumping from a reservoir at its site into a reservoir at the next station site. The operation of the pumps and maintenance of the proper levels is entirely automatic. There is plenty of detail and there are clear illustrations.

ROCKET FIRING STATION AT CHURCHILL by Captain Thomas P. Nack, Corps of Engineers. Upper atmospheric research has been conducted at Fort Churchill, Manitoba, Canada for the past fifteen years. This article, which is well-illustrated, describes the construction of a permanent rocket firing installation to replace the semi-permanent one which was destroyed by fire. Not many details of design or construction are given but the article is interesting because of the extremes of temperature between summer and winter which occur at the site.

HYDROGRAPHIC SURVEYS WITH ELECTRONICS by Omega H. Shamblin. On the 280 mile reach of the Mississippi River from the mouth of the White River to a short distance above the Louisianna–Mississippi State line the bed is highly unstable and the width varies from ½ to over 2 miles. Re-surveys are necessary at frequent intervals to keep current data available, especially for maintenance and construction planning. In this highly technical article a method of greatly speeding up the work by the use of electronic means for the continuous measurement of distances from a known point on the river bank to the moving sounding boat is described.

### MILITARY ENGINEER FIELD NOTES

STOP BURYING MINES by Captain Henry H. Covington, Corps of Engineers. A short argument in favour of no longer burying anti-tank mines in view of the increased speed of movement expected in future wars and the increased fire power available to cover the mine fields.

SLOPE STABILITY IN KOREA by Lieut-Colonel Thomas T. Jones, Corps of Engineers' A note, with illustrations on the problems met in Korea in connexion with hill-side and mountain top construction when estimating safe slope angles.

ENGINEERS IN THE COLD WAR. A Summary. This brief resumé of what the Army' Navy and Air Force Engineers are doing to help countries which ask for it with all kinds of engineer construction and training is most impressive. For instance since the beginning of the programme Army Engineer training teams have been assigned to civic action missions in eighteen countries while the Air Force has assisted in the development of air transport services in Bolivia, which included the provision of twenty-eight airfields and fifty-two landing strips. The Engineer school undertakes the training of military engineers from many countries. There is no doubt that provision of such assistance has a stabilizing influence and the effort is thoroughly worth while.

J.S.W.S.