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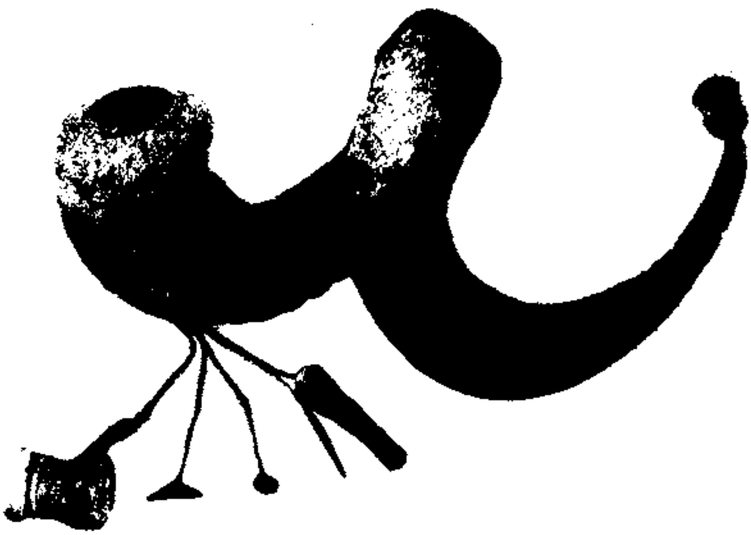

This snuff box was presented to the Mess in 1844 by George Sim, Bengal Engineers. It is one of the many historical pieces of the RE HQ Mess collection. Photographs and descriptive details, written by the Late Colonel J. M. Lambert, of fifteen Mess portraits and forty one pieces of Mess silver are included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

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DECEMBER, 1969

The Panoramic Road Project in Malta GC

MAJOR R. JUKES-HUGHES, RE, CEng, MICE, AMIHE,
and MAJOR D. A. JOHNSON, RE, MA, CEng, MICE

INTRODUCTION

THE Panoramic Road is one of several projects currently being undertaken for the Public Works Department, Malta, by 524 Specialist Team RE[1] The project comprises a fifteen-mile scenic route with car parks and picnic areas along the south-west coast of Malta, and it was conceived by the Department in the early 1960s. A small sum of money was included for it in the 1964–9 Five Year Plan, and the design of the road was put in hand. About three miles of road had been designed when the team arrived in Malta in May 1968, and construction was in progress along about half a mile of road. However, this was mostly concerned with widening existing roads, and it was becoming apparent that future work on the project would impose a severe strain on the technical resources of the PWD. The Director of Public Works therefore asked 524 Specialist Team RE to undertake the design and planning of the remainder of the project on their arrival in Malta. He laid down Zurrieq and Ghain Tuffieha as the start and finishing-points of the road, but otherwise gave the team a free hand to get on with it.

PRELIMINARY RECONNAISSANCE AND PLAN

Aim

The advance party of the team arrived in Malta on 1 May 1968, and began work on the preliminary reconnaissance and plan for the road. The first task was to select an aim for the project, and agree it with the Director. The aim selected was this: "To provide a scenic route along the south-west coast of Malta which will improve access to some of the most beautiful scenery in the island, as well as to sites of historical and archaeological interest." It should perhaps have been qualified by a rider such as "while spoiling the countryside as little as possible", but this has certainly been borne in mind throughout.

Factors

There were, of course, a number of factors which would affect this aim, and which had to be taken into account in making the preliminary plan. The more important of these are listed below:

(*a*) *Panoramic Considerations.* The road clearly had to be aligned so that it would be an attractive road to drive along, and so that it would go through or near the areas from which the best panoramic views could be obtained. These areas were selected in the preliminary reconnaissance, and a note was also made of any unattractive areas, such as quarries and hutted camps, which should be avoided. Two typical views from the alignment are shown in Photos 1 and 2.

(*b*) *Topography.* The terrain inland from the coast lies relatively flat at about 400 ft above sea-level for the first two to three miles west of Zurrieq, although the coastline itself is steep and sharply indented. Thereafter the terrain rises quickly up to the Dingli Plateau above Fawwara, about 800 ft above sea-level, and continues along this plateau for the next eight to nine miles. It then descends sharply below Bingemma to 400 ft above sea-level, and continues descending more slowly towards Ghain Tuffieha. As in all highway projects, the topography of the region has a major bearing on the alignment of the road, and its effect becomes greater the nearer one takes the road to the coast. It is closely tied up with the next three factors of aesthetics, economy and kinematic considerations.

[1] Other projects include contract management of a £2 million industrial estate of forty-two factories, the construction of eight factories and the roads and services on another industrial estate, and the construction by direct labour of a one-mile-long dual-carriageway trunk by-pass which includes a 300-ft-long reinforced concrete flyover.

Photo 1. The Blue Grotto. This photograph was taken from a picnic area constructed just off the road alignment.

(*c*) *Aesthetics.* This should be an important factor in the design of any highway engineering project—although there are plenty of unfortunate examples in Malta, as in the United Kingdom, where it has barely been considered. In this particular project its role was vital, because the road would pass through what is perhaps the last unspoilt region in Malta. The road must be so shaped that it becomes an organic part of the landscape, and does not cut through it merely to satisfy design criteria, or for reasons of economy. There are two main aspects of this factor namely: alignment and unity. The alignment is particularly important, because no amount of landscaping, tree-planting, etc, can ever correct a bad preliminary alignment. There are a number of principles one can follow in selecting the alignment, such as following the contours (especially important where the hillside is terraced), avoiding long straight stretches, avoiding the skyline, and preserving well-established trees and shrubs. Many of these points are well illustrated in a photograph of the forward alignment of the road at Photo 3. The second aspect, unity, means keeping the structure of the road and bridges in harmony with their immediate surroundings. Again there are a number of ways of helping to achieve this. First one must keep the road as narrow as possible commensurate with traffic requirements, so as to keep it in scale with the surroundings. Next the retaining and parapet walls could be faced with random rubble, so as to match the rubble terrace walls and field walls which are such a common feature of Malta's landscape. Similarly the hard shoulders could be paved with stone, and bridges, culverts and road furniture such as benches and litter bins might also be made of stone. Finally the road must be landscaped, trees and shrubs planted, rubbish removed, and soil dumps merged in with the general lie of the land. Some of these points are evident in Photo 4.

Photo 2. Fawwara. A fertile area beneath the cliffs. The road in the centre of the picture was constructed by sappers at about the turn of the century.

Photo 3. The forward alignment prior to laying the sub-base. This alignment is excellent from an aesthetic viewpoint. The stone coping will weather fairly quickly and it should then blend well with the surroundings.

Photo 4. A side view of a completed section of road, showing how architectural unity is achieved between the road structure and its immediate surroundings.

The Panoramic Road Project In Malta 3 & 4 (*d*) *Economy*. This is always a major factor in highway projects, because there is seldom any obvious financial return to be shown for the vast capital expenditure required. Fortunately some considerations coincide with the aesthetic requirements, such as keeping the road narrow and disturbing the ground as little as possible. Economy can also be achieved by following existing roads and tracks where possible.

(*e*) *Kinematic Considerations*. This means designing the road so that it can be negotiated safely and comfortably at a given speed. In this case it was not considered necessary to design the road for any specific speed throughout. It was thought, however, that a maximum gradient should be specified and that, where practicable, the road should be designed for a speed of 40 mph. Where it is impracticable on aesthetic or economic grounds to keep to this speed, the curves are being designed for speeds of 30 or 20 mph. Checks are made to ensure that visibility distances are adequate throughout.

(*f*) *Road Safety*. This is closely tied up with the kinematic factor—particularly in so far as visibility distances on horizontal and vertical curves are concerned. Also important are good junction design, adequate visibility distances at junctions, lay-bys and parking areas, and good road signing.

(*g*) *Land Usage*. Land in Malta is necessarily somewhat limited, and agricultural land must be conserved where possible. Where it is necessary to pass through it, land can be saved by using retaining walls rather than embankments.

(*h*) *Geology*. This factor plays less of a part in Malta than in most countries. There are only two short stretches where the road is not built on rock—above Fawwara where the blue clay outcrops, and again at the other end of the Dingli plateau where there is a major slip plane. Emphasis in these areas must be on following the natural lie of the land as much as possible, so as to reduce the height of retaining walls and cuttings, and providing adequate drainage so that water is not allowed to enter the subgrade.

Alternative Routes

There were obviously a number of areas where there were two or more possible alignments, depending on which of the factors was deemed to be most important. For instance, should the road be taken around by Kuncizzioni, where there are excellent panoramic views to be obtained, or should it be kept inland for aesthetic and economic reasons, allowing the existing road to Kuncizzioni to remain as a spur road? In such cases it was generally thought preferable to keep the road inland and provide spur roads, because in this way the countryside was less likely to be spoilt. Having decided on all these alternative routes, a preliminary plan was made, and this was published in a preliminary report of the project at the end of July 1968.

Preliminary Plan

The preliminary plan was in four parts: The first part dealing with the provisional alignment of the route, the second specifying the geometric design criteria to which the road was to be designed, the third specifying the form of construction, and the final section dealing with estimates of cost and time.

The provisional alignment was shown on a 1:25,000 scale map of Malta, which was overprinted by 42 Survey Engineer Regiment. The map showed the alignment of the proposed main route, spur roads and footpaths, and the location of proposed car parks and picnic areas. Also shown were the location of beauty spots and places of interest, and of points from which good panoramic views could be obtained. The provisional alignment is shown in outline in Annex "A".

The geometric design criteria for the project were based on criteria for similar roads throughout the world, modified to the needs of Malta. For instance, the carriageway widths of all-purpose two lane highways in rural areas are generally specified as 20–24 ft in the UK and USA. The Panoramic Road will not connect any centres of commercial importance, and it runs contrary to the main road system radiating from the Valletta area. It is very unlikely, therefore, that the road will be used to any appreciable extent by commercial traffic. Furthermore there are no enormous pantechnicons and coaches of the type found in larger countries, and there is unlikely to be a requirement for them in the future. A paved carriageway width for the project of 20 ft was, therefore, selected. Other criteria were selected in a similar manner, and they are summarized at Annex "B".

The section dealing with construction covered such matters as the specification for the subgrade, roadbase and surfacing; the form of construction of bridges, culverts, parapet walls and retaining walls; the method of drainage and details of road marking and signing. These will be discussed in more detail later in the paper.

In the final section of the report a preliminary rough estimate of the total cost of project was detailed. This was calculated by measuring up a section of completed road near Dingli, and costing it using data supplied by PWD Malta and the MPBW. The cost arrived at for this section, which could be considered as typical of the terrain over the route as a whole, was £40,000 per mile. The cost of the whole project, allowing a proportionate amount for spur roads and parking areas, came to £1·1 million. The initial section is, in fact, costing about £55,000 per mile, but in sections where existing roads are to be improved the cost will be considerably lower. The report concluded with a recommended programme of construction, leaving those sections where roads already exist until last.

DETAILED DESIGN

To produce the detailed design from the preliminary alignment, the road was divided into seven sections. These were about 10,000 ft long, and were bounded by lateral roads. Each section was designed in turn by a design team of one clerk of works (construction), one surveyor and one assistant surveyor, the latter being a Maltese NCO from Royal Engineers, Malta. When in the field, the team had two PWD chainmen and when in the office, a draughtsman assisted with the drawings.

Field-work

The field-work was a straightforward tachyometric survey along the preliminary alignment. Instrument stations were permanently marked on bedrock or with cartridge cases set in concrete, a 10,000 ft-section having between twenty-five and forty such stations. The tachyometric survey covered a strip at least 150 ft wide. When the final line was not quite certain a much wider strip was taken to ensure that sufficient ground was covered. The boundaries of all fields on either side of the road were accurately recorded, together with all buildings, wells and cisterns. Any water channels that fed cisterns below the road were also noted, as these cisterns had to be provided with an alternative supply when the road was constructed. Another item on the field list was to measure the depth of top-soil. In terraced fields this is most deceptive, and can be anything from a few inches to several feet. It can also change suddenly from one field to the next. The survey and field-work for one 10,000-ft section took about four weeks, or twenty working days.

Horizontal Alignment

The survey results were plotted as the survey progressed. The strip plan was drawn on tracing cloth, and intermediate prints were taken on dyeline tracing paper. The advantage of using these prints to plot the horizontal alignment is that the lines can be drawn and rubbed out, and if a mistake is made another print can be run off. It also preserves the original in good condition. When the alignment is finalized it can be traced on to the original.

The design criteria were decided upon during the preliminary investigation. They were subsequently slightly changed and the final form is shown in Annex "B". A lot of time was spent on the first section deciding upon the most satisfactory design method for the horizontal curves. It was decided that Criswell's method, as given in *ME*, Vol XIII, Pt 1, was the most suitable as the curves are easy to set out. For the 40 mph design speed the curves in *ME*, Vol XIII, gave long transitions, and the minimum radius was too great to suit many of the curves encountered on the Panoramic Road. Criswell's tables for mountainous roads, using a rate of change of centripetal acceleration of 2 ft/sec³ proved ideal, and have been used for all sections. To avoid cuts or embankments, and to fit the road to the contours, it has sometimes been necessary to design the curves for 30 or 20 mph. Transitions have been used up to a radius of 1,432 ft, as above this radius the transition length in Criswell's tables is so short that it does not justify the extra work in calculating and setting them out. All curves were widened along their inner edges, from 1 ft at a radius of 1,400 ft to 3 ft 6 in at a radius of 100 ft. Superelevation has been used on all curves from a minimum value of 1 in 36 to a maximum of 1 in 12. In cuttings and side-hill cuts a crossfall of 1 in 36 was used to assist drainage. In all other cases a camber of 1 in 36 was used.

Vertical Alignment

After the horizontal alignment had been drawn, the longitudinal section was plotted. Vertical curves in the form of a simple parabola have been used. In drawing the vertical section the aim was to keep the road in about 1 ft of fill and minimize the amount of cutting in rock. All vertical curves were checked to ensure that the minimum visibility was 300 ft between two points 3 ft 9 in above road-level. When the vertical section was complete the design team walked the road section in the field. At this stage any alterations could be made quickly before the bulk of the level calculations have been made. After the alignment had been confirmed the road levels were calculated. Levels were given every 100 ft on straight sections and every 50 ft on curves. Formation levels were given on the centre-line and on either edge of the road. Cross-sections were drawn every 100 ft to show the original ground-level and the formation level of the road. Cut and fill quantities were then calculated from the cross-sections.

Drainage

Malta has an annual rainfall of 20 in concentrated into a few winter months, and intensities of 1½ in per hour are not uncommon. Drainage was therefore considered essential and, where possible, grips have been provided to drain water into fields or into the farmers' cisterns. When necessary an open trapezoidal ditch has been provided, with small culverts at appropriate places. Catchment areas above the road are in most places very small, and run-off can be accommodated in the road drainage. For large catchment areas a rainfall intensity of 1·5 in per hr was used. In terraced agricultural land a run-off factor of 0·4 was taken, and in rocky areas 0·8.

Ancillary Features

When designing any road there are many features which border the road and have to be designed in conjunction with it, of which road junctions and access to private properties are the most numerous. Staggered junctions are provided where secondary roads cross the main route. These are surveyed and a separate drawing produced showing all details of the junction. Car parks, spur roads to places of interest, and picnic areas are also important features. Car parks have been sited off the road where this is possible, and where possible have been hidden from it. Lay-bys have been provided in some places where there is a good view, but cars are not expected to stop for long. Places of historical and archaelogical interest have been by-passed by the road and are served by spur roads. These have been designed as single carriageway 12 ft roads with passing places every 200–300 yds.

Landscaping

The landscaping must be carefully thought out in both the design and construction phases of the road. The preservation of existing trees and vegetation has already been mentioned—this being particularly important in a country where trees take a long time to grow. For the same reason construction plant must be restricted to the formation width. In areas of cut where it is necessary to exceed this width, the resulting scars must be hidden either by constructing field walls, or by reshaping the ground with top-soil and sowing. Existing field walls may also have to be realigned so that they flow in with the road. Trees and shrubs are being planted at strategic points along the roadside, and in some cases they are being used to sheild ugly quarries which are close to the road. They are also being sited in picnic areas, where they will provide shade as well as enhancing the area.

Design Report

The design of a section of road took the three-man team about one month in the field and six weeks in the office. At the end of this time a design report, which included a full set of drawings, was produced. The report included all setting-out details for the curves and a detailed estimate for the section. A construction account has been kept on the section under construction, and the estimates were based on rates obtained from it.

CONSTRUCTION

The Maltese Islands have had an unemployment problem for many years, and this is reflected in their methods of road construction. Traditional methods of construction are favoured because they require a high proportion of unskilled labour. These methods have again been employed on the Panoramic Road, but where possible improved upon. It has been possible, with close supervision, to ensure a reasonably high standard of road construction.

Work on this project started shortly before the team arrived in Malta, under PWD engineer Leonard Mahoney. The initial work involved improving an existing road leading south from Zurrieq. The team appointed a clerk of works to take over the site supervision on 1 August 1968. This was initially on a full-time basis, but it is now covered by daily visits. The speed of construction is dictated by the amount of money voted for the project. In the current financial year this is £90,000, which enables about 1¾ miles of road to be constructed. At the time of writing (May 1969), construction is complete up to about 200 yds short of the Hagar Qim junction, and site clearance and earthworks are in progress beyond this junction.

Earthworks

With the exception of two short stretches on blue clay, the road is being constructed entirely on limestone of various degrees of hardness. The first step in the construction process is to remove the top soil, and stockpile it for landscaping later on. Rock excavation is carried out by blasting, and the material excavated is generally suitable for fill. It is also necessary to import fill, and the quality of this has varied considerably. It was often quarry overburden in lumps up to 2 cu yds and seldom well graded. However, the contractors supplying the fill have now learned that any material oversize or poorly graded will be rejected. The fill is placed in 12-in layers by dozer, and well rolled with a 10-ton smooth-wheeled roller. Limestone is a good fill material, and if well compacted produces an excellent subgrade. However, it has proved difficult to trim to the required level, and to overcome this a 4-in sub-base of second-quality stone has been used. This has been laid by a Barber Greene paver and has produced a very good waterbound macadam.

Structures

Retaining walls and parapet walls are the most important aesthetic features of the road. When they are needed in side-hill cut or in agricultural land, they can be seen from a distance and must blend in with the landscape. Many types of wall are used in Malta, but a feature of the landscape is the dry stone rubble wall. This construction has been copied so that the retaining walls blend with the terrace walls of the fields. The outer skin of the retaining wall is of uncoursed rubble, the inner wall is shuttered, and concrete is poured between. The parapet wall is a continuation of the retaining wall with a double skin of uncoursed rubble, 2 ft thick and infilled with concrete. These walls constitute a high percentage of the total cost of the road and are slow to construct. Any other method would not be acceptable aesthetically, and the extra time and money are well worth while. Drainage structures are completed while the fill is being placed. There is only one bridge, at Wied Babu, and this has

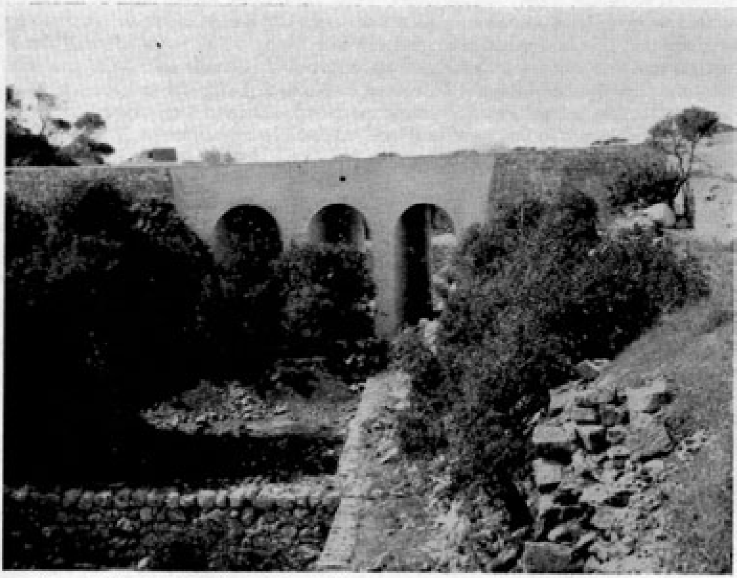


Photo 5. Wied Babu Bridge. This will be the only bridge on the 15½-mile-long road.

Photo 6. The 6-in-deep roadbase being laid by a Barber-Greene Paver. Note the footpath formed in crazy paving in the foreground.

The Panoramic Road Project In Malta 5 & 6

3 × 10 ft RC slabs simply supported on stone piers. False arches have been incorporated to give it the appearance of a masonry arch bridge. As with most stone work in Malta, the bridge has been rendered with "xahx". This is a mixture of stone dust, cement and water which forms a hard skin and prevents erosion of the soft limestone. The finished bridge is illustrated in Photo 5. Large culverts are a simple box construction, using "Franka" limestone block walls and a reinforced-concrete roof. Wing walls are in uncoursed rubble. Asbestos cement pipes of 12 in or 18 in diameter are used for small culverts.

Pavement

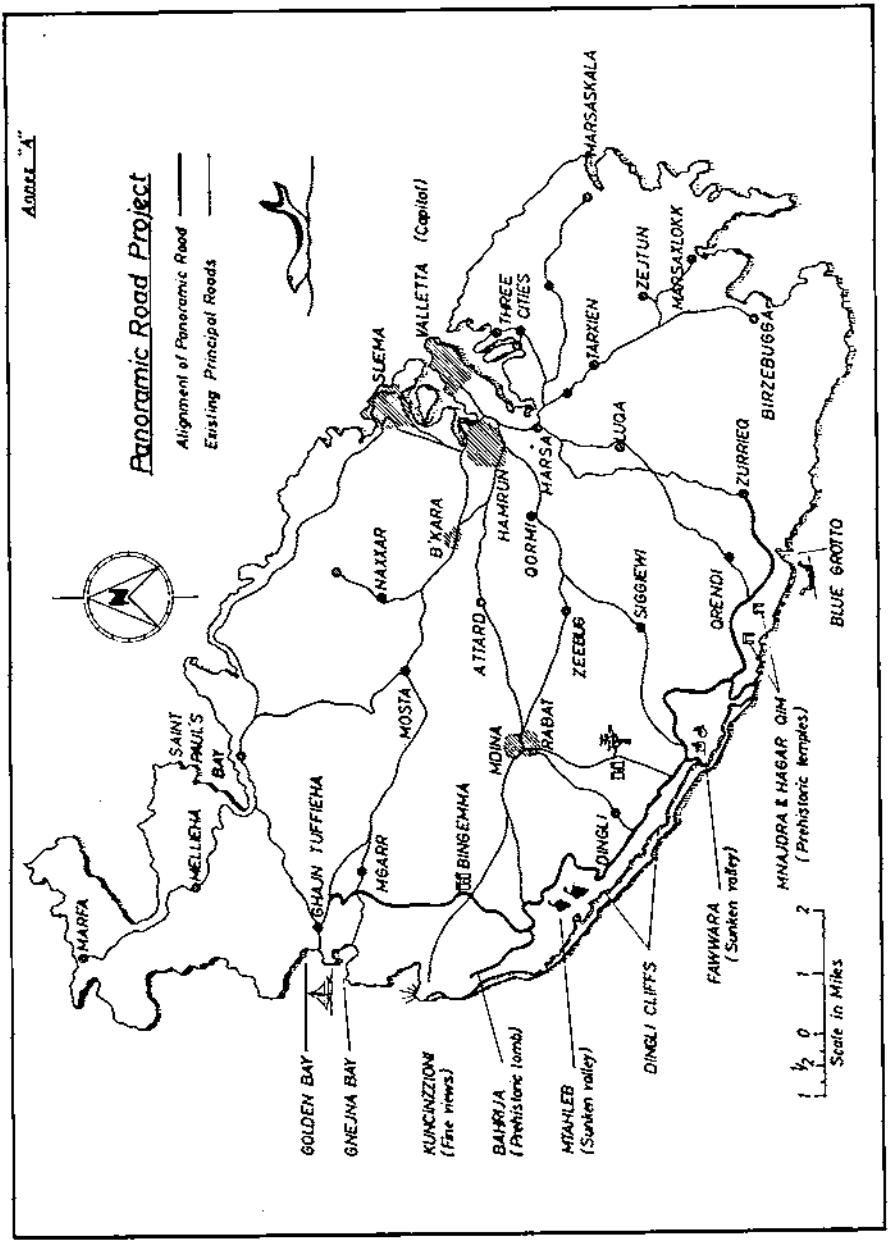
Road surfaces in Malta are not always up to the acceptable standard of many European countries. The main faults are an uneven surface, patchy application of bitumen, and poor camber. A high-quality surface can only be obtained if the subgrade and roadbase are well compacted and even, and care is being taken to achieve this on the Panoramic Road. The roadbase is being laid in two equal layers by a Barber-Greene paver, to give a total compacted thickness of 6 in. The material used is a well-graded first-quality crushed stone of 1½ in in nominal size. This is watered well and compacted with a 10-ton smooth-wheel roller. The procedure is illustrated in Photo 6. The road is being given a temporary surfacing of grouted macadam, so as to allow any settlement to take place under traffic. Class 1A bitumen emulsion is spread at about ½ sq yd per gallon by bucket, after which ⅜ stone chippings are spread at 30–50 sq yds/tons and rolled. Class 1B bitumen emulsion is then spread at about 2 sq yds per gallon, and the surface is blinded with dust and rolled again. The permanent surfacing will be laid two years later, and will consist of a 2½-in-thick single-course bitumen macadam to BS 1621. This will be laid by the Barber-Greene paver, and should produce an excellent and durable finish.

CONCLUSION

The design of the road has provided many problems, some of which are seldom met in military engineering, but have nevertheless been excellent training for the design team. The methods used are simple and produce a good design which is easy to set out. By providing good supervision, and ensuring that materials are of the highest quality, the standard of road construction has been greatly improved.

Acknowledgement

The authors thank the Director of Public Works, Malta, Mr S. J. Mangion, OBE, FICE, BE & A, A & CE, for permission to publish this paper.


Annex "A"
Panoramic Road Project
Alignment of Panoramic Road
Existing Principal Roads
MARSASKALA
ZEJTUN
MARSAXLOKK
VALLETTA (Capital)
THREE CITIES
TARXIEN
SLIEMA
BIRZEBUGGA
LUQA
MARSA
ZURRIEQ
HAMRUN
B'KARA
NAXXAR
QORMI
SIGGIEWI
QRENDI
BLUE GROTTO
ATTARD
ZEEBUG
MOSTA
SAINT PAUL'S BAY
MDINA
RABAT
MNAJDRA & HAGAR QIM (Prehistoric temples)
FAWWARA (Sunken valley)
DINGLI
DINGLI CLIFFS
MGARR
BINGEMMA
GHAJN TUFFIEHA
MELLIEHA
MARFA
GOLDEN BAY
GNEJNA BAY
KUNCINZZIONI (Fine views)
BAHRIJA (Prehistoric tomb)
MTAHLEB (Sunken valley)
1 ½ 0 1 2
Scale in Miles

ANNEX "B"

GEOMETRIC DESIGN STANDARDS

1 PAVED CARRIAGEWAY WIDTH

(*a*) Main roads	20 ft[1]		
(*b*) Spur roads	12 ft		

2 HARD SHOULDERS, minimum — 2 ft 6 in

3 GRADIENT

(*a*) Ruling gradient	1 : 15 (6·7%)		
(*b*) Maximum gradient	1 : 12 (8·3%)		

4 VISIBILITY DISTANCES

(*a*) Design speed	40 mph	30 mph	20 mph
(*b*) Min overtaking distance	950 ft	750 ft	500 ft
(*c*) Min stopping distance	300 ft	250 ft	150 ft

5 HORIZONTAL CURVATURE AND SUPERELEVATION

(*a*) Camber and crossfall	1 : 36		
(*b*) Maximum superelevation	1 : 12		
(*c*) Min radii with full superelevations:			
Design speed	40 mph	30 mph	20 mph
Min radius	430 ft	290 ft	120 ft

(*d*) Transition curves introduced where radius is less than 1,432 ft.

6 VERTICAL CURVATURE

(*a*) To be parabolic	
(*b*) Min visibility over summits	300 ft

[1] Since changed to 25 ft Carriageway without hard shoulders.

Organizing Combat Engineer Tasks

CAPTAIN S. K. KHANNA, RE

INTRODUCTION

ALTHOUGH the Principles of War and various aspects of it are of great importance to officers planning operations, no easy reference is available to the engineer officer for planning and executing a combat engineer operation. Much guidance is contained in *Military Engineering*, Volume I, Part II, *Engineers in Battle 1953*, and various other pamphlets, but a need does exist for a consolidated list of principles to which engineer officers should be able to refer when planning their operations. The technical task is only a small part of the operation, and it should always be preceded by careful planning and good deployment, followed by good reorganization.

Logistic engineering tasks, where time is not always a critical factor, will require a different approach from combat engineering tasks in battle where time is always of utmost importance.

AIM

The aim of this paper is to outline the principles which should be observed when organizing a combat engineering operation. It is mainly designed to assist troop commanders in BAOR.

PRINCIPLES

The following principles should be observed:

(*a*) Selection and maintenance of the aim
(*b*) Early warning
(*c*) Good grouping
(*d*) Concurrent activity
(*e*) Thorough reconnaissance
(*f*) Correct stores
(*g*) Good orders
(*h*) Preparation
(*j*) Good deployment
(*k*) Rapid execution
(*l*) Reorganization

Selection and Maintenance of the Aim The aim of the operation will normally be given to the troop commander by his squadron commander in his orders as the troop task. These orders may be given at a formal orders group, at a briefing on the ground, or by radio. Whatever form the orders may take, it is extremely important to pick out at once what the aim is and then to relate all planning and activity to it. As the correct selection of the aim will hold the key to successful planning, the troop commander must ensure that he gets it right. The aim of a troop, given the task of constructing a heavy ferry and transporting a squadron of tanks across a river by a given time and then to dismantle the ferry, will be to transport the squadron of tanks across the river by the time stipulated, and not just to build and dismantle a heavy ferry. The construction of the ferry is a means of achieving the aim; the dismantling is a part of reorganization.

Early Warning The troop commander must warn his troop by the quickest possible means, usually by radio, immediately after receiving his orders of their next task so that preparation can start forthwith. The basic principle is that the men, the equipment and the materials should be set in motion towards the works as soon as possible. The Warning Order must contain the following:

(*a*) Outline of the future task.
(*b*) Earliest time of move with degree of notice
eg "At one hour's notice to move from 191800 Z",
(*c*) RV and time of "O" Group, and
(*d*) Brief administrative instructions affecting resting, feeding, regrouping, drawing of stores and preliminary move to assembly area if necessary.

It is important that this Warning Order should be brief or else it will defeat its own object. It is not a substitute for good orders later.

Good Grouping In order to achieve concurrent activity, quick reactions and develop efficient drills, it is important to divide the troop permanently into tactical groups as follows:

(*a*) "R" Group	—	Troop Commander, Orderly/Driver Operator and Driver Operator
(*b*) "O" Group	—	Troop Staff sergeant, Section Commanders, MT NCO, G 1098 Storeman, NCO IC attached—eg RCT transport, plant
(*c*) Harbour Party	—	Reconaissance Sergeant, Driver Operator and guides as required
(*d*) Main Body	—	Commanded for movement and initial preparation of equipment by reconnaissance sergeant and section seconds-in-command

It is, of course, necessary to divide the main body into working parties which are listed in training pamphlets and vary from task to task. As far as possible these parties should be based on permanent sections commanded by their usual NCOs.

Concurrent Activity The battle procedure for deployment on any task must aim to achieve concurrent activity, that is everyone doing their own job at the same time rather than only one thing happening at any one time. The table at Annex "A" illustrates how this can be done within the troop. Good battle procedures of this type ensure that the best use is made of the time and men available, adequate preparation is carried out and sufficient time is allowed for rest and administration, both of which are extremely important.

Thorough Reconnaissance The need for a thorough reconnaissance before making an appreciation and ordering the correct quantities of stores is self-evident, but cannot be over-emphasized. This is the first element of the technical aspect of the operation and must be carried out thoroughly, quickly and without taking any short cuts. Good and clear designs should then be produced on the appropriate forms which will later be used by troop NCOs.

Correct Stores The second technical element of the task is the early ordering of the correct stores which may have to be prepared in a busy Support Squadron, with other urgent tasks on hand, and a shortage of transport, not to mention non-availability, enemy activity, accidents and adverse weather conditions. Transportation to the task may take many hours and may be a critical factor. It is essential, therefore, that the correct stores are ordered immediately after the plan has been made. To ensure the success of the operation it is essential also to observe the following points:

(*a*) Stores should be checked and tested immediately on receipt.

(*b*) They should be subdivided and prepared for the task by the parties which are going to use them.

(*c*) They must be stored in a taped stores area on the site and guarded. Stores not in use must always be returned to the stores area or put in the pocket of the user if they are small. Small stores must never be put down on the ground outside the stores area as they are bound to get lost.

(*d*) They must be cleaned and properly accounted for on the completion of the task which may be well before the end of the operation.

Good Orders The best-planned operation is likely to fail if the men are not absolutely clear about what they are doing from the beginning to the end. This can be achieved, initially, by comprehensive and clear orders delivered well and without unnecessary asides, so frequently resorted to by RE officers and senior NCOs. They should:

(*a*) Include a detailed co-ordinating instructions paragraph which must cover, amongst other things, all the timings from the beginning to the end of the operation.

(*b*) Not include technical details and drills which are standard and covered in manuals, since these are unnecessary and make orders groups too long and confuse the NCOs.

(*c*) Always be issued in the format set in Staff Duties in the Field, a suitable example of which is shown at Annex "B". This format must be taught to junior NCOs by troop commanders. It is also the troop commander's responsibility to ensure that section commanders pass orders down, having worked out the details of their section task and the tasks of each individual. Time must be allowed for this.

Preparation A good plan and orders must be supported by adequate preparations in the harbour area. These include the distribution of stores, tactical loading, testing and prefabricating as many items as possible. Preparation should include a detailed rehearsal to ensure that every man will know exactly what to do from the moment his vehicle stops on the work site to the time it finally leaves it. The first few minutes are most important and men should be able to set about their task at once without any further briefing or talking.

Good Deployment The principle of concurrent activity will be achieved through good deployment which is in turn made possible by good grouping. The table at Annex "A" shows how each of the groups deploys on the work site. It should be noted that the move forward is phased to:

(*a*) Make the best use of time,
(*b*) Get maximum rest,
(*c*) Avoid unnecessary concentration and
(*d*) Avoid the troop waiting near the FEBA where infantry and tanks may be fighting.

Rapid Execution Time is always a vital factor in war, and tasks must be organized in a way which will assist their rapid execution. This will assist our own forces to surprise the enemy and win the battle. Slow execution, on the other hand, will give the enemy the opportunity to seize the initiative and may result in heavy casualties to our own forces. All training, preparation and rehearsals must be geared to achieving speed in carrying out the actual task. Another important factor is that the G Staff use planning times listed in pamphlets for particular tasks and the battle is geared to these times. If they are not met, operations are likely to fail.

Reorganization The completion of a task must not be considered as the end of an operation. For instance, the firing of a demolition, or the laying of the last mine, does not mean that the troop has no more work. At this stage the momentum must be maintained and the troop should reorganize and prepare for the next task. This reorganization must include:

(*a*) Reporting task completed and sending in paper work,
(*b*) Tidying work site,
(*c*) Checking, cleaning and repairing stores—this is very important,
(*d*) Reloading all stores,
(*e*) Moving to harbour area,
(*f*) Cleaning, feeding, backloading casualties,
(*g*) Replenishment,
(*h*) Rest for next task.

Reorganization should be carried out rapidly but thoroughly, as at this stage the troop commander will probably be planning the next task. Reorganization should aim to bring the troop to the same level of readiness in stores, supplies and freshness as when they first entered battle. In this way it will be able to operate over a long period without efficiency being impaired. Stores losses and damage can make a troop non-operational as a sapper troop and must always be guarded against.

CONCLUSION

When organizing engineer tasks all aspects of the operation, from the time of the receipt of the initial order to the completion of reorganization, must be considered and planned in detail observing the guiding principles outlined above. It must be remembered that the actual task is only a small part of the whole engineer operation and the technical aspect must be considered in the correct perspective within the context of the whole operation and the battle in general.

ANNEX "A"

TROOP DEPLOYMENT – CONCURRENT ACTIVITY OF GROUPS

STAGE	TP COMD	RECCE SGT and harbour party	TP O GROUP	MAIN BODY (with Ssgt)
1	(*a*) Tp comd receives orders (*b*) Issues warning order (*c*) Recce and prepares plans	(*a*) Assist to comd with recce (*b*) Recce new harbour and collect stores		Check, test and prepare AFG 1098 stores for task
2	(*a*) Prepares orders (*b*) Issues orders	Moves main body to new harbour area	(*a*) Move to RV for O Group (*b*) Attend O Group	(*a*) Moves to new harbour area with Recce Sgt (*b*) Ssgt attends O Group
3	Returns to new assembly area and briefs Recce Sgt	Briefing	(*a*) Tie up technical details and work parties with Ssgt (*b*) Divide men into parties and detailed briefing of troops	(*a*) Checking and tactically loading equipment initially under recce sgt and sect 2ic and then under Ssgt (*b*) Briefing (*c*) Rehearsal
4		Moves forward and sets out tasks site		Prepares to move
5				Moves to task site and starts work

ANNEX "B"

SEQUENCE OF ORDERS

First describe the ground and point out places which feature in your orders on a map or model.

1 *SITUATION*
- (*a*) *Enemy Forces*
- (*b*) *Friendly Forces*
- (*c*) *Atts and Dets*
  - (1) Under Comd
  - (2) In DS
  - (3) In Sp

2 *MISSION*

3 *EXECUTION*
- (*a*) *Gen Outline*
- (*b*) **1** *Sect*
- (*c*) **2** *Sect*
- (*d*) **3** *Sect*
- (*e*) **4** *Sect*
- (*f*) *Recce Sgt*
- (*g*) *Storeman*
- (*h*) *NCO IC RCT tpt*
- (*j*) *Coord instrs*
  - (1) Timings
  - (2) Routes
  - (3) Harbour areas
  - (4) Cushion areas
  - (5) Orders of March
  - (6) Track plan
  - (7) Concealment
  - (8) Sentries
  - (9) Alarms
  - (10) Action on attack
  - (11) Orders for fire control
  - (12) Boundaries
  - (13) Preparation and rehearsals
  - (14) Rest

4 *ADMINISTRATION AND LOGISTICS*
- (*a*) Ammunition
- (*b*) Feeding
- (*c*) Dress
- (*d*) Recovery
- (*e*) Medical
- (*f*) Resupply
- (*g*) Allocation of stores

5 *COMMAND AND SIGNALS*
- (*a*) Own position. SHQ location
- (*b*) Special signals instructions
- (*c*) Password

SYNCHRONIZE WATCHES

QUESTIONS AND QUESTIONS BACK

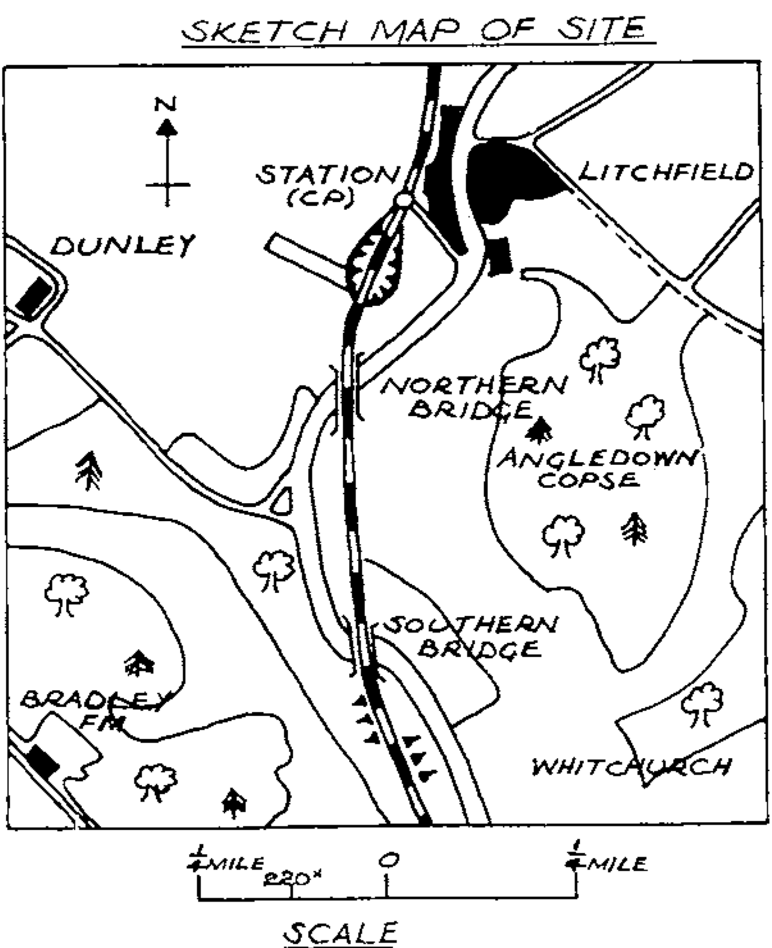
Bridge Demolition at Litchfield

CAPTAIN R. C. OBBARD, RE

THE A34 runs north between Winchester and Newbury. It carries a constant traffic of heavy vehicles, including triple-decker car transporters, all of which have to negotiate the obstacle of three railway bridges and associated S-bends within a mile of the village of Litchfield. Here the road winds about, passing under the disused railway line three times for no apparent reason.

During March 1969 Hampshire County Council were engaged on extensive re-alignment of the A34 in the Litchfield area. This work involved removing considerable portions of the old railway embankment and the two southern bridges in order to replace the old winding road with a road containing smooth transition curves and clear sight lines.

The work was to proceed with minimum interference to traffic and the Council was faced with the problem of removing the two skew masonry arch railway bridges



without any major rerouting of traffic. It was decided that the quickest way to remove the bridges would be to blow them down. This was to be done late on a Saturday night with the aim of clearing the road by the morning, Saturday night being selected because of the low traffic density at that time. The task of demolishing the two railway bridges was given to 37 Engineer Regiment.

This task was recced early in the year by 33 Field Squadron before any earth moving had been done and, on certain assumptions of abutment thickness, a plan for the demolition was drawn up. Work was to start on site on Monday, 24 March 1969, to drill the boreholes in time for the demolition on the following Saturday. Unfortunately 33 Field Squadron flew out to Anguilla on the day work was due to start and a replacement squadron had to be found to perform the task at very short notice. Two Troop of 10 Field Squadron first heard of the job on the afternoon of Friday, 21 March 1969, and by expending a considerable amount of energy on that day was able to start drilling on Monday. At that time the two bridges looked exactly as shown below—two solitary arches with all the embankment removed behind the abutments.

The original plan was to attack each bridge with a line of boreholes just below the springing of the arches and another one near the ground in each abutment. As it was necessary to break the bridges into pieces small enough for plant to clear with ease after the demolition, two lines of boreholes were to be placed in the fill above the quarter points of the arch.

By the end of 24 March 1969 it was obvious that certain parts of the plan would have to be changed. In the first place the fill had been removed from the arch ring so borehole charges could not be placed above the arch, and drilling into the arch ring itself, with traffic passing below, was considered unsafe. Borehole charges were, therefore, replaced by cutting charges laid above the arch ring at the quarter points. Secondly the original recce had assumed the abutments to be 9 ft thick and a 6 ft borehole was therefore specified. Although the abutments were 9 ft thick in parts it was found that only the first 18 in was brickwork and this was backed by placed chalk blocks. The chalk was taken as giving the abutments stability, but not much strength. It was decided therefore to blow the loose chalk off the back of the brickwork and at the same time to shatter the brickwork itself. The borehole length was thus reduced from 6 ft to 2 ft. This produced a considerable saving of explosive, but was also found to be essential for another reason. The rock drills could make good headway in the brickwork, but were completely useless in the wet chalk which was rather like putty in parts. It is extremely doubtful that we could ever have achieved 6 ft boreholes in this material with the equipment available.

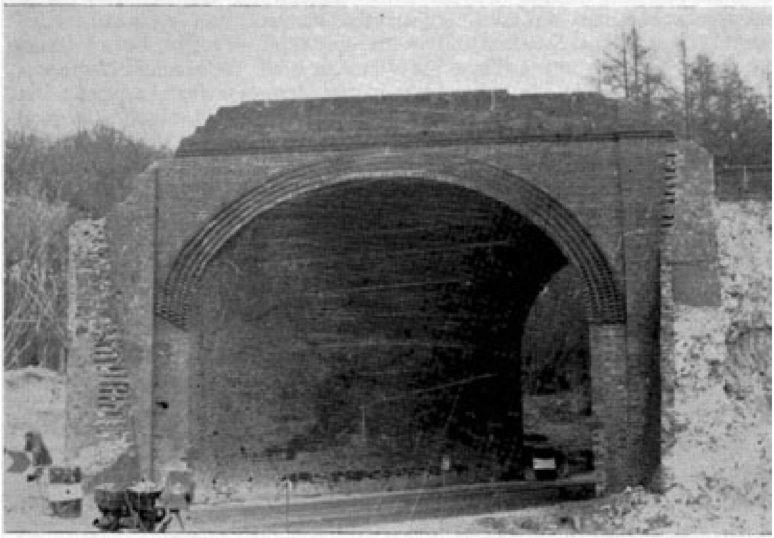
Once we had become familiar with the task and used to operating the rock drills work went ahead rapidly and by Wednesday all the boreholes had been prepared. On Thursday the two firing points were constructed and sand-bags were placed on the arch rings in preparation for tamping the cutting charges. Placing the charges on Saturday was all that remained to be done. This was a slow process and took the whole troop from 0930 hrs until 1730 hrs to complete.

Two and a half pounds of either PE 3A or PE 4 was placed in each borehole and initiated with a loop of det cord and two primers. The charge was placed in position using wooden ramrods and then tamped with wet chalk.

The firing circuit was quite elaborate in order to ensure that all the charges blew. No chances were taken which might have resulted in delay in opening the road again if a charge had failed to fire correctly. Each bridge was detonated both with safety fuze and electrically using five electric and one 27 detonator per bridge. As a point of interest, the det cord ring main was placed over the arch and the electric firing circuit placed around the base of the bridge. The circuit was so designed that all detonators could be placed at ground-level.

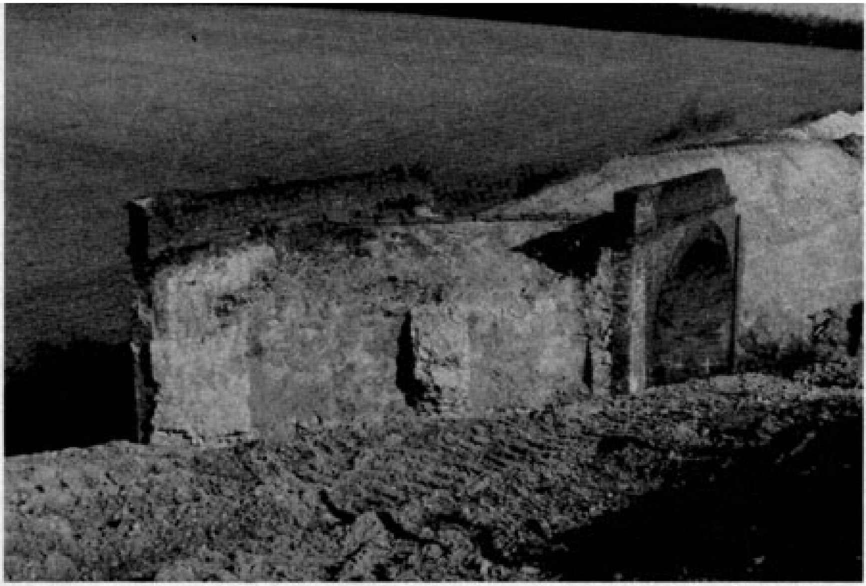
Finally we only had to wait for the correct moment to fire the charges. At this stage traffic was still passing under the bridges oblivious of 261 lb and 265½ lb of explosives in the northern and southern bridges respectively.

Northern Bridge.



Southern Bridge.

Bridge Demolition At Lichfield 1 & 2



View of top of arch showing fill removed from arch and the placed chalk blocks in the abutments. Note sandbags in position.

The area round the bridges consisted entirely of fields and woods, the nearest house being 700 yards away, and there were very few pathways or approaches to the bridges except along the roads. This made it unlikely that anyone would wander into the danger area, but, as a precaution, a safety cordon was placed round the bridges at 400 yards range, with ample radio contact to the firing point, to ensure that no one penetrated the danger area.

The climax of the operation was swift. At 2230 hrs the road was closed to traffic and sand was placed on the road to protect it from falling masonry. The first bridge was blown at 2330 hrs and the second at 0005 hrs. Both bridges were converted largely to brick rubble and, after the remains had been inspected for any unfired charges, the Council's plant got to work. With one D8 dozer the northern bridge was cleared off the road by 0120 hrs and the southern bridge was similarly dealt with by a D9 dozer by 0200 hrs. Both bridges had been neatly cut off at road level and when the sand was removed by a road sweeper the road was completely unmarked under both bridges. At 0210 hrs the road was reopened to traffic. Thus the A34 had been closed for a mere 3 hrs 40 mins. The following morning the only evidence that the bridges had ever existed on the sites were the two severe bends in the road located in an open area for no apparent reason.

Anglers Moved for Bomb

"CAPTAIN SCARLET"
49 Bomb Disposal Squadron, RE

A PARAGRAPH of some thirty words in a local paper dated 10 August 1969 told of the discovery and making safe of a 600-lb bomb; the greater part of the paragraph being concerned with the inconvenience suffered by anglers moved to ensure their safety.

Behind the printed paragraph lay a task that was started with the knowledge that it would involve a wide range of techniques, some of which had not been exercised for some eleven years, but no one could foresee the drama of the ending. Everything has a beginning and that is the place to start.

In the spring of 1941 a stick of bombs fell across the marshy farmland near Petworth in Sussex. Three bombs exploded killing a number of cattle and the fourth left a hole about twenty inches in diameter which ran at an angle into the earth to an unknown depth.

The incident was reported by the police to the Bomb Disposal Unit and some days later a team arrived to recover the bomb. In the early days of bomb disposal specialized equipments were at a premium and reserved for bombs whose removal was essential to the war effort or public safety. The Petworth bomb, due to its geographical position, was unlikely ever to be placed in this category. Therefore, after working for several days and encountering considerable difficulty with water and strata, the team was withdrawn to a more pressing task; the position of the bomb was recorded and it was abandoned. The relevant information was then placed in the records held by the unit headquarters.

In March 1969 a phone call was received by Bomb Disposal Unit, RE, to the effect that a land-reclamation project was to be started in the autumn of 1969 in the Petworth area and the caller was disturbed by a local rumour that an unexploded bomb lay in the area to be excavated.

A reconnaissance based on the 1941 record was carried out by the SSM of 49 Bomb Disposal Squadron, RE, WOII S. D. Hambrook, RE, and it immediately became apparent that the record was neither accurate nor complete. It was useless as an aid to the exact positioning of the bomb which, without doubt, lay somewhere within the area: twenty-eight years of rural growth had removed, or successfully concealed, any surface evidence of the bomb. Two days of patient and diligent detective work followed and, based on a mixture of calculated assumption and experience, a position was decided upon where the UXB might lay, if it existed at all.

Some days later a location team went to the marked area and, using water pressure, drilled holes into the ground to a depth of 25 ft, down which a locator measuring magnetic field strengths was lowered. Positive readings were obtained on the second hole, but the third could not be drilled deeper than 15 ft due to the presence of a large hard object. The bomb had been located at a depth of 16 ft 6 in to its centre. The time spent determining the bomb's position was well spent; it was only 2 ft from the proven position. Clairvoyance? No, a mixture of experience, assumption and a "feeling in the bones" developed over ten years spent clearing unexploded bombs.

Because of the very wet and marshy conditions that prevailed at the site the first step toward recovery of the bomb was to install specialized pumping equipment (de-watering equipment) to pre-drain the area before excavation started. Once installed this equipment, aided by ancillary pumping sets, was to run for 240 hours without stopping and pumped over a half a million gallons from the excavation.

By Monday, 4 August, all preparations had been completed by Sergeant MacAndrew and his section, including the laying of the template to enable digging to proceed and WOII Hambrook to take command of the operation. All excavation was to be by hand as the unstable strata could not be mechanically excavated and revetted simultaneously and thus afford protection of the crew against "cave-ins". It had been planned to work two shifts of seven hours per shift. However, as no accommodation could be found where the landladies would agree to provide meals at a very early or a very late hour it was arranged that the working day would be from 7 am until 6 pm, with shifts through the rest and meal periods. The plant operators and fitters were on site working a twenty-four-hour on and off shift to tend the de-watering and power equipment, under the supervision of Corporal Evans.

Excavations started in earnest on Tuesday, 5 August, and proceeded with little difficulty through clay, gravel and running sand until 11.25 am on Saturday, 9 August. It was at this time that a battered and crumpled tail unit was recovered at a depth of 13 ft 3 in; this was positively identified as a tail unit from a 250-kilogram bomb. This bomb is sometimes fitted with an extremely sensitive and excitable clockwork fuze, prone to restarting if subjected to even a slight degree of vibration. Headquarters BDU were notified of the find and requested to load the immunization equipments for despatch to the site.

The shaft had been excavated to 14 ft through the unstable and changing strata layers into hard blue clay in which the bomb lay. The blue clay lay on running sand through which flowed a multitude of underground streams and these then gushed up into the shaft through breaks in the clay floor bringing with the water considerable quantities of sand which rapidly began to form a rising bottom! The only way to counter this, and to prevent losing the bomb, was to excavate more than flowed into the shaft and to work without stopping until the bomb was uncovered and made safe.

The main mass had been located at a depth of 16 ft 6 in. Following a quick reorganization of labour, a briefing of everyone on site as to the urgency and method of work and a warning that the SSM was about to change from his normal happy self into a rear-kicking, snarling slave-driver until the bomb was uncovered, and, with a cry of: "Let's shift muck", the chase was on. A further 3 ft was excavated, and by 5 pm the bomb lay uncovered; a 250-kg in mint condition so well preserved by the blue clay that paint and stencil markings on the casing were intact and legible. The fuze head was cleaned and immediately identified as a 17 series "much to be respected" clockwork fuze; one which presents a very real threat to bomb disposers even after twenty years buried in the earth.

During the cleaning of the bomb casing around the fuze pocket a slight weepage of a dark oily liquid smelling strongly of ammonia, and recognized as being nitro-glycerine exudation, was noticed coming from the fuze-pocket weld. The rising bottom was kept down by plugging the shaft bottom with a layer of sand-bags and the water removed by yet a further continually running pumping set.

A plan, prearranged with the local police, to clear and seal the area to all but the disposal team was put into operation, and by 6 pm the area was quiet but for the thudding of the pumping sets, a sound so familiar with the disposal team that it was almost unnoticeable.

At 6.30 pm, after having been previously alerted, Captain C. E. Nicholls, RE, the troop commander, arrived at the site, bringing with him the required immunization equipments; he checked that the enforced precautions were adequate and conferred with WOII Hambrook. After a further inspection of the bomb it was decided to enforce evacuation of the site of all persons except the two men until the fuze had been immunized, the source of nitro-glycerine leakage established and the main filling identified.

After preparing the equipment both men redescended into the 17-ft-deep shaft that resounded to the continuous roar and vibration of the pumping equipment, which could not be stopped if immediate flooding, and possible collapse of the shaft, was to be avoided. It was decided that the use of the electronic stethoscope, designed to give warning of a fuze being reactivated, was demoralizing and time-wasting, as it would be impossible to pick out the light ticking of a clock from the bedlam issuing from the headphones. Doing the only thing possible, both ignored the fact that the fuze, in an excellent condition, may have been ticking and could explode the bomb at any moment and continued to ignore this for a further ten hours!

The fuze was then drilled prior to immunization; one man drilling and the other keeping a steady but gentle flow of water around the drill to keep the trickle of nitro-glycerine from being detonated by the drill point. With the hole drilled the equipment was quickly connected into the fuze and some thirty minutes later, with the immunization completed, the two men came up for a smoke and, at a safe distance from the shaft, a briefing of the remainder of the team, all but five of whom were stood down until 9 am the following day.

At 8 pm the work recommenced, Captain Nicholls and Sergeant-Major Hambrook returning to the bomb, this time to gain access to the main filling for identification prior to removal. As the bomb was in excellent condition, it was decided to remove the base plate rather than cut a hole in the bomb casing, and this proved almost as easily done as said, the base plate being only hand tight. As this was unscrewed and removed from the bomb the shaft became quickly filled with extremely strong, bitter acrid fumes, emanating from the bomb's interior, similar to old-fashioned smelling-salts; the effect of which was to cause coughing, retching and nausea in both men until the task was completed some nine hours later. Inspection of the bomb filling showed it to have been powder filled and that the filling had deteriorated to such an extent that some two gallons of nitro-glycerine, this the most concentrated unstable and catastrophic explosive of all, had been formed as a product of deterioration and lay in the bomb with the remaining 200 lb of hardened powder explosive either floating as lumps in the nitro-glycerine or adhering to the bomb casing.

No tools or specialized techniques exist for such a situation and the only solution was removal of the fill by hand. Two wooden spatulas were made and strict instructions given that no one, other than the two men, was to approach within a quarter of a mile of the shaft during the removal of the filling.

To enable them to reach freely into the bomb, without snagging and to minimize the risk of friction causing a detonation, both men removed all clothing above the waist. They took it in turn to reach through the base aperture and gently sieve through the nitro-glycerine for the lumps of powder; these had to be broken between the fingers before being withdrawn from the bomb and placed into water-soaked sand-bags for removal and disposal.

As the effect of the fumes became felt Sergeant MacAndrew was positioned at the top of the shaft to watch for signs of those working below being overcome by this hazard. He remained in this position acting as safety and contact man for some eight hours without rest.

Putting a hand into nitro-glycerine can be likened to putting it into ice-cold slush. In addition an extremely painful burning occurs in any skin break and around the nail quicks, with general stinging on any skin in contact with the liquid; unless one is completely devoid of human responses this requires, at the least, a stiff upper lip! The spotlights attracted myriads of insects, among them large numbers of mosquitoes, that proved vicious and troublesome throughout the task. These took immediate advantage of the rain-soaked semi-naked bodies and had the feed of a lifetime. By this time both men experienced a feeling of utter frustration. The natural reaction to a bite is to slap the insect quick and hard, but with hands and arms encrusted with nitro-glycerine a slap would have developed into a bang, so it became a case of ignoring the bites, though it was to take some two weeks for the resulting "wounds" to heal.

The work of extracting the explosive progressed slowly, lumps and slush being extracted by hand and bagged; small quantities of nitro-glycerine were siphoned off and diluted in a solvent. The two men changed jobs frequently; one reaching into the bomb and the other bagging explosive, diluting nitro-glycerine and trying to minimize the risk of explosion by washing down the bomb case and working area. Finally at 5 am on Sunday the bomb was sufficiently clean of explosive to enable the fuze pocket to be cut out of the bomb for removal from the shaft and it was detonated to remove the danger of the uncertain fuze.

All uncertainty removed, it was now time to relax, and Captain Nicholls and WOII Hambrook settled down to a quiet cup of tea and a cigarette.

WOII Hambrook had worked some twenty-nine hours without warm food or rest, during which time he lost the skin completely from the soles of both feet due to being saturated for most of the time. Both Captain Nicholls and WOII Hambrook had been exposed to extreme danger from the uncertain fuze and very unstable explosive for a period of eleven hours without a break, and both, without hesitation, did what they thought had to be done as a normal bomb-disposal operation.

It may appear that the task revolved around two men, but this is not so, and both, if asked, would say that the successful completion of the task and disposal of the bomb was a result of the careful planning, preparation, support and hard work of the Bomb-Disposal Unit, RE.

Having disposed of the bomb, all that remained to be done was the refilling of the shaft (1,224 cu ft of earth excavated by hand in four days) and the withdrawal of all plant and equipment to the Unit HQ at Chattenden. This took a further four days of hard labour until finally the site was returned to the owners with little to show that a bomb had ever been there other than a small paragraph in the local newspaper.

Disaster Aid in the United Kingdom

LIEUT-COLONEL J. H. JOINER, RE, BSC (ENG), MICE, MIStructE

INTRODUCTION

In recent years there have been several disasters in the United Kingdom in which, at one stage or another, assistance by the Armed Forces has been requested. Typical examples of such disasters are the Torrey Canyon oil pollution of the south-west coast, the Aberfan tip disaster, the July 1968 West Country floods, and the September 1968 Home County floods, but the list is by no means exhaustive. Many articles have already appeared on the welcome and worthwhile assistance given to local authorities by the Armed Forces in these and other disasters, and details of some of these articles are given in Annex A for those who may be interested, details are also listed of three articles dealing with Royal Engineer disaster aid overseas.

In the main, however, assistance has been given on an *ad-hoc* basis, without pre-planned organization; the purpose of this article, therefore, is to consider various aspects of military aid to the UK civil community in times of disaster and thus to highlight some of the problems involved in pre-planning. It will also consider the use of the Royal Engineers in the disaster role, with particular reference to command and control.

It is hoped that this article, based upon a more detailed paper on the same subject, may give rise to correspondence in the *Journal*, as the expression of views by officers who have taken part in disaster relief operations could considerably help the pre-planning of future assistance.

THE CALL FOR ASSISTANCE

"*Military Aid to the Civil Community*," A pamphlet by this title has recently been widely issued by the Ministry of Defence to all local authorities and other civil organizations within the United Kingdom. It clearly lays down the procedures to be followed by local authorities in requesting aid, not only in times of emergency and disaster, but also in cases of requests for routine assistance. There is nothing new in the idea of military aid to the civil community, but the pamphlet sets out to detail all the various aspects of Service assistance, to show what the Services may be able to do, and to indicate how aid may be sought.

This last point is important. The onus is normally on the local authority to request Service assistance should an emergency arise, and this it would do to the nearest Service unit or civilian police station. There could be circumstances, of course, in which the Services may volunteer assistance, for example: in the Glasgow hurricane disaster of January 1968 the GOC and the Chief Engineer offered direct military assistance from the start, assistance that was gratefully accepted.

An instruction equivalent to the pamphlet mentioned above has been issued to the Services. This sets out to co-ordinate existing Service instructions and bring them into line with the civilian pamphlet.

FACTORS AFFECTING MILITARY ASSISTANCE

A number of factors concerning a disaster considerably influence the degree of military assistance requested and indeed desirable, and also the nature of this assistance.

The Nature of the Emergency

Assistance given as a result of an emergency will normally follow as a result of either a natural disaster or a sudden catastrophic event or accident.

Natural Disasters in the UK are most likely to take the form of serious flooding resulting from excessive rain, hurricane or storm damage, or possibly a landslide;

such disasters will normally result in a request for military assistance, dependent, of course, upon other factors dealt with below. Luckily this country is spared the devastating damage caused in some parts of the world by earthquakes.

Accidental Disasters may take the form of rail or air crashes, shipwrecks (possibly with widespread consequences, such as in the Torrey Canyon disaster), flooding due to a dam failure (as with the Frejus dam failure of 1959), failure of building or bridge structures (as with the Ronan Point collapse of 1968), or many other forms. In the main such disasters are efficiently and promptly dealt with by the police and fire services, with their special training and techniques in rescue, although medical assistance from the Services may well be requested, and engineer assistance may be requested in the case of a structural failure.

The Scope of Disaster

The scope of the disaster, both geographically and in terms of seriousness, will affect the likelihood of a request for military assistance. In the case, for example, of minor flooding, which in itself would not result in a call for help, the fact that it may be geographically widespread would make military assistance, with its backing of communications, transport and manpower, desirable. On the other hand, military assistance would be equally desirable in the case of a more serious but localized disaster, in which military skills could be used to great advantage.

The Competence of Local Authorities

Without doubt there must exist a considerable variation throughout the country in the efficiency and organization of local authorities in their ability to deal with disasters of any scale. A well-organized authority will have less need to call for military assistance than one less well organized. Unfortunately, however, it is the less well-organized authority, through lack of impetus, that is most likely to procrastinate in requesting assistance, with the result that full advantage is not taken of available help.

Finance

Financial considerations would not normally affect the decision of a local authority to request Service assistance in the case of a serious emergency. Such considerations may affect the degree of assistance requested, however, and could sway an authority if the disaster was of a minor nature. It is therefore worth while considering these financial aspects.

The general principle is that money specifically provided by Parliament for Defence purposes ought not to be used for other purposes, and therefore that civil organizations for whom the Armed Forces perform services outside the scope of normal military duties should bear some or all of the costs. The civilian pamphlet referred to previously states that in emergencies:

(*a*) All charges may be waived when attempts are made to save human life.

(*b*) Extra costs will be charged during the period of immediate danger to life and property.

(*c*) Full costs will be charged for any subsequent assistance given, where there is no training value to the Services.

In assessing charges the specific training benefit to the Services and the commercial cost of performing the task are taken into account. Extra costs are defined as those directly attributed to the task, for example the cost of movement to the area, and the cost of Ministry of Defence stores expended. Full costs include all expenditure involved by the assistance, such as basic pay and allowance for personal, travel and subsistence allowances, the cost of rations, and so on. There is, however, an important proviso regarding charges, made in the Service instruction, in that Army Commands have the discretion to abate charges where assistance can be regarded as normal training. This proviso could be applied in many cases, for example in assistance involving bridging operations, to waive some of the financial charge on a local authority.

CONTROL AND ORGANIZATION

Overall Command

The type of disaster being considered within this article is a major disaster within the United Kingdom. In this context the responsibility for prevention of further loss of life and damage, for organization of relief, and for command of the rescue services is undoubtedly a civilian one. If the disaster is fairly localized, then no doubt the appropriate local authority, up to county council level, will take command, and how this command is exercised will depend upon local policy. A possible solution envisaged by Surrey County Council, and suggested by them to the Ministry of Housing and Local Government, is one that foresees two phases to a disaster relief operation.

(*a*) *The warning and rescue phase*. At this stage life saving and measures to prevent further risk to life and property are paramount. Over-all co-ordination of all services and agencies will almost certainly be vested in the Police Forces.

(*b*) *The welfare and restoration phase*. The main preoccupation here will be sorting out the chaos and trying to bring life back to normal. The Police Forces may still be in control, but local authorities, at all levels, will be responsible for over-all organization.

A disaster, however, may well cover several counties, and although in some cases it would be perfectly satisfactory for each county to act independently with its own relief programme, it could be that action in one county may affect conditions in another.

Regional Emergency Committees, which are chaired by a junior Minister and have nominated representatives from key Ministries, the Post Office, Chief Constables and the Services, are appointed in peacetime and may be summoned to deal with an emergency at the instigation of the Home Office, if the emergency so warrants it. Unfortunately there does not otherwise exist a single civilian agency empowered to take overall control of a situation, and although the GOC of a Geographic District or the C-in-C of a Command would be ideally suited to take such control, as was done in the case of the Hamburg floods of 1962, when all rescue and relief agencies were put under German Army Command, it is most unlikely that such a solution would be acceptable in the United Kingdom. If the Emergency Committee is summoned, the Services may be called upon to provide staff and facilities to assist its working.

Military Command and Participation

For efficient operation all the Armed Services in a disaster operation must be under the command of a single military commander. In the disaster area there is bound to be an echelon of command with geographic responsibilities and the local commander, with his local knowledge and contacts, is rightly the man to control Service assistance. Depending upon the extent of the disaster, the military commander may well be the GOC-in-C of a Geographic Command, the GOC of a District or possibly a less senior officer.

The UK Command Structure. The present military command structure in the UK complicates the matter to some extent, in that although Geographic Commands and Districts have full command of training and administrative units within their area, they do not have command of operational units, other than for local and routine administration, operational command of these units being vested in HQ Army Strategic Command. Since training and administrative units normally do not have the establishment of men or equipment to operate efficiently away from base for a number of days on disaster relief, this means that the Ministry of Defence must agree at an early stage to certain units of Strategic Command being placed under command of the local Military Commander. Naturally in an emergency Geographic Commands would assume command of operational units pending Ministry of

Defence approval, but the fact remains that certain units may already have been committed elsewhere by HQ Army Strategic Command.

A second complication is the structure of Geographic Command and District HQs themselves. Since these HQs do not have a major operational role in peacetime, they are, in the main, established for a purely non-operational administrative role. In some cases their establishment would make it difficult to produce an operational HQ, and in most cases they will lack the vital communications organization required to operate efficiently.

Military Operational Headquarters. A possible answer is for a Military Operational HQ to be readily available to a Geographic Command or District, which could be called in if required by the GOC, and would then function under command of the Geographic HQ. This Military Operational HQ could well be an all-arms Brigade HQ, but since engineer tasks are likely to predominate in disaster relief work, it is suggested that a regular operational engineer headquarters might well be the most appropriate. This could be HQ 12 Engineer Brigade, which already has disaster relief as one of its possible roles, and which commands in peacetime the most readily available sapper force, with all the requisite specialists; or for a lesser disaster the RHQ of one of the regular Engineer Regiments could be used.

The Role of the Geographic HQ. The detailed role of the Military Operational HQ will be considered later, but it is considered that, in general terms, the Geographic HQ would:

(*a*) Directly command certain reinforcing Strategic Command units, such as medical units and possibly some transport units.

(*b*) Handle administration of all reinforcing Strategic Command units brought into the disaster area.

(*c*) Accept and vet all requests for assistance from local authorities.

(*d*) Deal with routine assistance, such as emergency food distribution.

(*e*) Pass requests for engineer assistance accepted by the Military Commander to the Military Operational HQ for action.

(*f*) Maintain close liaison with the Command Secretary.

Exercise of Command and Control

The over-all organization of command and control will depend without doubt upon the circumstances of the disaster, and no two cases will be alike.

Disaster HQ. The civil authorities will most probably set up a Disaster HQ at the earliest opportunity; indeed, in a widespread disaster, such as a flood, two or more Disaster HQs could be set up, possibly run by adjacent counties or local authorities. At such an HQ one would expect to find:

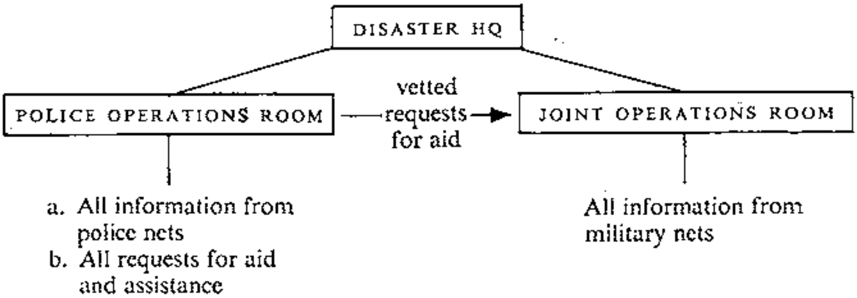
(*a*) *The Disaster Relief Controller*, possibly a Chief Constable or other local authority representative, depending upon local policy, and also the phase of the disaster (ie the warning and rescue phase, or the welfare and restoration phase, as explained previously).

(*b*) *Local Representatives* of the Police Forces, county and other local councils, county and/or borough surveyors' staffs, and of other civil administrative departments involved.

(*c*) *Military Representation* as suggested below.

Military Representation will vary considerably, depending upon geographical considerations. The Military Commander may decide to be represented personally or through a staff officer, he himself remaining at his own military HQ. On the other hand, if his HQ is at a considerable distance from Disaster HQ, he may decide that the Military Operational HQ advocated above should place itself alongside Disaster HQ, whilst he and his staff remain at Geographic HQ. Much depends upon the degree to which the Military Commander decides either to integrate his staff with that of Disaster HQ or to remain quite separate, simply operating as an agency to act upon specific requests for help.

The Organization of Disaster HQ. A possible organization, assuming a high degree of integration, is suggested below, but this is but one of many satisfactory solutions.



The Joint Operations Room may well include various military staff, again depending upon the degree of integration; such staff may include representatives of the Royal Engineers (including Engineer Resources), the Royal Signals, the Royal Corps of Transport, and Command and District Staff, as well as various local authority representatives. Ideally the Joint Operations Room and the Police Operations Room should be adjacent to allow constant interchange of information. Indeed, a Police Operations Centre, of which there are a number throughout the country, would be a very suitable location for the complete Disaster Headquarters organization, but this also will depend upon the geographic situation and local policy.

ROYAL ENGINEER PARTICIPATION

The Engineer Task

The nature of an emergency or disaster will obviously considerably influence participation by the Corps of Royal Engineers. Thus at one end of the scale a minor flood may involve military assistance with distribution of food and bedding, evacuation of flood victims, drying out of property, and so on. This assistance may be given by any Service unit, possibly even by an Engineer Regiment, simply because it is the nearest unit to hand. At the other end of the scale, the same minor flood may result in the sweeping away of civil bridges, the disruption of water supplies, the breeching of river banks and so on, and in this case the Royal Engineers would be involved in their own right, carrying out useful and necessary engineering tasks. In general terms, however, it can be assumed that disaster relief will invariably include a major element of engineering work, and possible tasks for the Sappers are shown in Annex B.

Involvement of the Engineer Headquarters

It is clear from what has been said that the Engineer Headquarters could not only fulfil a useful function in providing the GOC of a Geographic Command and District with a Military Operational HQ, but will also be necessary in any but a minor disaster to provide the requisite engineer control for the GOC. The envisaged disaster task of this headquarters is thus to:

(*a*) Provide a Military Operational HQ, if requested by the Geographic Commander in the disaster area, which would work alongside the civilian Disaster HQ.
(*b*) Organize deployment and use of Royal Engineer units available.
(*c*) Provide engineering direction to these units.
(*d*) Co-ordinate use of transport by these units.
(*e*) Co-ordinate provision of Royal Engineer resources.
(*f*) Receive and evaluate engineer intelligence.
(*g*) Co-ordinate liaison with local authorities.
(*h*) Command any non-engineering units of Strategic Command that may be placed under its command.

Support of a Military Operational HQ

The Engineer Headquarters acting in the role of a Military Operational HQ would, in the main, be established to carry out this role, although some administrative backing may be required depending upon the remoteness of the disaster area. Some support from other arms and from the Engineer Resources organization would, however, be necessary.

Communications. In most cases the principle method of communication will be the GPO telephone network, but since this could well be damaged in a disaster, full use would be made of the existing radio net of the Engineer Headquarters reinforced as necessary by the Royal Signals. In certain circumstances the provision of a TASS terminal would be advantageous.

Transport. It is inevitable that in a disaster there will be a great demand for additional transport. This should give rise to no serious problems that the Royal Corps of Transport cannot deal with without delay, but it is considered essential that from the very beginning a transport liaison officer should be attached to the Military Operational HQ. His job would be to organize in all aspects the considerable transport requirement of the HQ necessary to move engineer stores, particularly bridging stores if flooding has occurred.

Air Support. From an early stage air support will be invaluable, and will enable the Military Operational Commander and his staff, and reconnaissance parties, to move to and within the disaster area rapidly, and will also allow rapid movement of small items of stores. The requirement is foreseen as one for a flight of up to three aircraft, fixed wing or helicopter as the situation merits, to be placed at the disposal of the Military Operational HQ, and this is obviously in addition to the many other aircraft that will be actively involved in disaster relief.

Resources. With a major element of engineering work involved in disaster relief, successful completion of the work must to a large extent depend upon ready availability of engineer stores and resources. It is suggested that when Standing Operational Procedure (SOP) are produced for disaster relief, full address details are included of Engineer Stores Depots, Bridging Camps and selected units (such as the RSME), together with the availability of certain items of engineer equipment, such as bridging, pumps and generators, watermanship equipment and so on. This will enable all concerned to obtain stores as promptly as possible, subject, of course, to priorities arranged by the Military Operational HQ.

It is also most important that an engineer liaison officer, possibly from the stores troop of one of the Engineer Regiments involved, be despatched to the appropriate stores depot at the earliest opportunity, so that he can advise Military Operational HQ direct on stores availability, and can also supervise the loading of stores required by his regiment.

Liaison. An extremely important factor in disaster relief is the provision of accurate and regular engineer information. This information can be channelled back to Military Operational HQ by liaison officers placed with local authorities and with police HQs, and since it has been said that there is a major element of engineering work involved in disaster relief, it is obviously advantageous to all if these liaison officers are provided by Royal Engineer units, and not from the staff of District or Command HQs, or from non-engineer units.

Since it is particularly important to have accurate information at an early stage, when many conflicting reports are likely to be received, there is much to gain by the despatch of liaison officers from engineer regiments to local Police HQs, or appropriate council offices as early as possible. Certainly at the early stages the Police Forces will be in the best position to assess the over-all picture, and early warning to engineer units will be invaluable.

CONCLUSIONS

Over-all Command. It is impossible to predict the exact form over-all control of disaster relief will take, but without doubt over-all control will remain with the civil authorities at the appropriate level. During the warning and rescue phase control will most likely be with the civil Police Force, whilst during the welfare and restoration phase responsibility will rest with local authorities, although the Police Forces may still be in charge.

Military Command. Although Geographic Command have the responsibility for military assistance in disaster relief, Army Strategic Command has most of the resources, and in an emergency the early release of appropriate units to the Geographic Command concerned is essential. This could be done by the issue of a code word by which all concerned would know that military participation in relief of a particular disaster had been approved by the Ministry of Defence.

Engineer Command. In most respects an Engineer Headquarters is the most suitable unit to form a Military Operational HQ to assist the GOC of a Command or District if requested. The main tasks of this HQ would be to:

(*a*) Provide the GOC of a Geographic Command or District with an operational HQ to supplement his own non-operational HQ.

(*b*) Co-ordinate all engineer aspects of the disaster relief and such other aspects as directed by the GOC.

Liaison. Early liaison with the civil authorities is essential and authority should be issued now for the despatch of engineer liaison officers to appropriate police HQs and local authorities at as early a stage as possible in any future disaster.

ANNEX "A"

BRIEF DETAILS OF RECENT ARTICLES ON DISASTER RELIEF

1. *The RE Journal—Sep 63.* "Sequel to Hurricane Hattie" by Captain N. H. Thompson, RE, deals with British Honduras disaster.
2. *The RE Journal—Sep 64.* "Earthquake Relief Work in Yugoslavia" by Lieutenant C. G. B. Brodley, MBE, RE, deals with the Skopje earthquake.
3. *The RE Journal—Dec 66.* "Belize Revisited or what the Sappers did in British Honduras" by Maj H. E. H. Newman, RE.
4. *The RE Journal—Mar 67.* "Aberfan" by Lieut-Colonel R. M. Merrell, MBE, RE, deals with the military participation in the disaster relief.
5. *The Sapper—Sep 68.* "36 Regiment opens up Routes in the West Country" deals with the West Country floods.
6. *The Sapper—Nov 68.* "Flood Relief in SW England" by Lieut-Colonel J. W. Elderkin, RE, deals with 71 (Scottish) Engineer Regiment (V) assistance in the West Country floods, and "Flood Relief" by Captain A. Nesbitt, RE, deals with the part played by the CEP, Long Marston.
7. *The RE Journal—Dec 68.* "Floods in the South West" by Brigadier M. E. Tickell, MBE, MC, and "36 Engineer Regiment and the West Country Floods" by Lieut-Colonel J. N. Holden, RE.
8. *The Sapper—Mar 69.* "Training Regiment Recruit Parties help in Flood Relief" by Lieutenant M. B. Mounde, RE, and "Flood Relief—3 Field Squadron carry out emergency bridge repairs" both deal with the SE Counties floods of September 1968.
9. *The British Army Review—Apr 69.* "Disaster Relief" by Colonel E. M. Mackay, MBE, deals with the Frejus disaster, Hurricane Hattie, the Skopje earthquake, Aberfan, and the West Country floods.

ANNEX "B"

PROBABLE TASKS FOR ROYAL ENGINEER UNITS INVOLVED IN DISASTER RELIEF

1. *Rescue Phase*

(*a*) Evacuation of victims by vehicle.
(*b*) Use of floating equipments (e.g. assault boats, inflatable dinghies, etc) to evacuate victims.
(*c*) Assistance with traffic control.
(*d*) Use of plant to open road blocks and clear fallen trees.
(*e*) Construction of light bridges to gain access to an area.

2. *Prevention of Further Damage*

(*a*) Demolition of structures left in a dangerous state.
(*b*) Relieving of flood water by cutting embankments, causeways, etc.
(*c*) Containing rising flood water by building bunds.
(*d*) Reinforcement of weak points in river walls, etc.

3. *Restoration Phase*

(*a*) Bridging and repair of breaches to restore roads.
(*b*) Emergency power for lighting.
(*c*) Provision of water points where sources have been destroyed or polluted.
(*d*) Removal of debris using plant.
(*e*) Assistance to the GPO to replace telephone lines.
(*f*) Provision of temporary accommodation (camp structures at schools and village halls).

4. *All Phases*

(*a*) Engineer liaison with local authorities.
(*b*) Provision of overlaid maps if required (produced from aerial photographs by 42 Survey Engineer Regiment).

"Taking to the Bottle"

LIEUT-COLONEL H. F. EVERARD, RE, FIPlantE, AMBIM

INTRODUCTION

SEVERAL of our national newspapers and one or two magazines have recently included reports on a new system of offshore oil storage which is being pioneered in Dubai in the Trucial States of Oman. I have recently had an opportunity of visiting the construction site and I believe the concept is of sufficient interest to merit this short article.

The Dubai Petroleum Company is a subsidiary of CONOCO (Continental Oil Company). The company first struck oil in the Fateh oilfield in June 1966. The field is situated in the Gulf approximately sixty-five miles off the coast of the Trucial State of Dubai. The first strike discovered two reservoirs, one at 7,600 ft and the other at 8,300 ft—the latter had an output of 6,000 barrels a day. Two further strikes in February 1967 and June 1967 produced another 10,000 barrels a day, which made the field a commercial prospect. It is anticipated that the field will have a twenty-year life.

To exploit the field fully it was planned to erect four drilling platforms each capable of drilling six wells. The offshore complex was to be completed by erecting a central production platform containing all the necessary processing equipment. The production platform would house the control centre for the whole complex. Oil would pass from the drilling rigs to the central platform through 16-in feeder pipes and from there to storage in 30-in feeder pipes. A complementary storage system would be required.

The offshore installation devised would cost approximately £20 million. At this price it would be cheaper in the long term than constructing a pipeline to the shore and there establishing a processing and storage installation with suitable tanker-loading facilities. Relatively little manpower would be required for the complete range of offshore activities, namely extraction, processing, storage and tanker loading.

STORAGE SYSTEM

The first stage of the storage system is already in place and consists of two tankers which had been damaged previously in collisions. The tankers provide floating storage up to a capacity of 250,000 barrels each. To provide further capacity a revolutionary system in offshore oil storage has been planned and the first vessel is in an advanced stage of completion. The system involves pumping the crude oil into an underwater "bottle" from which tankers can be loaded at sea. The "bottle" will hold 500,000 barrels giving a total storage capacity in the complex of 1,000,000 barrels. For very large tankers a full cargo will require the contents of several bottles. The first of these storage vessels is being constructed at Dubai by the Chicago Bridge and Iron Company.

SPECIFICATION

The "bottle" has been designed to the following specification:

(*a*) To hold 500,000 barrels of crude oil.

(*b*) To function submerged in 155 feet of water anchored by skirt piles.

(*c*) To withstand 40-ft waves at 10·5-second repetition intervals, 100-mph winds and 3-knot bottom currents.

(*d*) To be a self-submerging structure stable in all positions with submergence controlled and reversible.

(*e*) To last for more than twenty years.

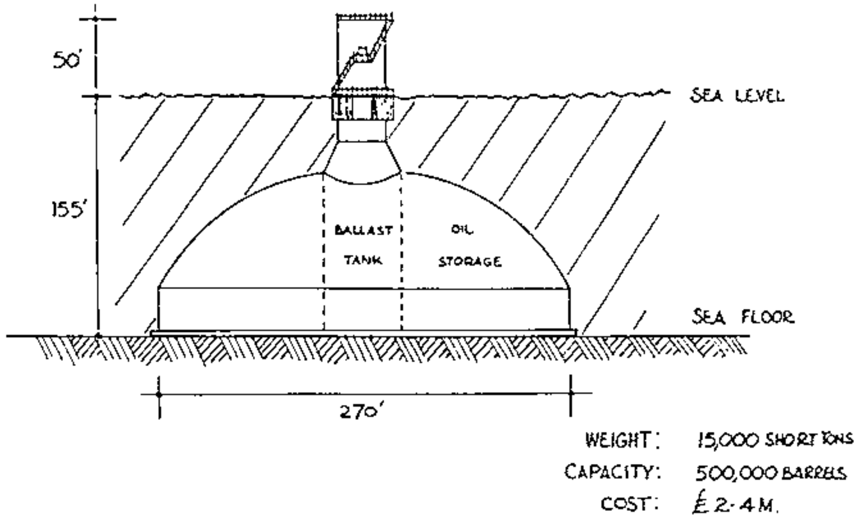
The central shaft above the ballast tank will house a 2,000-barrel surge tank and sufficient accommodation for operators, personnel and equipment. The column is designed to support a conventional rig platform if required. It is strong enough to moor a 150,000-ton tanker for loading, although it is understood that for this prototype the Company will use a mono-buoy.

Oil is forced into the storage chamber through the 30 inch Feeder pipe.

The anodes are clearly visible. Sea level will be approximately at the level of the vertical fenders half way down the central column.

The central shaft with its rubber faced fenders can provide mooring for a 150,000 ton tanker. The shaft is strong enough to support a conventional rig platform if required.

Taking to the Bottle



PRINCIPLE OF OPERATION

The tank will operate on the water-displacement principle. In an "empty" state the storage tank is full of sea water. As oil is produced it will be pumped into the bottom of the storage tank. Oil, being less dense than water, will find its way to the top of the tank, displacing sea water, which will be forced out at the bottom. The hydrostatic head produced will be sufficient to load the tanker. When oil is transferred to tankers the reverse process will occur; that is the sea water will displace the oil.

During the design stage the principle of operation, although simple in theory raised a number of problems. Among the problems solved were:

(*a*) The contamination of crude oil by salt pick-up.
(*b*) A content gauging method.
(*c*) Oil/gas separation.
(*d*) Removal of wax and sludge.

CONSTRUCTION

Four years of intensive design and environmental study preceded the construction stage. Scale models (50:1) were made to solve the major problems in installing the tank on the sea floor. Tests for horizontal and vertical wave force effects were conducted in an extended wave tank experiment. Various specialists were consulted during the design phase, including analysts in wave forces and interface waves, soils and pile driving. Some knowledge was gained from previous experiments in offshore storage conducted in the Gulf of Mexico two years ago. The Dubai tank, however, is of a different design and is fifteen times larger in capacity.

The construction phase has taken over a year. The tank has been built in a dry dock excavated from the sand adjacent to the shoreline on the Dubai Coast at Jumeira. The site is impressively simple in layout and in the provision of supplementary facilities. Two small wooden structures house an office-cum-store and a canteen. These are the only buildings on site. Apart from the completed tank the central feature of the site is a massive 150-ton construction crane. The heaviest single unit load hoisted during construction was approximately 85 tons. Briefly the stages of construction were:

(*a*) Central ballast tank.
(*b*) A ribbed skeleton of the oil-storage section.
(*c*) Plating the oil-storage section.

One major problem that had to be overcome was the need to prevent electrolytic action on the steel plates of the storage tank due to its immersion in salt water. The remedy devised was to attach a large number of aluminium alloy anodes externally over the whole body of the tank. The anodes are replaceable.

LAUNCHING

Launching is planned to take place in three stages (see illustrations at Annex "A").

(*a*) *Stage 1.* The construction dock is excavated to a depth slightly above sea-level and the launching dock is excavated to a depth slightly below sea-level. Both docks are lined with a thin, low-cost polythene material to retain water for a sufficiently long period to effect the flotation of the vessel.

(*b*) *Stage 2.* The tank is floated from the construction dock into the launching dock. From the launching dock a channel is constructed to connect with the sea. In a floating posture the vessel draws about 9 ft. Compressed air at 3½ lb/sq in is pumped into the oil-storage chamber. This gives additional buoyancy and the vessel will draw from 9 in to 1 ft less. At this pressure air will just begin to bubble out from the underside of the storage chamber.

(*c*) *Stage 3.* A channel is constructed with drag-lines and dredgers from the launching dock through the blow sand and the beach out to the required water depth in the open sea. The sketch shows that as the channel is excavated the construction dock empties and the water-level in the launching dock reduces to sea-level. The principle is similar to a canal lock. The launch takes place at high tide. A tug is used for towing the vessel; a restraining tackle is fitted aft and it is connected to an anchored winch. Lateral restrainers are connected to excavator crawlers which provide mobile anchorages.

POSITIONING

The tank is towed to its final location sixty-five miles offshore, where it is submerged in 155 feet of water. It is then anchored by its flange to the sea floor with skirt piles. Submersion can be fully controlled by use of the central ballast tank. Air, under 30 lb/sq in pressure, is pumped into the tank. The submersion process is arrestable and it can be reversed if required.

MAINTENANCE

It is planned that as far as possible maintenance should take place in situation with the use of divers. The storage tanks have been marked in many places with letters/numerals to facilitate the identification of sections of the structure. Those parts requiring attention can be relayed to the surface in code form by the diver, where it can be accurately located or identified by reference to a master drawing.

CONCLUSIONS

It is clearly too early yet to evaluate the success of this new system of storage. Theoretically one should wait twenty years before pronouncing that it has completely fulfilled the specification; however, accurate predictions as to its estimated life should be possible after a year or so of service.

With the present escalation in tanker capacities larger storage vessels than this prototype may be necessary. The economics of the vessel size or the number of vessels must to a large extent depend on the total daily output of the field, the field life and the average capacity of its visiting tankers.

If successful the tanks will eliminate the need for pipelines to the shore. The large shore installations associated with offshore fields in the past will be superfluous. There will be a significant decrease in future in the over-all investments in an offshore field by producers.

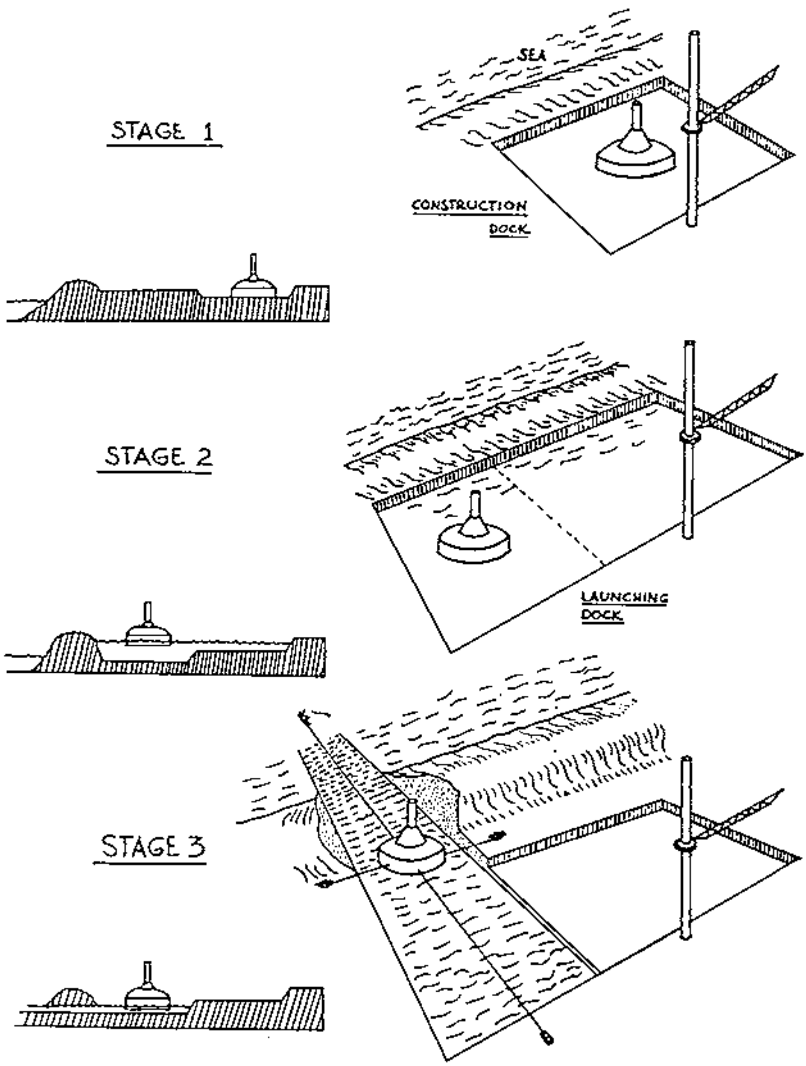
As a last thought perhaps there could be a military application to this system of storage. In a modified form the tanks would be difficult to locate and difficult to destroy.

Afternote

The "bottle" was successfully launched on 7 August 1969 and is now submerged in its offshore location.

Annex A

LAUNCHING SEQUENCE



for the purpose of sectional illustration the direction of launch in Stage 3 has been shown as being in a straight line from the construction dock, in fact as the picture sketches show the direction of launch turned through 90°.

Civilian Plant Management

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INTRODUCTION

THERE have been many papers written on management techniques in recent years, due to the wider use of computers in civil engineering works, and in particular with the general use of CPS, PERT, RAMPS and other methods of network analysis. The effect of these techniques has been far reaching and has embraced almost every aspect of the highly competitive contracting world. Plant management has not escaped the rigid programme planning, nor the intensive financial scrutiny of the three major plant users, namely county council direct labour organizations, civil engineering contractors and plant hire companies. The results of the research have brought about an increase in plant utilization, from 20–35 per cent in 1963, to 65–85 per cent in 1968 and the utilization figures are still rising.

Management has been defined as "creating conditions which allow the efficient use of all resources available to an organization, directed towards a specific end". The resources, money, materials, labour, methods, machines and time are the means by which the "specific end" or aim is achieved, and the method used in expending these resources is dependent upon the nature of the aim. The fundamental difference between the army and civilian plant management organizations lies in the aim, in that the Army is concerned with economy of time and survival during a period of war, but has little incentive in peace, whereas the civilian organizations depend upon financial economy and efficient management for their very survival. The requirement for management techniques is, therefore, greater in civilian practice, where production time is measured in terms of profit, and frequently results in a seven day/eighty hour working week.

It is perhaps necessary to expand the aim and define the function of plant management before outlining the general controls which are applied in the successful plant user organizations. The profit-motivated aim is toward increased performance, namely "productivity", which is not to be confused with "production". Productivity is defined as the ratio between input and output, ie efficiency, and the cost per unit quantity is the true measure of performance, the multiple of which is productivity. The efforts of management are, therefore, directed towards the factors which govern and control performance. They are as follows:

(*a*) Plant commitment programming (from information extracted from the Network Analysis).
(*b*) Maximum plant utilization.
(*c*) Programmed maintenance.
(*d*) Accurate owning/operating costs.
(*e*) Accurate costing on measured work.
(*f*) Efficient repair organization.
(*g*) Efficient stores backing.
(*h*) Incentive bonus scheme.
(*j*) Efficient site control.

The combined results of these factors are normally "fed back" to the management on a monthly cycle, to coincide with the monthly site measurement valuation. It must be realized that the civilian management organizations are not only controlling work in progress but are also competing for future projects and initiating forward planning procedures. It is essential, therefore, that accurate company operating costs are known when entering competitive tender.

PLANT UTILIZATION

In embarking upon the subject of plant utilization it is necessary to distinguish between "the professionals" and "back-lane hire firms" who have second-rate machines and second-rate organizations. In a good company, or local authority, the utilization system follows a standard drill and this is basically:

(*a*) Prediction.
(*b*) Allocation.
(*c*) Review.
(*d*) Update.
(*e*) Control.
(*f*) Record.
(*g*) Analyse.

The prediction on plant commitment is determined from the network analysis for existing and future projects, which the organization has secured. The commitment also contains elements of plant for contracts which the organization hopes to gain, and this requirement is assessed from the preliminary planning procedure at the pre-tender stage. The plant commitment schedule is then drawn out as a "bar chart" showing the requirement state of each item of company-owned plant on existing, future and probable future contracts. If these charts show periods of under- or over-commitment, the information is "fed back" to the CPS network to determine availability of "float", and the plant requirement is recast in order to obtain a balance with the highest possible utilization. If overcommitment occurs without availability of "float", then additional plant must be hired to augment the company's holding.

The availability of the contractor's own plant can greatly influence the tender price for a contract, in that it is political commercially to accept a contract at lower rates to ensure the employment of heavy plant items and to provide continuity. Overcommitment of company plant induces higher tender prices to offset increased expenditure on hired plant. Utilization is, therefore, an important instrument of management at the pre-tender stage in both the determination of unit rates and the requirement for continuity of work. Lack of continuity could be a critical factor to the financial stability of the company, for a machine carries a *pro-rata* financial liability for overheads, depreciation, insurance and interest on capital expenditure, whether it is gainfully employed or not. Continuity also has a great effect on labour relations and job security of company employees.

Once the "commitment state" is forecast, plant items are selected for the particular activity on the contract, and are allocated provisionally within the time schedule on the "bar chart". This is subject to review in the light of contracts being won or lost in tender, and the system is updated accordingly to show the current situation. When the contract stage is reached items of plant are finally committed to the project on an estimated time basis, after reference to the network analysis. The progress on site is carefully observed and controlled to prevent a time overrun if the future machine commitment is critical.

The control of plant and recording of site hours worked in relation to output in measured units is the responsibility of the site manager or agent. The record of plant hours worked is submitted weekly by the plant operator to the site agent on a time sheet, which is checked for accuracy against time card records held by the site clerk, and copied to the accounts section. The time sheet details the claimed hours in to actual hours worked, standing time, inclement weather, breakdown/repair and servicing, and also shows the operations performed, or jobs carried out, by using a "job code number" recorded on the time sheet. The types of time sheet are vast and various, and are normally tailor-made to suit the particular company using them. A typical example of the time sheet used is shown at Figure 1. The other submission from site for financial control is the monthly measurement, listed as bill of quantity items showing the quantity of work carried out during the month, "bill" rates and the value of that work now in hand for payment.

The plant time sheets and monthly measurement are analysed to assess the plant utilization in direct relation to time and also the plant performance in cost per unit measure. The utilization with respect to time is the ratio between possible hours of

WEEKLY PLANT TIME SHEET

Fleet No ________ Week ended ________ 19__

Class/Type of Plant ________ Reg No ________ Scheme/Project No ________

Day	Hours									Miles Hours Run	Fuel Recd	DVR Signature	Allocation		
	Working	Travelling		Standing					Total				Hours	Job No	Code cost
		Own Power	Loader	Idle	Inclem. Weather	Break down	Serv	Other Reason							
Mon															
Tues															
Wed															
Thurs															
Fri															
Sat															
Sun															
Totals															

Fuel

	Petrol	Derv	Gas Oil	Other
B/F previous week				
Received				
Consumed				
C/F to next week				

Certified

Agent

Accounts Section

Layout for Weekly Code Costs

Signed ________
Machine operator

Signed ________
Gen foreman

Figure 1

work and actual hours worked expressed as a percentage. Similar figures are calculated for standing time, inclement weather and breakdown/repair. The results are summarized for the management on an average utilization figure for each class of vehicle or item of plant. A typical summary *pro forma* is shown at Figure 2.

Published plant/hour utilization figures are occasionally suspect because some organizations assess the possible hours of work as a forty-hour "flat" week, whereas the actual hours worked on site may be eighty hours. If plant has worked for sixty hours of that time the real utilization is 75 per cent; it is often shown, however, in relation to the forty-hour week, thus giving an imaginary 150 per cent utilization. The performance of the item of plant is obtained from the total cost of the hours worked in relation to the agent's measurement of work done, which effectively give two important pieces of information.

(*a*) Output in cu yd/hr.
(*b*) Cost per cu yd.

The plant management thus has the tools of control and can readily see variations in performance, cost or utilization, on which corrective action can be initiated.

REPAIR AND MAINTENANCE

In general, the largest single charge in the operation of constructional plant items is repair cost, and this not only includes the obvious labour and machine parts but also repair workshop overheads distributed over the plant fleet on a proportionate basis. Repairs are a direct charge to the individual machine and are reflected in the hourly operational cost, which tends to vary adversely with respect to the age of the machine. Initially on a new machine repair costs are relatively low, rising in an upward curve as the work hours increase over the useful life of the machine.

Average hourly repair costs are best obtained from actual experience in a particular organization, as the standard of maintenance and efficiency of repair tends to vary between companies. The generally accepted "rule of thumb" method for assessing the average hourly repair costs over the life of a machine is given by:

$$\text{Average hourly repair cost} = \frac{5 \times \text{initial cost of machine}}{10^5}$$

Repair costs are influenced by four main factors:

(*a*) Machine application.
(*b*) Working conditions.
(*c*) Routine operator maintenance.
(*d*) Programmed maintenance/repair, ie preventative maintenance.

Machine application is directly related to machine performance, in that the higher the output the greater the requirement for sustained effort at peak performance. There are two factors which determine the level of output, machine capacity and cycle time. Both are variables; as the load carried by a machine is dependent upon the load factor or density of the soil being moved, ie the density of the soil determines the "payload". It is, therefore, possible for an operator moving high-density material to achieve a higher output, by working under maximum power and capacity, on a shorter cycle time, preventing machine overload and consequential repairs. The required balance between machine capacity and cycle time is found by experiment on site.

Routine servicing in accordance with the manufacturer's instructions and recommendations is the direct responsibility of the machine operator, and he is allowed to claim the appropriate servicing time within the working week. The income of civilian plant operators is inflated by incentive production bonus and entirely dependent upon machine/operator performance; they are, therefore, meticulous in routine servicing and quickly recognize and report symptoms likely to lead to mechanical failure which would effectively preclude bonus payments. In the event of mechanical breakdown on site "first-line" repairs are carried out under the direction of the foreman fitter, within the limited scope of the site repair workshop facilities. If a major defect develops, then the machine is returned to a central repair depot for attention.

The responsibility for the organization of repair workshops, major overhauls, repairs and programmed maintenance lies with the plant manager, who also controls the stores section for spares support. When on programmed maintenance, machines are recalled to workshops for a full inspection at predetermined intervals on "hours run" prediction, the frequency and value of "hours run" being dependent upon company policy and the type of machine. Repair and/or renewal of suspect parts is made at this time.

A further routine inspection is made on site, midway between workshop inspections, by travelling inspectors who certify in a report that correct operator maintenance has been carried out and that the machine is in good working condition. If faults are found, stores section are notified of the probable spares demand. The dates on which a machine is required for workshop maintenance are shown on the plant commitment chart discussed earlier, and provide a useful visual aid using coloured markers for overhaul, breakdown and programmed maintenance, giving an immediate indication of the workshop workload, the length of time that a particular machine has been disabled, and the availability of company machines to cover emergency breakdown, beyond the capability of site fitters.

The records and returns produced by workshops are mainly a requirement of the accounts section for costing purposes. Accurate recording of time and materials expended on individual repair is essential, not only for producing machine operating costs but also for providing data for assessment of "standard job times" in relation to specific operations.

The two returns producing the basic information are fitter time sheets and stores issue vouchers; both are referenced with a job number and cost code number, which refer to the particular machine under repair. The job numbers are initiated by workshops as an instruction to the foreman fitter and are the authority for stores issue.

On completion of the work the job number is "closed", the details of the repair, time spent, spares consumed and initials of the fitter responsible for the work are entered on the repair record card for the particular machine. A machine returning to workshops with a recurring fault is attended (without bonus payment) by the fitter who effected the initial repair. This practice tends to prevent the sacrifice of efficiency for bonus payment.

The repair record card provides a complete repair history of a machine from purchase to disposal, and also provides a useful cross-reference check for stores accounting.

The stores accounting system is normally a dual responsibility, where the plant manager is responsible for the physical stock account and replenishment, the accounts section being responsible for the numerical account, stock checks and financing. Most stores accounting is computerized for issue, receipt and allocation of charges for stores against the relevant sub-account, in accordance with the code cost number.

The physical stores holding is based upon the annual "frequency demand" on particular spares, and the availability of those component parts from manufacturers. The "frequency demand" is determined by the computer on analysis of stores issues over a period of time, and the numerical stores holding is designed to meet this requirement. The primary aim of the system is to prevent available capital resources being destroyed in unnecessary stores holding.

ECONOMICS AND COSTING

The success of a contractor or local authority in competitive tender depends upon the rates quoted in the bill of quantities, or in the case of a plant hire company the quoted hire rates for the machines. The financial success depends upon the difference between those quoted rates and the unit cost rates to the company concerned, ie profit. In short, the whole system of management is geared to produce accurate unit cost rates, or owning and operating cost in the case of plant items. Once accurate costing is achieved, examination of cost analysis will highlight deficiencies in the system and allow any necessary corrective action to be taken.

Estimated unit cost rates on a new type of machine contain two basic elements, standard fixed charges, or owning costs, and variable charges related to the hours worked by the machine, referred to as operating costs. Standard fixed charges are constant costs associated with machine ownership, and include insurance, taxes, depreciation, overheads and interest which the capital would have gained on investment had the machine not been purchased. The variable costs are such items as fuel, lubricants, repairs, servicing, routine replacement and operators' wages. The two main factors which influence the estimate of costs are the company's assessment of the economic life of the machine concerned and its resale value at the end of that time. The generally accepted opinion of the economic life of a tractor is between 12,000 and 14,000 hours, depending on the type of work carried out, but this is complicated by some manufacturers offering a return value of 42 per cent of the purchase cost at approximately 5,000 hours and 37½ per cent at approximately 6,000 hours. At 5,000 hours the machine has probably been retracked, including renewal of idlers, rollers and sprockets, and therefore the second offer is perhaps more economic, giving a further 1,000 hours utilization. An appreciation of the costs is made on an almost standard *pro forma* to assess the unit cost rate, under typical headings:

ESTIMATE FOR HOURLY OWNING AND OPERATING COST

Type and class of machine ....
Estimated economic life .... (hrs)
Estimated resale value .... (£)

(A)	COST DELIVERED (including ancillary equipment)	
(1)	Delivered cost on site	£...........
(2)	Deduct discount per cent	£...........
(3)	Deduct resale value	£...........
(4)	Net cost for depreciation	£
(B)	STANDARD FIXED CHARGES (hourly)	
(1)	Depreciation $= \dfrac{\text{Net Cost (£)}}{\text{Economic life (hrs)}}$	....
(2)	$\dfrac{\text{Annual charges, insurance and taxes}}{\text{Estimate annual use (hrs)}}$	....
(3)	$\dfrac{\text{Interest at 7 per cent on delivered cost}}{\text{Estimated annual use (hrs)}}$	....
(4)	Overhead charges:	
	$= \dfrac{\text{total annual charge to machine}}{\text{total annual charge to all machines}} \times \dfrac{\text{total overheads}}{\text{annual use (hrs)}}$	....
	Hourly owning cost (total)	
(C)	VARIABLE CHARGES (hourly)	
(1)	Fuel consumption (gal/hr) × fuel cost	....
(2)	*Lubricants*	
	Engine } Consumption gal/hr × cost	....
	Transmission } Consumption gal/hr × cost	....
	Hydraulics } Consumption gal/hr × cost	....
	Grease } Consumption gal/hr × cost	....
	Filters } $\dfrac{\text{annual cost}}{\text{annual use (hrs)}}$	....
	Oil changes } $\dfrac{\text{annual cost}}{\text{annual use (hrs)}}$	....

(3) *Repairs*

$$= \frac{5 \times \text{cost of machine delivered}}{10^5} \quad \text{............}$$

$$(4) \quad \frac{\text{Operating wages, subsistence, etc}}{\text{average hours worked}} \quad \text{............}$$

Hourly operating cost (total)

The total hourly cost to the company is the sum of the owning cost and operating cost, to which must be added the profit to arrive at the hire rates. Contractors also normally add a profit margin to be held in the plant account for replacement or purchase of additional equipment.

The costing section of the company receives the time sheets of all employees, stores issue returns, plant sheets and site monthly measurements from the company's agents, all referenced with the relevant project number, operation code number or machine number. The individual machine account is debited with the actual hourly owning and operating cost, including repairs and stores issues indicated on the fitter time sheets and credited with the hire charge income. The estimated operational cost of the new machine can be compared over a period of time with the actual cost and adjusted if necessary. The site agent's monthly measurement is the most significant return to a contractor, where each item in the "bill" is allocated a code cost number allowing cost elements of labour materials and plant to be extracted from the time sheets and delivery notes to produce a total operation cost against a measured quantity. A cost sheet is tabulated showing the actual unit cost for each "bill" item during the particular month and also a "total to date" rate. A typical example of a cost sheet is shown at Figure 3.

It is normal for contractors to produce a three-monthly valuation sheet, which is effectively a profit and loss statement on measured work, showing the measured quantities to date priced for comparison purposes at both cost rates and "bill" rates. The extended values give a net gain or loss for each item, and provide a useful reference for subsequent tender prices.

The data processing to produce unit cost rates can also be used to give statistical information, for use in plant control in the form of:

(*a*) Plant utilization percentage.
(*b*) Machine output in cu yd/hr.
(*c*) Machine cost per cu yd.
(*d*) Fuel consumption.
(*e*) Standard job times for workshops, by direct comparison to similar repairs.
(*f*) "Frequency demand" on spares.

The information is basic, but it is the collection and examination of such basic information which allows variations in performance to be investigated and rectified thereby effectively providing management with the tools of control.

MANAGEMENT STRUCTURE AND PLANNING

The management of constructional plant is normally a dual responsibility, in that the plant manager is responsible for the utilization, mechanical reliability of the machine and the efficiency of company operators; whereas the site agent controls, and is responsible for, the work of the machine on site and is concerned mainly with the performance of both the machine and operator. Operators are recruited, employed and/or dismissed by the plant management; the site agent therefore accepts a company machine and operator on site on the same terms as hired plant and expects similar service and performance.

The management structure for the control of plant follows a similar pattern in the three main plant user organizations, the plant manager having the authority and

MACHINE UTILIZATION FOR (MONTH)

Date ________________ ________________ Plant Control Office

Machine (Fleet No.)	Possible Hours for Work	Hrs Worked		Standing		Inclement Weather		Repairs		Remarks
		hrs	%	hrs	%	hrs	%	hrs	%	
Cat D G C. (93)	80	60	75	10	12½	—	—	10	12½	

Figure 2

COST SHEET

Month Ending ________________

Scheme ________________

Project No ________________

Item No	Code Cost No	Description of Work	This Month													To Date												
			Qty yds			Amount			Total	Unit cost			Qty yds			Amount			Total	Unit Cost								
			sq	cu	Lin	Labour	Materials	Plant	£ s d	sq	cu	Lin	sq	cu	Lin	Labour	Material	Plant	£ s d	sq	cu	Lin						

Figure 3

responsibility for plant function, irrespective of his level of seniority within that management structure. The general responsibility includes plant utilization, performance, correct application of machines, maintenance and repair, selection of new machines for purchase and control of spares backing. The typical command structures shown in Figures 4 and 5 indicate the delegation of authority in two main lines of descent:

(*a*) The plant controller.
(*b*) The plant engineer.

The plant controller is normally an engineer trained in work study and management techniques, and is responsible for the assessment of plant commitment from the network analysis preparation of statistical information, cost analysis and recommendations for improvement or corrective action on the existing system of control. The plant controller has little physical contact with site work once the machines have been committed.

The plant engineer is primarily concerned with the performance and efficient mechanical management of company plant items and his responsibilities lie in the control and recruitment of tradesmen for the repair workshops, site repair organization and plant operation. Plant operators are responsible to the plant engineer for routine maintenance of machines and machine application, but to the site agent for the execution of the work in the project. The plant engineer exercises control of maintenance on site through the plant inspectors (referred to under maintenance and repair) who tour project sites periodically inspecting machines to ensure that operator maintenance is carried out and also to report on the mechanical state of the machine.

Plant operators, by the nature of their employment, are "mobile" and move either within company projects or as specialists to areas with a large development programme. There is a demand for experienced plant operators, which has been inflated to an artificial "high" at the present time by the Government's creation of "development areas" where a 42 per cent grant is available for the purchase of new plant, designated to work on projects within that area, for a period of three years. This has not only successfully encouraged construction companies to increase their plant holdings but has also created an increased demand for experienced plant operators and a requirement for plant operator training to meet that demand.

Experienced plant operators and plant fitters are normally recruited as a result of advertisement in the daily or technical press, and occasionally by recommendation or personal contact with the company concerned. In a national company the initial demand for operators can be decreased by importing specialists from other company regions if the local labour supply is exhausted. The recently formed industrial training board relieves the situation by satisfying the requirement for the training of additional operators for companies, who contribute towards the board's training scheme. Initial residential training courses are organized on the operation and maintenance of excavators, tractors, scrapers and loading shovels and give a minimum 100-hour machine experience during a two week period, where students work the normal 10-hour construction industry day. The course fee to contributing companies of the training scheme is in the region of £60. This initial training course provides a minimum experience in site conditions.

The requirement for fitter staff is proportional, but less than the demand for plant operators, as, on average, there is one fitter to every ten machine items. Trained fitters are recruited in the same way as trained plant operators, but in addition most companies have an apprentice training scheme, organized in conjunction with local technical colleges. The technical training, aimed at the City and Guild examinations, involves one year of full-time education and subsequent training on "day release" subject to the satisfactory progress of the apprentice. The "day release" agreement allows the apprentice to attend technical college for one day a week on company pay, the remainder of the week being devoted to practical repair under the supervision of a qualified fitter. He thus combines theory with workshop practice.

TYPICAL PLANT HIRE ORGANIZATION

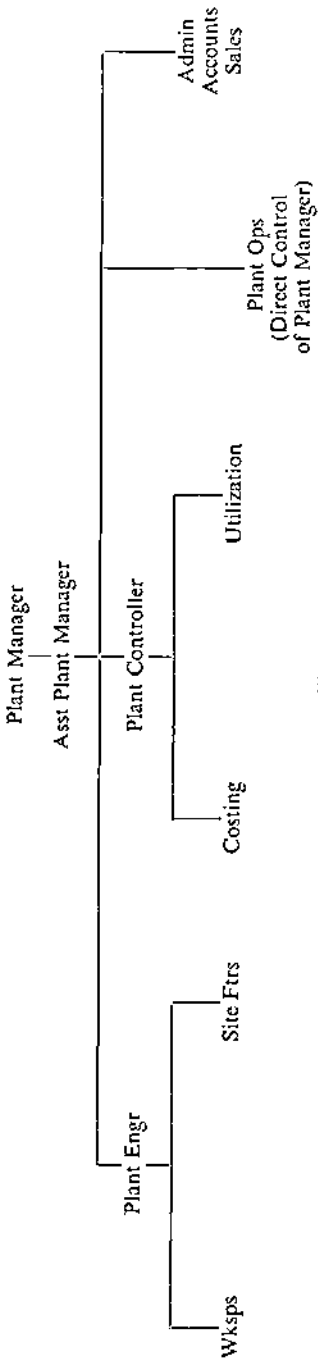


Figure 4

TYPICAL COMMAND STRUCTURE

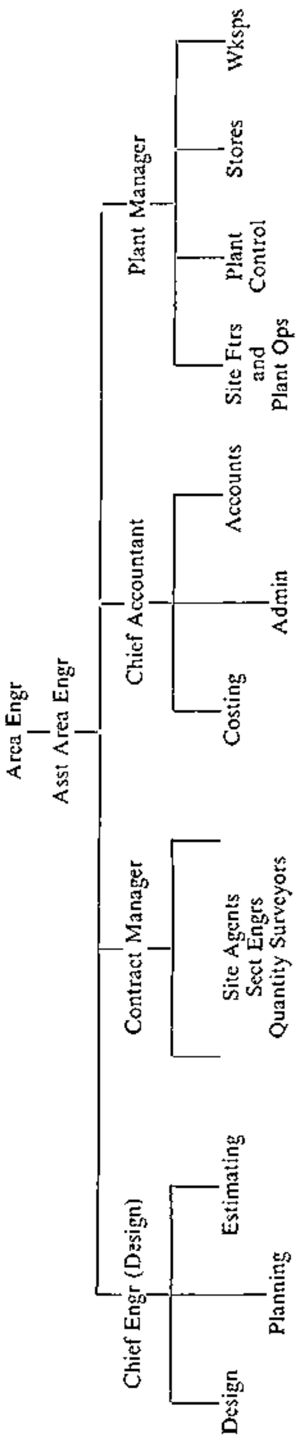


Figure 5

THE CONTRACT

The accepted tender and the resulting contract can spell financial success, or disaster, to the contractor depending on how well the management has assessed the value of the work and the time required to complete the project. Most contracts contain a penalty time clause, so programme planning must be precise. The contract provides a challenge to the management on its own declared terms, any loss reflecting on the ability and efficiency of estimating programme planning, costing or the site organization of the company. The management techniques, demanding the returns for analysis and applying controls, provide the statistical data on current and previous contracts and consequently the basis for accurate assessment of cost and time factors, at the time of tender.

Preliminary planning procedure is carried out by the estimating department at the pre-tender stage to assess the value of the contract and the availability of company resources. The plant required for the project is provisionally allocated pending acceptance of the tender. The site agent destined to control the work on site is then involved at the post-tender stage, once the contract has been secured and the firm programme planning initiated. The network analysis is prepared after liaison with the agent and plant manager on the selection and commitment of plant, temporary works, access, co-ordination of sub-contractors and statutory undertaker's work. All major decisions on policy and method of construction are taken at this pre-planning stage, leaving the implementation and administration of the plan to the site organization.

The site agent is entirely responsible for the organization and progress of the physical work on the project, his main functions being to ensure that activities are carried out within the critical programmed times and that the completed work is measured and certified for payment by the employing authority. The supporting costing organization provides the agent with information on financial progress on individual "bill" items, bonus rates, the "performance" of machines and plant utilization figures. These factors indicate the strength and weakness of the site control system and guide the agent in decisions for improvement on concentration of effort.

CONCLUSION

The motivating force producing the effort and measure of control applied by civilian management to analyse company performance and promote efficiency is financial economy. A civilian organization cannot exist without a profit return for capital expenditure. It is, therefore, finance which produces the competitive atmosphere surrounding plant and contract management, and it also provides the incentive to search for new and better techniques to overcome competititon and survive in commercial practice. The adoption of similar systems of management control by contractors, has resulted in decreasing differential in tender prices, and it is not uncommon today to find all tenders on a £1 million contract to be within 1 per cent of the lowest tender, even finer limits being found between intermediate prices, indicating that the economic limit is being reached.

The purpose of this paper has been to outline the methods employed to achieve efficiency in civilian plant management, without making any direct comparison in the text, with the Army system, apart from drawing attention to the difference in the aim in the initial paragraphs. Lieut-Colonel Mitchley's article in the June issue of the *RE Journal* on "Constructional Plant Management in the Army" examined Army plant management in detail and brought out three significant points which would appear to condemn Army plant management:

(*a*) Lack of experience by both management and operators.

(*b*) Underutilization of plant (one-fifth of civilian usage).

(*c*) The Army has a lower serviceability rate than a commercial firm could tolerate and still remain solvent, despite an often higher proportion of fitters to machines.

In view of these admissions, it is unreasonable to attempt to compare the Army with civilian plant organizations, where the "professionals" are specialists working up to eighty hours per week to meet a target commitment, supported by a technically qualified and experienced management. By the same token, the Army has a different role and the technical ability of its management is directed to fulfil a need in time of aggression. The system is not expected to compete as a commercial basis, but plant management is one aspect of "sapper tasks" which could benefit and become more efficient by an economic approach.

Note by Editor:

A letter submitted by Major A. S. Hogben, RE, commenting upon this article is included in the Correspondence Section of this *Journal*.

GLOSSARY OF TERMS

CPS	Critical path scheduling.
PERT	Programme evaluation review technique.
RAMPS	Resource allocation multi-project scheduling.
Network analysis	A group of techniques for presenting information to assist the planning and controlling of projects. The information is represented by a network showing the sequence, logic and interrelationship of all project activities.
Activity	An operation or process consuming time and possibly other resources.
Duration	The estimated or actual time required to complete an activity.
Float	The time available for an activity in addition to its duration.
Cycle time	Time taken to complete a circuit of operations, ie loading, hauling, dumping and returning. . . .
Load factor	The ratio between the density of a material (loose) and the density (bank), ie $\text{Load factor} = \frac{\text{lb cu yd (loose)}}{\text{lb cu yd (bank)}}$

Down to Earth in Space

CAPTAIN A. M. BELL, RE

THE news headlines of 4 October 1957 heralded a new age. Russia had put the first man-made Earth satellite into orbit. SPUTNIK 1, a polished aluminium sphere weighing 184 lb, stayed ninety-two days in the hostile environment of space that man had set out to discover. It was another three and a half years before man himself followed the early instrumented packages with any chance of survival and safe return. And now, not twelve years after the beginning of the Space Age, the centuries-old dream of mankind has become a reality—men have walked upon the Moon and returned to tell the tale! And still louder the critics cry: "Is it worth the cost? What of the poverty and suffering here on Earth?" Unfortunately it is now only such space flights as those to the Moon or fly-by missions to neighbouring planets that are thought news-worthy by the Press and broadcasting services. The almost routine launchings of satellites in the Russian COSMOS or American NIMBUS series tend to be forgotten in the heated debates as to whether the vast cost of space research is giving value for money. Yet a large part of that unheralded space effort, world-wide, is devoted to a better understanding of our planet Earth and, through that understanding, the improvement of weather forecasting, disaster warning, crop and forest surveillance, communications and the many other facilities that are now finding a use for the satellite.

The International Geophysical Year in 1957/8 was devoted to gathering as much information as possible about the Earth, its environment and how it is affected by other celestial bodies. Before the IGY man had been no higher than seventeen miles above the surface of the Earth and had not the ability to stay at such heights for any length of time to gather varying scientific data. Rocket probes, with even shorter times at any given height, were able to give but a glimpse of high altitude data. The satellite, first used as a scientific instrument during the IGY, made it possible to gather information continuously at any height and also to see large portions of the Earth simultaneously. It became a valuable addition to the scientist's toolbox and, once it had proved itself, researchers in many fields found uses for it. Today there are few areas of scientific research that have not carried out experiments in space. In an article such as this I can only give a few examples of what has been achieved, how it is likely to affect life here below and the possibilities for the future.

GEOPHYSICS

The first year in space was entirely devoted to gaining data about the Earth and its atmosphere. Putting any sphere into orbit and accurately tracking its speed and path through the atmosphere will give an indication of the density of the atmosphere and anomalies in the gravitational field along its orbit. These parameters are necessary for the more accurate prediction of orbits for later space craft, and indeed SPUTNIK 1 found that at heights of 150 miles the atmosphere was six times more dense than the previously accepted figure. The early satellites carried sensors to gain data on other parameters such as pressure, temperature and composition. The latter is particularly relevant to an understanding of the ionosphere and how it is affected by solar radiation. This in turn is necessary for the better forecasting of conditions for radio communications using the ionosphere as a reflector. Experiments to determine the magnetic and electric fields surrounding the Earth led to the discovery, by the first American satellite, EXPLORER 1, of the Van Allen radiation belts. Much work was done on finding how the Sun and the surrounding universe affected conditions on Earth by experiments to determine the amount of radiation (cosmic, X-ray, ultra-violet) reaching Earth at any given time; how much was absorbed by the atmosphere

Photo 1. A general view of cloud patterns over Europe taken at midnight by an infra-red camera system aboard a **NIMBUS** weather satellite.

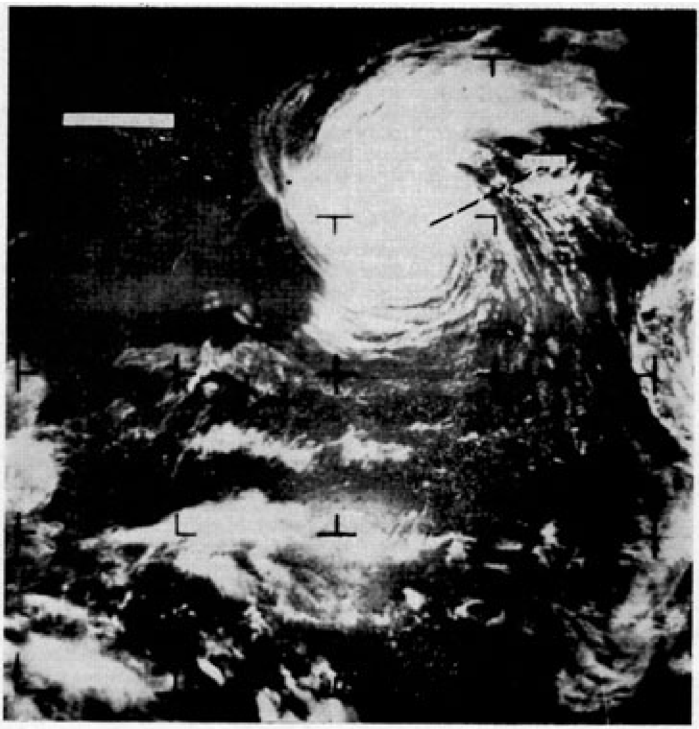


Photo 2. Hurricane DORIA spotted by a NIMBUS satellite as it moved into Chesapeake Bay, USA.

intercepted or jammed. The second method requires a sophisticated form of tracking antenna, but there is no noticeable delay time in two-way traffic. If there are a number of such satellites in any sector of the sky at one time, then a military user can select any one of them without his opponent knowing which one to track. Both these systems are in operation now.

The first private venture into space was a form of communication satellite. OSCARs 1 and 2 (Orbiting Satellite Carrying Amateur Radio) were small transmitters built by radio "hams" into a satellite and given pick-a-back lifts into orbit in December 1961 and June 1962. The more sophisticated OSCARs 3 and 4 are now in orbit relaying ham radio messages worldwide. Intercontinental communications went a step further with the launching of TELSTAR in July 1962. This satellite was the first capable of transmitting TV and the project was paid for not by the Government but by the American Telephone and Telegraphic Company. TELSTAR had a low orbit, however, and in July 1963 and August 1964 SYNCHOMs 2 and 3 were parked in geostationary positions over the Atlantic and Pacific oceans respectively. The next stage in changing space activity from the sole control of the Government to a public commercial venture was the formation in 1962 of the Communications Satellite and how much reflected; what conditions prevailed on Earth at the same time and how were magnetic and electrical phenomena affected by that radiation that did reach Earth. This, in fact, was exactly the purpose of the IGY timed to coincide with a period of maximum solar activity, and the satellite added a vast amount of geophysical data to the storehouse of information gathered in that period. The three British satellites in orbit are mainly devoted to work in this field. All three were put into orbit by American rockets. The first and second were American satellites with British experimental equipment inside. The third, UK 3, was designed, built and tested in Britain before being sent to the USA.

METEOROLOGY

The first TIROS satellite was orbited in April 1960 and since that time there has been a regular series of both TIROS and NIMBUS satellites sent aloft to look at the weather. Although much is learned from the resultant cover, these satellites do more than take photographs of the clouds. They are also able to give an idea of the heat balance of the Earth, the difference between the heat received by the Earth from the Sun and that reflected back into space by the clouds. It is also now possible to collect the values of temperature and humidity at a number of heights between ground level and the weather satellite. Since a satellite in a polar orbit can cover all the world in one day, this makes it possible to get an overall picture of likely major air movements. It is also possible to find the temperature of the sea and the strength and direction of the wind blowing over it, giving a good indication of what is happening on the face of the Earth under any given set of atmospheric conditions. The pictures taken by the weather-watching satellites and other photographic missions have shown clearly how much useful information can be gathered in this way. Already many lives have been saved and much damage prevented by early warning of hurricanes, seen on photos from space, that would not have been picked up by ground-based meteorogical stations or aircraft until some time later. By knowing the height and temperature of cloud masses and their general direction of movement it is possible to predict where rain is likely to fall or where a drought is imminent. A daily photo coverage of snow areas and glaciers makes it possible to see far more easily when they begin to melt and hence when flooding is likely in certain areas. The early acquisition of such information is of immense value to agriculture, water conservation and hydro-electric power schemes.

COMMUNICATIONS

With the large increase in the density of road and air travel in the last few decades and the consequent traffic jams in both media, Arthur C. Clarke's cry "Don't commute—communicate" must be on the mind of every businessman caught in some jam on the way to an important meeting. True we have not yet reached the stage of direct satellite communication to every home and office, but certainly the groundwork has been laid in the last few years. Research into the ionosphere and the effects of solar activity on it, as well as the finding of new wave funnels in the upper atmosphere, has greatly increased the predictability of long-range, ground-based communications. The first radio transmission of the human voice from space was made in December 1958 when a tape-recorded Christmas message by President Eisenhower was broadcast from a SCORE satellite. Various communications programmes followed in an attempt to find the most suitable system. There are two ways of maintaining world-wide communications: (1) three geostationary satellites uniformly distributed above the Equator; (2) a number of moving satellites at a lower level. The first system allows the antenna for the transmitting and receiving stations to be fixed, but, because of the distance involved (a satellite must be at a height of 22,300 miles to be geostationary without the aid of positioning rocket motors), imposes a slight delay between question and answer in two-way traffic. It has little military use, since the position of the satellite is known at all times and transmissions can therefore be

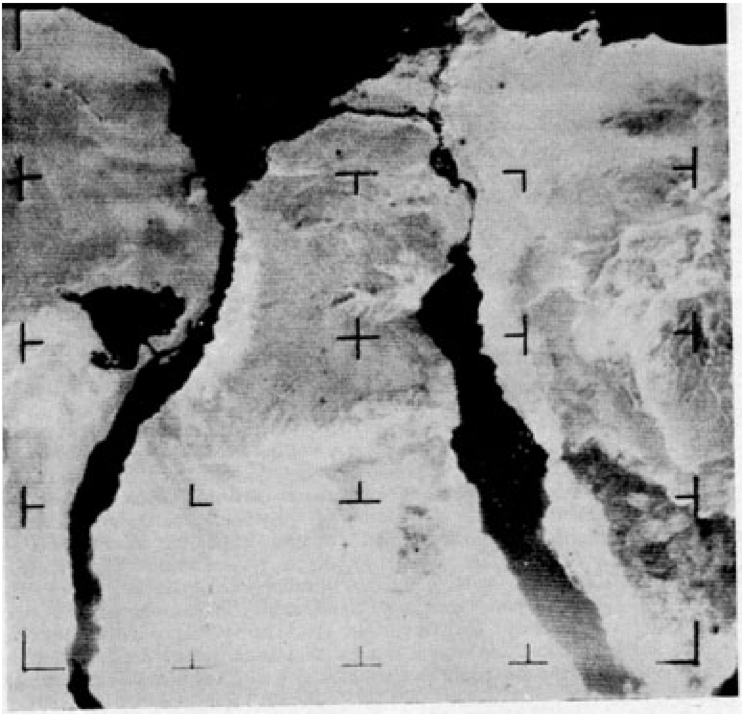


Photo 3. A view of the River Nile during a flood showing in one picture the total extent of the flooding. At right is the Red Sea and Sinai Peninsula.

Company (Comsat). The Company's first satellite, EARLY BIRD, was launched in April 1965 and it is in a geostationary orbit over the Atlantic. With over half the world already covered by the various American communications satellites and the rest by the Russian MOLNYA, we are on the brink of another revolution that is likely to change our way of life as much as the transport revolution of the last century.

The primary aim of all three European space organisations, CETS, ESRO and ELDO, is to have a European satellite communications system independent of American control. Britain is at present a member of all three organizations and is supplying the first-stage rocket booster for the present ELDO launcher.

FORESTRY AND AGRICULTURE

The possibility of better meteorological forecasting has already been brought out above, but a daily photo cover of the world can do more than predict floods and droughts. With infra-red colour photography it is now possible to see disease in trees and crops before it is noticeable to an observer on the ground. This form of photography (at present taken from aircraft not satellites) is already being used over large forest areas. Individual diseased trees can be singled out from the resultant photo coverage. Early remedial action can save thousands of acres of timber. Where there is no such photo cover only small areas of a forest can be visited at a time and the chances of finding a single diseased tree soon after it becomes affected and before it spreads the disease are slight. The same applies, naturally, to large areas of cultivated crops such as wheat, rice or cotton. Not only disease but also fire ruins thousands of acres of timberland every year and here again the satellite is capable of giving early warning. It is possible by taking pictures at different wavelengths, to find the "signature" of a particular crop from infra-red photography. Thus it is possible to get a far more accurate knowledge of worldwide crop distribution and also a complete picture of the extent of damage caused by any major disaster almost as it happens. This has obvious advantages in the rapid assessment of the relief required in the event of such a disaster.

OCEANOGRAPHY

There has been an enormous surge of interest in this field recently and there is much work to be done both above and beneath the sea. The North Sea Gas and Texan sea oil rigs have shown but a small portion of the resources that are available under the three-quarters of the Earth covered by sea. Fish farming is as yet, in its infancy, as is the farming of underwater crops. Underwater hydro-electric power from the harnessing of deep-sea currents is still an engineer's dream. Most of the work in this field must, of necessity, be done *in situ*, but the satellite is able to give an overall surface picture that is an important part in these studies. Large shoals of fish near the surface of the sea change the composition of the water in such a manner that their presence can be detected by suitable photography. Surface currents and thermoclines can be charted simultaneously and concurrent conditions watched over an area vast in comparison to that covered by flying patrols and weather ships. There is also the possibility of having large numbers of suitably equipped buoys put to sea and controlled by a satellite. These buoys could record conditions far below as well as on the surface and relay them to a satellite. This in turn would collect information from a number of buoys and relay it to a ground station where a deeper and more accurate picture of the area could be assembled than with any presently operational system.

NAVIGATION AND SURVEY

Although the situation is improving yearly, large areas of the world are still not covered by radio navigational aids and the navigator has to rely on the stars for a positional fix. Before the advent of the satellite the surveyor could not accurately calculate the distance between land masses that were not intervisible. Land masses, therefore, although accurately surveyed within themselves, were fixed on the face of the earth by observation of the stars. The accuracy of this calculation depends on a knowledge of gravitational anomalies and can lead to errors. Many of the islands in the Pacific Ocean, last charted in 1921 and even by Captain Cook in some cases, are found to be fifteen to twenty miles away from their chart positions, when using modern navigational aids. The satellite has made it possible to cover large areas with a single radio beacon and to "see" over the horizon. The US Navy started experiments in 1960 in this field with their TRANSIT series to test the efficacy of the satellite for navigational purposes. A network of navigational satellites is now operational and the *Queen Elizabeth II* is equipped to take advantage of this system. The US Navy also had the first geodetic survey satellite ANNA in orbit, though very soon followed by the US Army Map Service SECOR programme. There are basically two ways of using the satellite as a survey beacon in the sky: (1) By using radio waves to measure the distance between one or a number of ground stations and the satellite. This method is independent of weather conditions. (2) By photographing a light beacon on the satellite against a star background from a number of positions. The present range of survey satellites, GEOS and PAGEOS, have given surveyors the chance of using either system and indeed a combination of the two gives a very accurate geodetic fix. The difference between such a fix and one calculated by observation of the stars gives a figure for the local gravitational anomaly, since the survey by satellite is unaffected by gravity. Circling the Earth with such a system will give a true picture of the size and shape of the globe and the position of land masses on it. (RE Survey teams are at present working with the US Army Map Service on two of their geodetic survey projects.)

GEOLOGY

The main work done in this field so far has been the photography of large geological features without adjusting the tone and texture of adjacent photos to match, as is necessary with aerial photography. Also it is possible to eliminate the "state-boundary fault" found when tying together the work of adjacent countries. Colour photography does clearly show the geological make-up of an area and it will soon be possible to use these to predict earthquakes or likely areas of underground mineral resources.

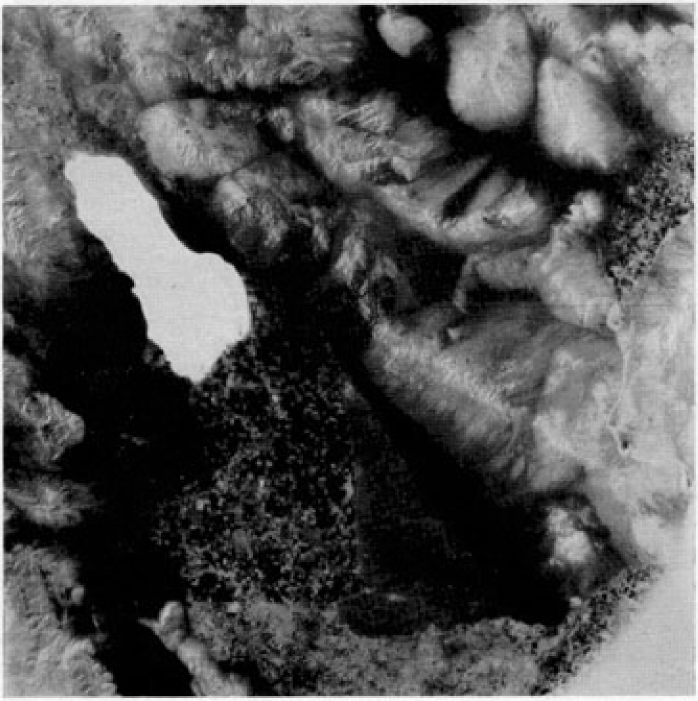


Photo 4A

See photo 4B

Down to earth in space 4a

Space medicine has become a whole new subject in itself, primarily to ensure the safety of the astronaut. But the experiments carried out in the harsh conditions of space are an aid to the understanding of life and so cannot be completely divorced from the medical research being done in ground-based laboratories. The purpose of the BIOSATELLITE series is to study the biological effects of weightlessness, the various forms of radiation and disturbance of the normal twenty-four hour earthly cycle on living organisms. In a series of experiments these conditions are studied individually and in conjunction on both plant and animal life. Although no such results have yet been reported, it may be that subjection to various forms of radiation while the body's daily "period" is upset or the body's calcium content is decreased through weightlessness, may be some long-searched-for cure; that a period of weightlessness where less effort is required to pump blood round the body is the rest an ailing heart requires. A spacebound hospital is not of the near future, but if it is a necessity for cure and treatment in the years to come, then the groundwork for that cure or treatment has been laid.

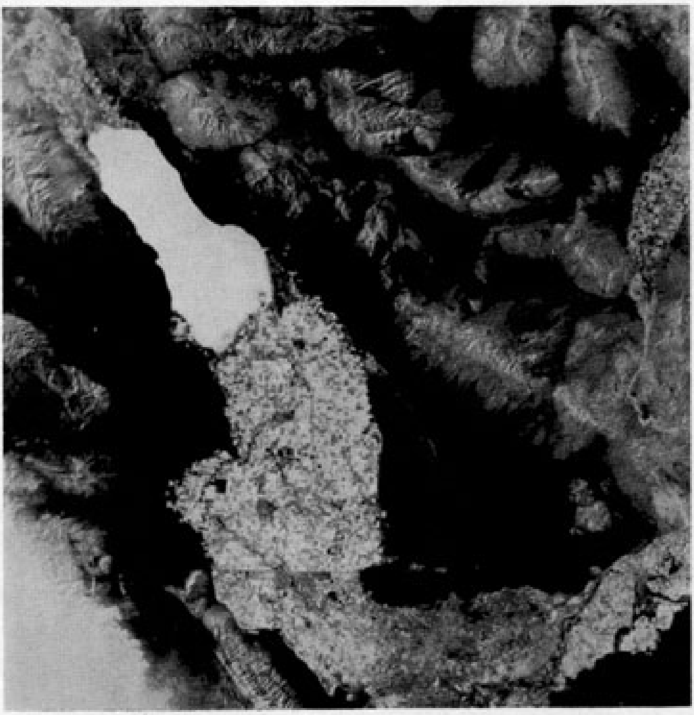


Photo 4B

Photos 4A and 4B. Photos of California's Imperial Valley taken simultaneously, but with different filters, from APOLLO 9. The camera system is a forerunner of one under development for use in the Earth Resources Technology Satellite to be launched in 1971.

Down to earth in space 4b

INDUSTRIAL PROCESSES

The building of satellites and the rockets necessary to put them into orbit has necessitated work by a large variety of industries, and also research into some complex industrial techniques. These techniques have found many useful applications in the complexities of modern life, both in manufacturing and chemical processes. The micro-electronics industry, an essential part of the efforts to squeeze a highly sophisticated system into the relatively small volume of a satellite, is almost entirely a result of the needs of space activities. Explosive forming of tough metals, a faster and more efficient method than using heavy presses, was developed to build large rocket boosters. The necessity of welding new alloys has brought a range of new techniques to that field. From research on protective coatings for satellites has been developed a number of new paints with protective applications for Earthbound vehicles. The list is a long one and not apparent to those who look for more direct and obviously beneficial advantages from space research. In the USA there is a large organization, the Office of Technology Utilization, devoted to ensuring that the results of space research and development are available to industry.

ASTRONOMY AND COSMOLOGY

"That's one small step for a man but one giant leap for mankind", so said Neil Armstrong on being the first man from Earth to tread upon the Moon. The heavens have been as a magnet to all manner of men since the dawn of civilization: the home of the gods to nearly all men; a source of romance for poets and writers; a new horizon for the adventurer; another problem for the philosopher to ponder. Many have been the theories put forward to explain the Universe and how it was created; theories on the origins of the Solar system and the birth of Earth. But Earthbound scientists have been hampered in their efforts to verify these theories by the blanket of atmosphere that surrounds us. Satellites brought the possibility of sending data-gathering instruments above the atmosphere to carry out experiments and to report on the conditions in space. In fact, early space probes found that space was not empty—there is a wind of solar particles pushing the Earth's atmosphere out into a tail on the side furthest from the Sun. The satellite is also able to monitor the many radiations in space that the atmosphere shields us from, but a knowledge of which is essential to the understanding of their sources. Another early development in space was the return of pictures from satellites passing close to other celestial bodies. In October 1959 LUNIK 3 flew round the Moon and relayed back to Earth pictures of the far side—a view no man had seen before! The highly successful RANGER and SURVEYOR series of satellites sent back close-ups of the Moon and MARINER 4 returned pictures that must have saddened the hearts of those romantics who had seen the "engineered" canals of Mars. All early plans for spacebound or Moon-located laboratories include telescopes, for, unhampered by the atmosphere, the astronomer will be able to see the Universe far more clearly. A radio telescope on the far side of the Moon will enable him to "listen" to the Universe without all the interference created by communications systems on Earth. Thus the satellite has given the astronomer and cosmologist the ability to gather data *in situ*, instead of having to interpret that tainted by the Earth and its atmosphere. It has made possible the opportunity to send instrumented packages to other planets in an attempt to find Life. And also perhaps, by solving the mysteries of the Universe; by verifying either the Steady State or Big Bang theory of Creation, to find Meaning. But ultimately man must follow the automatic satellite into space not merely "because it's there" but because he is a most adaptable and flexible machine, and as such, the only one capable of carrying out many of the experiments in space. Many of the advances in astronomy have come through accidental sightings; through searching for one phenomena and seeing unconnected phenomena that leads to a whole new field of research. A Moon-based telescope controlled by computer is unlikely to have the human ability to notice such events as it will have strict instructions on what it should look for. Had it not been for astronauts' ability manually to override the computer on Apollo II, the spacecraft would have landed in the bottom of a rock-strewn crater. By manually controlling the descent the astronauts were able to land safely in a site more scientifically advantageous. Left to an automatic satellite, the mission would have been of far less scientific value even if it had landed without accident. If useful experiments are to be continued in space, man must have the ability to conduct those experiments himself. The Apollo programme to land a man on the Moon, therefore, must be seen, not only as a gimmick for political prestige, but as a necessary step in man's continuing exploration of the heavens.

Here again I would emphasize, however, that, though the majority of these experiments in space are for the benefit of the astronomer and cosmologist, many have Earth-oriented applications. It is hoped that one of the experiments left on the Moon by the members of Apollo II, the laser reflector, will lead to a better understanding of continental drift and also to the possibility of forecasting earthquakes.

Colonel John Glenn, the first American to orbit the Earth, said of its military aspect: "Where man has learned to function, he has learned to fight". The era of spacecraft dog fights is not, one hopes, close at hand, but certainly the satellite has its military uses. A major part of both the Russian and American space effort has been paid for through the military budgets of those countries. It is difficult to assess all the military advantages to be gained from the satellite, since the results of military projects are rarely published, but the areas at present under investigation are fairly well known. The advantages and disadvantages of the various communications systems have been listed previously under that heading. The military interest in navigation and survey satellites has also been noted earlier. For the accurate firing of ICBMs and to keep track of a world-wide Polaris submarine network it is essential to know exactly where everything is on the face of the Earth. The satellite is also a very useful surveillance aid, as it can keep a daily photo-watch on the whole world and any large-scale construction or thermonuclear experiments can thus be detected. It is of strategic value in that a watch can be kept on the resources of both food and minerals available to the enemy within his own boundaries. It can pick up radio signals and signatures that would be unobtainable to ground-based stations on the borders of a large country, since it can be orbited within tens of miles of ground level. The satellite can thus be seen as a valuable addition to the military arsenal, offering world-wide communications, navigation and surveillance. The "hovering bomb" or geostationary thermonuclear device parked over a potential enemy, although giving little warning of having been fired, is prone to capture or destruction *in situ* with present rendezvous techniques in space, and is unlikely to be a weapon of the future.

This then has been the first few years in space; the beginnings of a venture that is about to change the pattern of living in the world as much as the Industrial Revolution or the Wright brothers' first flight. Has it been worth it? Could the money not have been better spent on solving the problems of disease and malnutrition here on Earth? True the cost of space research, when looked at in comparison with any one research or relief project on Earth, looks large. But when divided amongst the many faculties that it is assisting the sum is seen in better proportion, and it is doubtful whether the money being spent on space medicine, for example, would materially benefit all ground-level medical research. If it were all given to one research project, say the cure of cancer, then it might be of value, but who is to say that research into space medicine will not find that cure along with many others? The satellite has proved to be such a useful scientific implement that to deny it to the scientist now would be akin to denying him the microscope. It has proved itself more than a scientific gimmick and is improving international communication and co-operation; is preventing the loss of life through weather forecasting and the loss of resources through early warning of disease and disaster. Besides giving man a far better understanding of himself and his environment, it has given him a new venture, a new step towards the age-old goal of the stars. The possibilities have been shown and found to be a necessary part of life on Earth. Since the resources and the resolve are there, one can only hope that the future will see the full potential of the satellite realized.

The British Legion—
What Does It Mean Today?

THE red poppy of remembrance is familiar enough, but all too many people, even those still serving in the Forces, know all too little about what it really symbolizes. Poppy Day does not merely signify a Day of Remembrance; it is a symbol of continuing work for the nation. Remembrance Day is not merely a nostalgic look back to the glories of war—far from it. It is an annual re-dedication of the British Legion's service to all those who have served their country. There are now some nine million ex-service men and women and their dependants in this country, and the Legion is there for any and all of them to turn to in need or distress.

The work of the Legion is not confined to elderly or disabled ex-service men. It is there to help all ex-service people, as well as those still serving and their wives, children and dependants, to return to enjoy a happy and well-adjusted civilian life. In addition the Legion's benevolence extends to all ex-service people. Out of every ten people that are helped only two are actually members of the Legion.

The British Legion has been in existence nearly fifty years now. In the first year the Legion's membership ran to 170,000 and increased steadily over the years until just before the Second World War it had 409,000 paid-up members. Today its paid-up membership is over half a million, with many honorary members and those excused subscriptions because of their age.

After the 1939/45 war one of the main problems that the Legion faced was housing, both for young and old ex-service men, and in a very short time four residential homes were opened, and since then several more have followed. In 1947 the house-purchase loan scheme was started whereby the Legion was prepared to lend to those in genuine need up to £250 for the deposit on a house. Since then the Legion has helped well over 20,000 families to buy their own homes. This is equivalent to a town of some 60,000–70,000 inhabitants.

Employment and rehabilitation continue to form an important part of the Legion's work, and altogether it provides employment under sheltered conditions for some 1,500 disabled men and women. There is a large rehabilitation unit attached

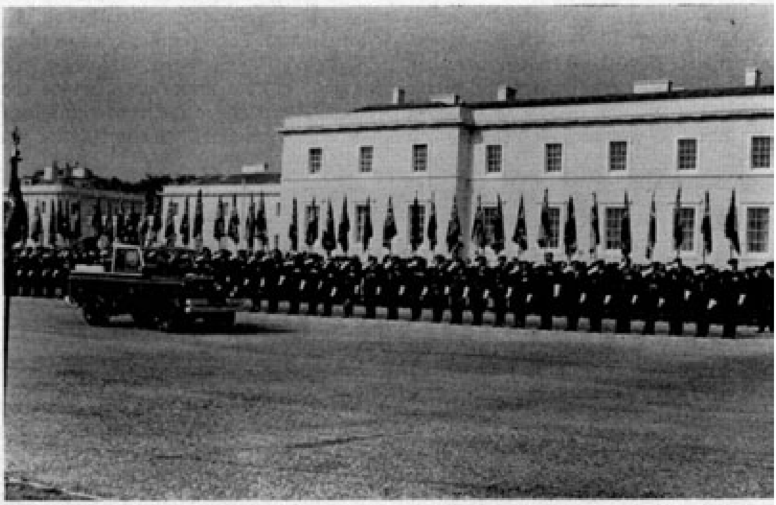
A Social Evening in The British Legion Club to the chest hospital at Preston Hall, near Maidstone, where there is a thriving village community. This village serves as a model for such establishments throughout the world, over 15,000 men having received treatment and training there.

In addition to the meaningful and worthwhile purpose that membership of the Legion gives, it can offer a widely varied social life in congenial company. There are over 4,500 branches of the Legion throughout the country and 1,011 affiliated clubs which have facilities for entertainment and sports ranging from bingo to bowling. Also a provision has recently been made to allow family members into most of the clubs. Sports participation is open to all members and there are a large number of local and national competitions and trophies.

Another aspect of the Legion's work is the way it looks after the interests of the war disabled and war widows. In addition to securing increases in the basic rate paid to all pensioners the Legion is still successfully conducting appeals for the payment of pensions for those who suffered injuries in the First World War. Every year thousands of pension cases are handled by the British Legion, with representation to an appeal tribunal provided if necessary.

To meet the cost of all this work the Legion relies on the generous contributions of the public and the support of its active and able-bodied Members. Poppy Day is still the major means of raising the vast sums that are needed.

In the coming years the British Legion's role will inevitably change. The numbers of disabled and war wounded are naturally decreasing with time and the Legion is now more than ever looking to the younger ex-service men and women for its members. With higher standards of living generally, and the resultant increase in leisure time becoming more widespread, there is as great a need as ever for an organization such as the Legion, with its ability to provide a social life with a purpose.



British Legion Parade at the RMA Sandhurst

Correspondence

Major-General R. L. Bond, CB, CBE, DSO, MC,
The Dukeries,
Compton, Guildford.

9 October 1969

OPERATION POST CROWN

Sir,—May I say with what great interest and pleasure this old Sapper read the admirable account of Operation Post Crown in the September issue of the *RE Journal*.

The impression it leaves with me is that the Corps is in fine shape and that the present generation of officers and men is full of highly qualified engineers, versatile and able to meet all the challenges of such an operation with great skill and energy.—Yours faithfully, R. L. Bond.

Major A. S. Hogben, RE, MIPlantE, AFInstPet,
HQ 29 Engineer Brigade (V),
Fenham Barracks,
Newcastle upon Tyne,
NE2 4NP.

29 September 1969

ARMY AND CIVILIAN PLANT MANAGEMENT

Sir,—Major Udall's article on Civilian Plant Management published in this issue of the *RE Journal* is of obvious interest to anyone connected with plant within the Corps and certainly should be read by any officer about to undertake a civil attachment to a plant contractor. However, Major Udall is writing as a civilian expert rather than an RE officer albeit a T & AVR one. As such he comments and compares often unfavourably the differences between civilian plant management and Army plant management, as described in Lieut-Colonel Mitchley's article published in the June 1969 *RE Journal*.

I believe that attention should be drawn to certain basic facts concerning engineer plant within the Corps which Major Udall appears to have overlooked. The prime reason for Royal Engineers holding and training with plant is to enable them to be capable of providing plant support to an army in war. Consequently there is a permanent requirement for machines, trained operators, fitters and management staff. Any aid to the civil community tasks, or projects in excess of routine training, must be looked upon as a bonus to the taxpayer and not costed against capital outlay and depreciation, since these charges exist whether the plant is utilized or not.

Civilian management technique is aimed towards increased productivity, ie efficiency expressed as a reduced cost per unit quantity of work. The Army's basic aim is to train its management to produce efficiency expressed as economy of effort and time when under stress. It is impossible to relate these two aims on a purely financial basis, since the Army does not tailor its plant fleet to fit peacetime tasks but rather adjusts its peacetime training and tasks to occupy a plant fleet designed to cope with an estimated load.

Despite these comments it is agreed that there is room for improvement in plant-management techniques within the Army not only to improve operational efficiency but also to improve financial efficiency. Thus satisfying both the soldier and the taxpayer. The former, as civilians sometimes forget, is in both categories.

Major Udall says that three points brought out by Lieut-Colonel Mitchley "condemn" Army Plant Management. They are:

(*a*) Lack of experience by both management and operators,

(*b*) under-utilization of plant, and

(*c*) a lower serviceability rate than a commercial firm could tolerate—despite an often higher proportion of fitters to machines.

Whilst agreeing that all three conditions certainly exist, I can see no reason for calling them points of condemnation. A possible exception is the case of low serviceability. I should like to comment on each of these three points in turn, starting with the question of low serviceability.

Low Serviceability—This is caused by a combination of two factors: initial machine failure and delays in returning the machine to a serviceable condition. Causes for initial failure are:

(*a*) Lack of plant operators, hence the failure to have one man one machine and the resultant inability of an operator to spot a minor fault before it becomes a major one.

(*b*) Lack of experience and practice of existing operators. This is dealt with separately.

(*c*) Too great a holding of old and/or obsolete machines. This is rapidly being rectified with the implementation of the casting policy.

(*d*) Lack of plant awareness among some non-plant specialists resulting in the incorrect use of a machine and the failure to appreciate the need for preventive maintenance

Causes for delay in the return of machines made unserviceable are more complex and often beyond the control of the immediate user, but those which reflect upon plant management at unit level are:

(*a*) Lack of a sense of urgency by officers and NCOs in units orientated towards combat engineering rather than engineer projects, ie BAOR until quite recently.

(*b*) Poor unit plant administration. Too often the plant in a field squadron is attached to the MT and put under a JNCO who is given no guidance by an officer or plant NCO. As a result of this spares are not bid for quickly, nor are they "chased" if there is any unaccountable delay.

Of all the above causes for low serviceability only the lack of a sense of urgency and poor administration are directly attributable to bad management techniques.

Dealing with the other two points: underutilization of plant certainly restricts the training of plant management teams and operators, but as was explained earlier any utilization above routine training is a bonus and the number and scope of additional tasks must be closely related to the current shortage of plant operators, and the ability to obtain suitable plant projects. Lack of experience certainly exists in large areas of plant management and operation, but this is partially balanced by a smaller group of highly experienced operators and management staff. This lack of experience is basically caused by the lack of operators. In BAOR, units held during 1967 only 51 per cent of their establishment of plant operators; the position has not altered radically since that date. The E-in-C has laid down the ideal standards for trade training within a unit to ensure an adequate spread of experience. It is interesting to compare these figures with those that exist in plant trades within BAOR units.

Standard	*Held %*	*E-in-C's Aim %*
Class I	7·8	20
Class II	9·7	40
Class III	82·5	40

There is obviously a shortage of experience within plant trades, but again this cannot be used as a reason for condemning Army Plant Management techniques.

Conclusions drawn from this letter must be that cost effectiveness of Army plant cannot by any standard be equated to civil standards and that it is accepted that, again by civil standards, operators lack experience, plant is underutilized and machine serviceability is low. However, this is not caused, except to a very minor degree, by bad management techniques, but rather by political and financial restrictions which prevent the full utilization of our plant and so restrict additional training of operators and management and the consequent increase of experience and appreciation of plant throughout the Corps.

Anyone who doubts the Corps' ability to utilize and adapt for our own use the latest management techniques, whether in plant or any other field, should be referred to the E-in-C's 1969 Annual General Meeting Address summarized in last September's issue of the *RE Journal*.—Yours faithfully, A. S. Hogben.

Colonel D. L. G. Begbie, OBE, MC,
British Army Staff,
British Embassy,
Washington 8 DC.
17 September 1969

CIVIL EMPLOYMENT OF SAPPER UNITS

Sir,—I was interested to read Professor Portway's letter in the June issue concerning protection against coast erosion and Brigadier T. W. R. Haycroft's letter in the September *Journal*.

The United States Corps of Engineers is, of course, the Federal agency for several important fields of engineering, and one of these is coastal engineering. Here their responsibilities concern the coastal zone extending from the tidal waters of estuaries out to the sea to depths where the building of structures is feasible. This is apparently defined as depths up to about 200 feet. The Great Lakes are included. Considered amongst the structures are navigation channels, piers, embankments, and the beaches. There is an interesting relationship of cause and effect between the work of the Corps inland on the construction of dams and reservoirs, and navigation channels and beaches.

The Corps of Engineers has a Coastal Engineering Research Center in Washington, DC, dating back to the 1920s. It is quite small and two-thirds of its research is done out-of-house at Universities. It maintains links with the Wallingford Hydraulics Research Station in the UK. Some of the Center's work concerns the evaluation of designs for breakwaters and groynes and for the protection of embankments, including dams, from wave action. One completed project of particular interest with which the Center was associated was the construction of the storm surge protection barrier across the mouth of the Providence River, Rhode Island.

Unhappily, however, the US Corps of Engineers have so far been unable to employ engineer troops on coastal projects except in emergencies. Some tasks, such as dredging channels and the pumping of sand to build up beaches, may not be suitable for troop training; others, such as the driving of sheet piling, requires skills which are not readily available at present in the US Corps of Engineers. But one senses that the real difficulty lies with overcoming the objections of the construction industry to the employment of troop labour. The situation as at present is that the Corps of Engineers are restricted to the management and important Architect/Engineer function and to providing a lead in research. They would envy us if we could do better.—Yours faithfully, D. L. G. Begbie.

Memoirs

MAJOR-GENERAL M. N. MAC LEOD, CB, DSO, MC

Colonel Commandant RE (Rtd)

ADC to King Edward VIII and King George VI 1936 to 1939

MAJOR-GENERAL MALCOLM NEYNOE MAC LEOD, Director-General Ordnance Survey from 1935 to 1943, died at his home in Dibden Purlieu, Hampshire, on 1 August 1969, aged 86 years.

The eldest son of Malcolm Neynoe Mac Leod of Rajpur Chumparun, he was born in India on 23 May 1882, and was educated at Rugby. He passed third into the Royal Military Academy, Woolwich, in the autumn of 1898, and on passing out he was awarded the Queen Victoria Gold Medal, the Pollock Medal and the prizes for Military Topography and Geometrical Drawing. He was commissioned into the Royal Engineers on 2 May 1900, the top of his batch.

During his two years' Junior Officer training at Chatham he played Rugby for the Corps and captained the side during his second year there. During the winter of 1901–2 he also played Rugby for Blackheath and Kent and was invited to join the Barbarians for their tour in Wales. He also represented the Corps at hockey, and he was an outstanding tennis player; in later years he played for both Sussex and Hampshire.

He was posted to India in May 1902, where he joined the Military Works Services at Jubbalpore, and after three years there he went on temporary attachment to the office of the Director-General Military Works at Simla.

In 1905 he was posted to the Survey of India, but, as a result of enteric fever, he was given six months' home sick leave, part of which he spent skiing in Switzerland—a pursuit looked upon in those days as a somewhat unusual one for a serving officer. On returning to India he rejoined the Survey of India and worked on the surveys of the Khyber and Malakaland passes and in the Central Provinces and the Punjab. In May 1910 he was promoted captain and soon afterwards he was transferred to the Headquarters of the Survey of India in Calcutta. The climate of Calcutta, however, brought on a fresh attack of fever and he was placed in charge of the Trans-Frontier Mapping Office at Simla, known as the "Simla Drawing Office". In March 1914, after an operation for appendicitis, he was invalided home and was in Millbank Hospital on the outbreak of the First World War in August of that year.

On being pronounced fit early in the following year he was ordered to Buxton to raise and train the 145 Army Troops Company, RE, and he took the unit to France in September 1915. He remained in command of the Company until early 1916, when he was transferred to the newly-formed Headquarters of General Rawlinson's 4th Army to raise the 4th Field Survey Company, RE. During the Somme offensive of 1916 the Company was involved in the development of artillery survey and the laying of guns on pre-selected targets without ranging, thus making surprise bombardment possible, and the production in the field of large numbers of tactical maps. In this latter connexion, so confident was the General Staff 4th Army of a return to mobile warfare, that it took a lot of convincing that things so immobile as printing machines and other map-production equipments were essential if tactical maps were to be produced in the vast quantities required. He continued to command survey units until the end of the war. He was promoted major in May 1916 and became an acting lieut-colonel in June 1918 when Field Survey Companies became Battalions. He was awarded the MC in January 1917 and the DSO in the following December.

After the Armistice he accompanied 2nd Army Headquarters to Cologne and remained there until selected in 1919 to become the Chief Instructor (Survey) at the

Major-General M N Mac Leod CB DSO MC

School of Artillery and to set up a Survey Branch at Larkhill. Before taking up the appointment he raised, and for a short time commanded, the 1st Survey Company RA, being probably the first engineer officer ever to command an artillery unit since the Gunners and Sappers bifurcated in 1716.

In 1923 he joined the Ordnance Survey at Southampton and the following year he married Elsie May, daughter of W. E. Gould, Esq, of Wooton, New Milton. He remained at Southampton until 1929, being successively in charge of the Control and Publications Divisions. Then followed six years at the War Office as GSO 1 MI 4, the Geographical Section of the General Staff whose main duties were the provision of maps for war, the collection of all geographical and topographical information of the Empire and foreign countries and the co-ordination of all survey organizations in the Empire. As a result of both his war experience and his service with the Royal Artillery Mac Leod held strong views on the sort of maps required for war, especially for the Gunners. He was convinced that the decisive factor which made the difference between the failure of all attacks in 1914, 1915 and 1916 and the successes of those in 1917 and 1918 was not the use of tanks, as was generally supposed, but the change in artillery techniques made possible by the introduction of survey methods of aiming whereby enemy guns were almost completely silenced by accurate counter-battery fire. He felt sure that, whatever the tank experts might say, heavy concentrations of artillery fire would still be needed in a future war and that this fire would only be effective if predicted methods, based on the right kind of maps, were used. To produce such maps would, in many instances, require the RAF to fly photo-reconnaissance sorties. The Air Staff, however, was not then interested in the tactical uses of survey photography and the General Staff was more intent on the development of Armour and the theories propounded at the time by Fuller and Liddell-Hart than on artillery tactics. To ventilate his views Mac Leod published numerous articles in the *RE Journal* and the *RUSI Journal* and lectured widely on the subject. He found a ready ally in Major-General G. Walker, CB, CBE, DSO, at that time Inspector Royal Engineers and Commandant School of Military Engineering and, with his help, Staff authority was obtained to convert 19 Field Company into a survey training unit.

In February 1935 Mac Leod was appointed Director-General Ordnance Survey with the rank of Brigadier. The affairs of the Department had at that time reached something of a crisis. As a result of the 1922 Geddes Axe its strength had been greatly reduced at a time when large arrears of map revision, left over from the 1914–18 war, had still to be made up, and following that there had been a postwar revolution in road construction and house building which had altered the face of the countryside. In addition social legislation, and in particular the Town and Country Planning Act of 1932, could not be put into operation without up-to-date official maps and plans, and for the most part these did not exist. An Inter-Departmental Committee, under the chairmanship of Sir J. C. C. Davidson, authorized the recruitment of extra staff for the Ordnance Survey to tackle the backlog of work and the retriangulation of Great Britain and the upgrading of the Director-General's appointment to Major-General in view of his greatly increased responsibilities.

As Director-General Mac Leod was responsible for the training and mobilization of the Survey units of the Field Army, since nearly all the personnel of the units to be raised, including the officers, were employed in the Ordnance Survey in peace. Mobilization in September 1939 took place at Fort Southwick, the quarters of 19 Company. Having been responsible for the training of all survey personnel in peace, Mac Leod was given the task of training new survey recruits on mobilization and was created "Inspector of Survey Units RE".

During the opening stages of the war the Ordnance Survey produced about nine-tenths of all the maps needed by the Army and Royal Air Force, as no large-scale service map-production organization existed.

The Dunkirk evacuation raised urgent problems since the Army map-production policy had not taken into account the possibility of an invasion. The stocks of maps in Command Stores and in the Ordnance Survey itself were based on training requirements only and sheets covering coastal areas, where an invasion might be expected, were sufficient only to meet the needs of possibly not more than one battalion. To produce sufficient maps of the whole of the south and east coasts would have meant printing some six million maps, a huge task that could not possibly have been completed in less than two or three months. It was, therefore, essential to start printing straight away maps of the most likely invasion areas and to obtain from the General Staff the necessary priorities. Once this had with difficulty been obtained a first-phase printing order was hastily drawn up and practically every private firm in the country that could print maps was co-opted to help, the Ordnance Survey producing the plates and the paper, and an empty warehouse in York was commandeered as a central map store. The Ordnance Survey also helped Home Forces in the fixation of certain battery positions and in other survey tasks.

Another matter that resulted from the Battle of Britain was the location of the Headquarters of the Ordnance Survey itself, situated as it was in the target area of Southampton. Although, due to impossibility of stopping any of the urgent work in hand, an immediate move to a safer spot was out of the question, a line was, however, secured on a large modern civilian printing works in Nottingham which could be taken over by Ordnance Survey personnel as a running concern if the need arose. Duplicate plates and stocks of paper were collected there and a small branch office established in order to facilitate the move should it become necessary. In addition parts of the organization were dispersed into huts on the outskirts of Southampton. The first Blitz on 23 November 1940 was a relatively small affair and only a few incendiary bombs fell on the Ordnance Survey offices which were easily extinguished by the fire party on duty. In a second raid a week later incendiaries and high-explosive bombs rained down in hundreds. The offices were fired in several places, the barracks, administrative buildings and the map negative and general stores besides other buildings were destroyed, including one in town in which three Air Photo Plotting Machines were housed. Heavy though the damage was, it fell mostly on the civil side of the Ordnance Survey and the military work, carried out in the Crabwood hutments, suffered only a short interruption. A vivid account of these raids was given in the citation for the George Medal awarded to (Survey) Boy Thompson for gallantry during them. It read:

"During an enemy air attack on Southampton on 23 November 1940, Boy Thompson was assisting a Sapper as lookout on a high building in the Ordnance Survey offices. He remained on duty throughout the raid, accurately reporting the fall of high explosive and incendiary bombs. When the attack was renewed on 30 November, Boy Thompson was a member of the fire-fighting party under Captain Keleher. When an incendiary bomb fell through the roof of a map store and fired large piles of maps inside, Captain Keleher broke into the room, which was full of smoke and fumes, and succeeded in playing on the fire with a hose. After a time he was overcome with smoke and fumes and had to withdraw. Two other men then attempted to take his place, but both were beaten back. Thereupon Boy Thompson, wrapping a wet cloth round his face, went in and succeeded in holding the hose on the fire until it was got under control. Later in the night, Boy Thompson, with another boy, volunteered to investigate and report on the state of a large three-storey building, on the roof of which incendiary bombs had fallen. He forced his way into an attic which was found to be ablaze, and made an accurate report to his superior officer. Though only 17 years of age, Boy Thompson throughout the night showed remarkable initiative as well as great devotion to duty and complete disregard of danger.

"All the above actions were carried out during a heavy bombardment with high explosive and incendiary bombs falling on an enclosure closely packed with large buildings, six of which were ablaze."

The Ordnance Survey was later evacuated and, although no more bombs fell on Southampton, its new offices at Esher and Chessington had many narrow escapes from the flying bombs and rockets when these started to fall on and around London.

Before Major-General Mac Leod's retirement in July 1943 at the age of 61 the Ordnance Survey had since the outbreak of war turned out over 100 million maps—a prodigious total three times greater than the total production during the First World War. In recognition of his outstanding services he was created CB in January 1942.

After his retirement he joined the 12th Battalion Hampshire Home Guard and became Second-in-Command to Lieut-General Sir Lionel Bond, KBE, CB, and when the war finished he undertook several unpaid and semi-public duties including the post of Chairman of the Ministry of Labour Disablement Advisory Committee.

In April 1946, at the invitation of the Government of Iraq, he went to Baghdad to advise them on an organization for their surveys. The visit was, however, marred by ill health and eye trouble and soon after his return he lost the sight of an eye due to a retinal detachment which an operation failed to restore.

He was a Colonel Commandant RE from 1941 to 1950.

REF has written the following tribute:

"It's a small world. I am writing these notes in the village of Comrie in Perthshire where General Mac Leod, as a school-boy frequently came to stay for his holidays with his uncle and aunt. Only today I have seen his photograph taken in 1894 at a cricket party.

"I have known General Mac Leod for over forty years. When I first met him at the Ordnance Survey in Southampton in 1925 I was one of the newly commissioned 'Forty Thieves' and the impression he made on me then and later was profound.

"He was a Colonel in MI 4, the Geographical Section General Staff at the War Office, from 1929–1934. I was then a G 3 and no one could ever have had a finer example of a really good Commanding Officer. Major-General Willis was with me at that time, and I am sure he will agree with me.

"Technically as a Surveyor he was unequalled and at that time the art of mapping from air photographs was just making itself felt. His help to men like Martin Hotine and John Salt was immense.

"In 1937 when I was Chief Instructor in Survey at the SME, Mac Leod, who was then Director-General Ordnance Survey, visited the YO batch who were in Devon on practical survey. His talks in the class room and his advice in the field were most helpful.

"From late 1938 until the outbreak of war in September 1939 I was General Mac Leod's Military Training Officer at the Ordnance Survey in Southampton—a terribly difficult job preparing a largely civilian thinking establishment for war. Without General Mac Leod's backing I doubt we would have been ready for mobilization in the Autumn.

"Immediately after Dunkirk in 1940 the Ordnance Survey were faced with huge printing orders for gridded maps of the UK for the Army since a German invasion was quite a possibility. Largely due to General Mac Leod, who was still DGOS, this problem was tackled by him and GSGS War Office and the help of Martin Hotine. Later when I was D Svy Home Forces many troubles arose but I found that a visit to Southampton usually helped as did the generous hospitality of the General and Mrs Mac Leod.

"In 1945, when D Svy Middle East, the Iraq Government asked me to recommend an eminent surveyor to fly out to Baghdad to advise them on their post-war Survey policy. Without hesitation I recommended General Mac Leod and it gave us all in Cairo great pleasure to entertain the General and to show him our Middle East Survey set up.

"Since then I have kept in constant touch with General and Mrs Mac Leod by letter. He was always most keen and anxious to hear any survey news and until quite recently, when his sight began to fail, he always wrote replies in his excellent handwriting.

"So passes another most distinguished senior officer of our Corps and as brilliant a military surveyor as we shall ever have."

COLONEL E. S. SINNOTT, CMG, VD, TD

COLONEL EDWARD STOCKLEY SINNOTT, who died on 9 August 1969, eleven days before his hundred and first birthday, was County Surveyor of Gloucestershire from 1907 to 1935 and served in the Royal Engineers in the South African and in the First World War.

Educated at Clifton College, he studied engineering at what is now Bristol University and in 1886 he was articled to John Ward Grindlestone, Chief Engineer of the Bristol Docks. On becoming a chartered civil engineer he worked first for the dock and railway engineering firm of Thomas Miek and Sons in London and Edinburgh and later spent six years in South Wales working on dock and railway construction in the Port Talbot area, then a rapidly developing industrial estate. During this time he was an active member of the Gloucestershire Royal Engineers Volunteers, becoming a captain in 1893. In 1899 he went to South Africa in command of a Section of the 2nd Gloucestershire Royal Engineers Volunteers which, together with several other Royal Engineer Volunteer units, volunteered for active service overseas —the first time that units of the Reserve Army were thus employed.

On returning from the South African War he worked for some time as a free-lance civil engineer in Cardiff, and in 1907, he was appointed County Surveyor for Gloucestershire, a post he held, apart from the war years, until 1935. In 1908 he joined the newly formed Territorial Force and became CRE of the 48th (South Midland) Division in 1912.

He went with the Division to France in March 1915 in command of the 1st and 2nd South Midland Field Companies (TF), his Division becoming part of the 5th Army Corps. He was mentioned in despatches and was created CMG in 1915. In 1918 he was promoted colonel.

In 1919 he returned to his work as County Surveyor, was made a Deputy Lieutenant for Gloucestershire and became deeply involved in the life of the county. On his retirement in 1935 he became a magistrate on the County Bench and honorary secretary and treasurer of the Friends of Gloucester Cathedral. He carried on his work for the Cathedral until well into his nineties.

Being too old for active service during the Second World War, he served in the local ARP.

In 1905 he married Violet Carew Potter, daughter of the Rector of Bishopston, Glamorgan. They had two sons and five daughters. One son died in 1916 and the other was killed on active service in 1941. His wife died in 1920, and in 1922 he married Violet Adela Peel, daughter of Colonel Frederick Peel. He is survived by his five daughters, ten grandchildren and seven great-grandchildren.

Colonel J K Tickell

COLONEL J. K. TICKELL

JOHN KAYE TICKELL, son of Charles Tickell, Indian PWD, was born at Lahore on 28 December 1894. He was a grandson of Lieut-General Richard Tickell, CB, Bengal Engineers, and the younger brother of Major-General Sir Eustace Tickell, Engineer-in-Chief from 1945 to 1948. He was educated at Bedford and the RMA Woolwich, where he was an outstanding gymnast. He was commissioned within a few days of the outbreak of World War I and, after a short course at the SME, joined the 59th Field Company in the 5th Division. He was mentioned in despatches, but soon after the Battle of the Somme was invalided home. When fit again he was sent to Chatham as Assistant Adjutant of the Training Battalion. Soon after the Armistice he was posted to Palestine, where he reconstructed the water-supply to Jerusalem from Solomon's Pools, near Bethlehem, and was employed on the building of the original Allenby Bridge over the Jordan—a Class 20 Inglis Bridge.

He was recalled to join No 4 Supplementary Course, after which he did an E & M Course and a tour as an Instructor at the SME. He was then appointed E & M Officer Eastern Command, and in 1928 was posted to Meerut, and later Mhow, in India. On return home he became Chief Instructor at the Boys' Technical School, Chepstow. On promotion to lieut-colonel in 1937 he was appointed CRE Jamaica, where he was serving when war broke out. On completion of his tour he was made O i/c RE Records, an extremely arduous post which he held until his retirement in November 1944.

On 3 September 1921 he had married Alida Mary, daughter of Colonel H. T. H. Hay, Indian Army, and since the war they have lived at Wormley near Godalming. There he died peacefully on 10 September 1969 after a long illness, and leaves a son and a grandson.

E.F.T.

Colonel F E Orange-Bromehead OBE

COLONEL F. E. ORANGE-BROMEHEAD, OBE

DICK O-B died after a brief illness during a visit to Cumberland on 18 July 1969. He was 76. His loyalty, quiet and unassuming nature and dry wit won him the trust and affection of all those with whom he dealt.

He was born in 1893. After leaving Cheltenham College he passed into the "Shop" in 1911, and was commissioned into the Corps in 1913. During the First World War he served with RE Signal Sections in Salonika, where he was twice mentioned in despatches in 1918. He was awarded the OBE for his war service in 1919.

After the war and a long E & M Course he went out to India in January 1923, where he served for several years on the North-West Frontier in the Indian Military Engineer Services as GE and ACRE at Kohat and Peshawar. He returned to England on leave in September the same year to marry Betty, the daughter of Lieut-General Sir Alfred Martin, KCB. They returned immediately to Kohat, where the maintenance of the roads, mainly through Independent Territory and pretty hostile at that time, was a large part of his job. He believed that the weapons of an escort would attract the interest of the Pathans and so went out alone and unarmed. Pathans also respect courage and the Punjab Frontier Force Regiments, with whom he worked and often messed, made him an honorary life member of their Association. An officer who was then a GE when OB was ACRE at Peshawar, recalls with appreciation his hospitality, cheerfulness and willingness to help a young and inexperienced brother officer through the tangles and pitfalls of Military Works Services. He held other E & M appointments in Murree, Ferozepur and Lahore. He received his majority in 1928.

He returned home in 1931 and in January 1932 was appointed OC 54 Field Company, then part of the 3rd Divisional RE at Bulford Camp. Another officer, who was then a newly joined subaltern in the Company, remembers the firmness, understanding and humour with which he kept all ranks aware of the purpose behind their work, and the atmosphere which produced a happy and efficient unit. He particularly recalls an occasion when: "It having been agreed that the Company, which was still unmechanized, would march to Wyke Regis Bridging Camp in May 1934, O-B and his wife devoted a number of week-ends to reconnoitering a route which almost completely avoided main roads, and to selecting three delightful overnight camping sights. The weather was kind and the result was a four-day idyll with, once we had left the Plain, bluebells all the way. This was peace-time soldiering at its best."

In April 1935 he returned once more to India, where he held Works appointments in Bangalore, Poona and Rawalpindi, where he was CRE. After the outbreak of war, he was promoted Colonel and sent to Quetta as Deputy Chief Engineer Baluchistan. Here he was responsible for building the road from Quetta into Persia as well as a number of airfields in the area.

He finally returned home in 1943 to become Deputy Chief Engineer, Eastern Command. While he was there he was concerned with the tricky task of beach mine clearance which was just beginning. In 1945 he became Chief Engineer Northern Ireland before retiring in July 1946.

He and Betty went to live in Suffolk, where they grew asparagus and apples for market with varying success. He also gave much of his time to his village and local activities. He was churchwarden and a member of the Rural District Council, where the qualities that had marked his service life were greatly valued.

One of the chief pleasures of his life was sailing. As a YO he was part-owner of a much-sailed concrete-ballasted fishing smack called *Mayflower*. During his tour in Bangalore a second *Mayflower* was built in the MES workshops. She was the first of a class of Snipes which formed the fleet of the Bangalore Sailing Club of which O-B was the first Commodore. Wartime sapper and infantry officer cadets, who included two of his sons, were among the many who enjoyed their Sundays' sailing on the Hesarghatta Tank, where the Club sailed.

There was more sailing at Poona. Whilst there he personally cut a race-winning suit of sails for his boat, whose set and performance gave rise to much envy and admiration. After the war he rejoined the Aldeburgh Yacht Club and was its Commodore from 1961/2. He passed on his love of sailing to all his three sons.

His Memorial Service was held at the Swefling Village Church. The packed church, and the many remarkable letters received by his wife, bore witness that he was held in the same affection by all those who knew him in retirement as he had been in the Corps.

B, J, F & R O-B

LIEUTENANT M. J. C. ASHMORE
and
LIEUTENANT A. W. WALKER

LIEUTENANTS ASHMORE and WALKER were two of a party of four Sapper officers who last summer set out from the Royal Military College of Science on an Adventure Holiday intending to reach Persia.

They were both killed instantly in a road accident near Salonika, Greece on 28 July 1969.

Martin John Christopher Ashmore was born on 25 November 1946. His father, Mr Sydney Ashmore, had a long and distinguished career in the Royal Regiment of Artillery, retiring as a Warrant Officer. As a Battery Sergeant Major he was awarded the Military Cross for continuous outstanding devotion to duty throughout the NW Europe campaign—a rare award for a Warrant Officer. His sister is serving in the QARANC.

Martin was educated at Alexandra Grammar School, Singapore, Huish's, Taunton and St John's, Singapore before entering the Royal Military Academy, Sandhurst.

CPC writes: "I first met Ashmore as a cadet at Sandhurst when he joined my Company in September 1965. He had a distinguished record. He became my Senior Under Officer and passed out first in the order of merit winning the Queen's Medal. He was also awarded The Institution of Royal Engineers Silver Medal and Prize for the most distinguished cadet of his term entering the Corps. His distinctions, however, were not only academic. He was a talented athlete and represented the Academy at Soccer, athletics and cross-country running and was captain of the Basketball team. He was also a good cricketer and tennis and badminton player and, when in Singapore before entering Sandhurst, he had played forward in the 'under 23' Rugby side. Chess was also one of his hobbies.

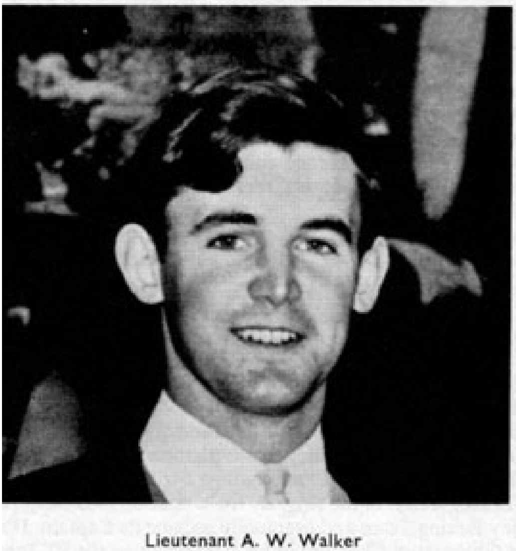
He was commissioned in July 1967 and after his YO Course he joined the 1st Division Engineers, of which I was CRE. He was posted to 4 Field Squadron and served with it for seven months before going to Shrivenham. In June 1968 he ran the Divisional Canoe camp in Denmark, the highlight of which was a 90 mile expedition in Limfjord, all food clothing tentage and equipment being carried in canoe. His greatest athletic achievement was his recent winning of the Army 3000 metres Steeplechase Trophy.

He was a very promising young officer, modest in manner but dedicated to his profession. It is a great tragedy that he should have died so young as he had a bright future before him."

Andrew William Walker was born on 28 October 1946 the only son of Colonel R. J. Walker, OBE and Mrs Walker. He was educated at Hawtreys and Eton (D. P. Simpson's). He represented Eton at both boxing and gymnastics. He was a gymnast of exceptionally high standard and was Vice Keeper of Gymnastics.

Andrew entered Sandhurst in January 1965 and quickly showed himself to be one of the outstanding members of his junior platoon and within a few weeks he established his reputation for skill and courage by nearly defeating the Captain of the Academy Boxing Team in the ring. By the winter of 1965 he appeared regularly for the Academy Boxing Team and eventually became its Captain. He was a founder member of the Gymnastics Club and in his last term won the PT Prize. He was also a member of the Free Fall Parachute Club. During the summer of 1965 he was attached to a field squadron engaged on building a road in Canada. Everyone was impressed by his enthusiasm and the way he drove himself to do more than was required particularly on outdoor exercises. In September 1966 he was made a

Lieutenant M. J. C. Ashmore



Lieutenant A. W. Walker

Lieutenant M J C Ashmore, A W Walker.

Junior Under Officer. He was commissioned into the Corps on 16 December 1966, the third in his Batch.

After his YO Training he became for a short time a Troop Commander in 9 Independent Parachute Squadron, RE where he continued his free fall parachuting activities and, when Her Majesty The Queen, in her capacity as Colonel in Chief of the Corps, visited the RSME on 28 March 1968, Walker was presented to her as one of our 'Skydivers'. He also jumped frequently with the Royal Marine Sports Parachute Club near his home in Devon where his youthful and cheerful approach to the sport was greatly admired. His interests however were varied and covered history and archaeology. He had a private dig on a mediaeval site near his home. He was also a keen motorist.

During his first Christmas leave from Shrivenham he was attached to 52 Airfield Squadron, RE then engaged on extending the El Adem runway. The staff of the Royal Military College of Science have written about his high officer qualities, his cheerful disposition and the air of confidence and authority about him. His Military Supervisor wrote that, above all others on his Course, he would have liked to have had Andrew serving in his unit.

The Royal Engineers can ill afford to lose two such splendid young officers, so full of vigour and life and of such high promise, and our deepest sympathies are extended to their families in their sad loss.

Book Reviews

HISTORY OF THE SECOND WORLD WAR
The War Against Japan Volume V
MAJOR-GENERAL S. WOODBURN KIRBY, CB, CMG, CIE, OBE, MC
with
BRIGADIER M. R. ROBERTS, DSO, COLONEL G. T. WARDS, CMG, OBE, and AIR VICE-MARSHAL N. L. DESOER, CBE
Edited by SIR JAMES BUTLER
(Published by HMSO. Price £6 6*s* 0*d* net)

This is the fifth and last of the Volumes describing the War against Japan.

In a Note by the Editor Sir James Butler writes: "Major-General S. Woodburn Kirby died, after a long illness, on 19 July 1968. He had looked forward eagerly to seeing the public appearance of this volume, the completion of the work on which he had been engaged for eighteen strenuous years. That, unfortunately, was not to be; but he had at least the satisfaction of receiving a copy of the volume in book proof form a few days before his death".

The Volume is in four parts covering the period from the capture of Rangoon and the opening of the American assault on Okinawa in April 1945 to the disbandment of SEAC in November 1946.

Part 1 describes the final operations in Burma and the plans for the invasion of Malaya, not put into operation due to the Japanese surrender in August 1945.

Part 2 deals with the battle for Okinawa which the Japanese defended traditionally to the last man and the last round, the sea battles between the Japanese suicide Kamikaze aircraft and the Allied Fleets, the close blockade of Japan and the bombing of her installations and cities, the plans for the invasion of Japan, the dropping of the two atomic bombs, the short campaign in which the Russians overran Manchuria and the final acceptance by the Japanese, at the insistence of their Emperor, against the wishes of his Service Chiefs to continue fighting, of the unconditional surrender of all their armed forces.

Part 3 deals with Lord Mountbatten's Post-Surrender tasks in the previously British territories of Malaya, Singapore and North Borneo and in addition Sarawak, Siam, French Indo-China and the Netherland East Indies all occupied by the Japanese. Foremost among these tasks was the rescue of some 123,000 Allied prisoners of war and civilian internees, scattered in tens of thousands throughout the whole vast area, whose condition was in most cases desperate and the rounding up, disarming and repatriation of three-quarters of a million Japanese troops, whose acceptance of their country's capitulation could not with certainty be counted upon, and the safekeeping of millions of tons of Japanese munitions and weapons. These tasks had to be carried out in widely dispersed, heavily populated countries where, for the most part, there was a great shortage of food and no reliable government with any shadow of independent administration and no police force. Indeed, the situation in the Netherland East Indies was further complicated by a confrontation with the self-styled Independent Republic of Indonesia, which the Japanese had allowed to grow up, bitterly opposed to the return of Dutch colonial rule.

Part 4 contains a résumé of the war against Japan. It also traces the history of the Japanese nation and her emergence first as a Far Eastern and then as a World Power with a vision of a Japanese-dominated Southern Region comprising Indo-China, Siam, Malaya and the Netherland East Indies to ensure her supplies of raw materials and oil, and a grandiose Greater East Asia Co-prosperity Scheme. The history concludes with the events leading up to the 1937 China "incident" and Japan's subsequent involvement in China, and her entry into the Second World War which, after spectacular initial successes, brought the country to the threshold of annihilation.

The Epilogue to the Volume summarizes how, once the enormously industrially powerful United States had recovered from Japan's initial surprise blow on Pearl Harbour and gained command of the sea and air, victory in the Pacific, although costly and not easily attained, was inevitable.

The situation in South East Asia was, however, completely different. Although Singapore was before the war recognized as the keystone of Commonwealth strategy in the Far East, the disaster of Dunkirk, the collapse of France, whose task was to neutralize the Italian Fleet in the Mediterranean, the need to hold the Middle East and to send convoys of armaments to assist Russia repel the German invasion made it impossible adequately to reinforce the place with land, sea and air forces to deter Japanese aggression, even after Japan had occupied southern French Indo-China in July 1941. It was believed that our real defence in the Far East, and the only deterrent the Japanese would recognize, was American naval power. This was shattered at Pearl Harbour in December 1941 and by March of the following year the weak Allied garrisons in the Far East had been overwhelmed and, other than the British and Indian forces closely pursued by the Japanese through Burma and a few beleaguered American troops in the Philippines, the British, Indian, Australian, Canadian, American and Dutch forces in the Far East were either dead, prisoners of war or fugitives in the mountains. Subsequent counter-offensives to expel the Japanese from their territorial gains were limited by the overall strategy that the defeat of Germany should take priority over the defeat of Japan, and the shortage of ships, landing craft, troops and aircraft that this limitation imposed.

Further it was essential to maintain Chiang Kai-shek and his Nationalist Government. His Army had held out against the Japanese since 1937 and, between then and 1941, had inflicted 600,000 casualties on the invading armies. At all costs it was vital to ensure that he did not make a separate peace with Japan. This policy paid handsome dividends. From the end of 1941 to August 1945 about half the Japanese forces serving overseas were tied down in China; the Japanese offensive of 1944 involved 620,000 first-class troops and was the largest land operation undertaken by them during the whole war. In all, during that period, 396,000 Japanese troops lost their lives in China. The cost to China of the eight-year struggle is given as 2·3 million officers and men, of which 1·3 million were killed, and the losses of civilian life and property incalculable. Chiang, however, was an intransigent person with whom to deal. At times the situation became almost Gilbertian. He consistently refused to co-operate with British plans for an offensive in North Burma unless included in the plan was a simultaneous major amphibious operation in the Bay of Bengal. The Americans, however, refused to allow resources being diverted for amphibious operations against Rangoon in order that every effort should be concentrated on opening land communications to China by way of North Burma, a vast engineering project which the British considered would be time-consuming and would not produce the capacity to carry a really worth-while flow of material to Chiang's forces.

In August 1945, following the dropping of the atomic bombs on Hiroshima and Nagasaki, Russia declared war on Japan and invaded Manchuria, where, after the Japanese surrender, they took no steps to prevent huge quantities of surrendered weapons and equipment falling into the hands of Mao Tse-tung and his disciplined force of 300,000 Communists backed by a large militia force in NW China. Furthermore, in spite of the efforts made by the Americans rapidly to transport Nationalist Armies to key areas such as Shanghai, Nankin and Peking to accept the surrender of Japanese forces, the Chinese Communists were able to force the surrender of a large number of Japanese in north and central China and take possession of their arms and ammunition. From then on the days of the war-weary Nationalist Government were numbered, and the Waker of the Sleeping Giant started to exert an inexorable hold over the country—a transformation in China more profound than had happened since the fall of the Manchu Empire.

The Russian declaration of war was the decisive factor in bringing Japan to accept the Potsdam Declaration, since the last chance of a hoped-for Russian intervention to bring about a negotiated peace went with it. It is noteworthy to learn from Japanese official sources that the atomic bomb attacks on Hiroshima and Nagasaki were dismissed at the time by the Chiefs of the Armed Services, despite the immediate destruction they caused, as no worse than heavy B29 incendiary attacks. They were then, of course, unaware of the long-term effects of radiation and fall-out. They also argued that, if crippling losses were inflicted on an invasion force, the Allies might be driven to modify their uncompromising surrender terms and there were still large Japanese armies overseas capable of resolutely continuing the fight. A struggle developed in the Supreme Council between those who held these views and those who wished to surrender before the country suffered complete economic ruin, further frightful destruction and the horrors of an invasion. Eventually the Emperor persuaded the Council to accept the Allied terms with the proviso that the Imperial dynasty was retained which, by implication, they had already done.

The Volume ends with the following epitaph:

"The most important results of the war against Japan were the emergence of Communist China as the dominant Power in east Asia in place of Japan, and the gradual disappearance of colonial rule by the Western Powers. A number of newly-fledged independent nations emerged, some of which were to remain within the western orbit, some uncommitted either to the West or to the Communists and others which came under Communist influence in whole or in part. It can therefore be said that, although Japan failed to gain control of the Southern Region and to set up her Greater East Asia Co-prosperity Sphere, she did succeed in her aim of ousting the European Colonial Powers from their dominating position in Asia."

J.L.

POST-SURRENDER TASKS
REPORT TO THE COMBINED CHIEFS OF STAFF
BY THE SUPREME ALLIED COMMANDER SE ASIA 1943–1945

VICE-ADMIRAL THE EARL MOUNTBATTEN OF BURMA

(Published by HMSO. Price 8*s* 6*d* net)

In the Preface to the Report Earl Mountbatten explains that, due to political considerations, it was considered inappropriate for it to be included with the rest of his narrative, published in 1951, covering his appointment as Supreme Allied Commander, South East Asia Command from 1943 to 1945. The report covers the nine-month period from the Japanese capitulation to the closing down of SEAC on 30 November 1946. It was, he writes, in many respects a more difficult and testing time than any during the war, and made no easier by the transfer to him, at the time of the surrender, of the Netherland East Indies from General MacArthur's South-West Pacific Command where an Independent Republic of Indonesia had been set up before he took over. In Malaya the relations between the Chinese and Malay populations were not easy. The decision to divide French Indo-China arbitrarily on the 16th Parallel, putting the country to the north of this line under Generalissimo Chiang Kai-shek, soon to be ousted by the Communists, sowed the seeds of a conflict not yet resolved to this day.

Following the ravages of war there was an acute shortage of food everywhere and no existing reliable civil government organization in any of the vast and far-flung territories for which he was made responsible with a population exceeding 128,000,000 people. Some 122,700 Allied prisoners of war and civilian internees, scattered in tens of thousands from Siam and Indo-China in the north to the Netherland East Indies in the south, and from the Andamans to the West and to Hong Kong to the east, whose condition was desperate and death-rate high, had had to be safeguarded and given relief. Three-quarters of a million Japanese soldiers had to be disarmed, concentrated and repatriated. French forces had to be reintroduced into Indo-China and Dutch forces into the Netherland East Indies, against the wishes of those who held power there, and conditions had to be created in former British possessions for a return to civil government.

In the Preface to his Report Earl Mountbatten says that he welcomes its publication as a means of recalling how difficult, urgent and complex the tasks were which our forces were called upon to carry out, and how well they met the challenge.

J.L.

GRETNA
BRITAIN'S WORST RAILWAY DISASTER (1915)

JOHN THOMAS

(David and Charles. Price 30*s*)

At 3.45 am on 22 May 1915, the first half of the 7th (Leith Territorial) Battalion the Royal Scots left Lambert Station on their journey to Liverpool and thence to the Dardanelles. The second half of the battalion was due to follow them shortly afterwards in another train.

Less than three hours later, of the gallant fifteen officers and 470 soldiers who had set off in such high spirits in the first train, 214 were dead and 204 injured as a result of a railway accident at Quintinshill, near Gretna. A tragic combination of circumstances, forgetfulness and errors led to a disaster unprecedented in railway history. The south-bound troop train collided at seventy miles an hour with a stationary local train, and a few moments later the night express from Euston to Glasgow, travelling at sixty miles an hour, ploughed into the wreckage causing terrible chaos and a blazing inferno. The troop train, which, with its engine and fifteen coaches, had been 213 yards long was reduced to a pulverised mass of wreckage occupying a length of only 67 yards. The fires were caused by live coals from the engines setting alight the overrun, shattered, highly combustible wooden-framed coaches of the troop train, and the Pintsch oil gas, used to light the northbound express, added to the flames. Fortunately the casualties in this train were relatively few, but, as a result of this frightful holocaust, 246 persons were injured and 227 were killed. The bodies of many of those killed were burned beyond recognition. It was the darkest day of British railways, and an incident, described by *The Scotsman*, as heart-rendingly mournful as any recorded in Border history.

The whole tragedy of errors started with an arrangement by two signalmen at Quintinshill to change shifts at 6.30 am instead of 6 am. At that time the volume of traffic passing over the line was high and, after ten hours in the box, the mental reaction of the night-shift signalman was at its slowest and the incoming signalman was too busy catching up with his entries in the train book to grasp the complicated traffic situation that was arising. Basic safety precautions were not observed and essential rules flouted with disastrous consequences, causing wholesale loss of life and eventually resulting in three humble and fundamentally honest men finding themselves face to face with the full awesome majesty of the law.

The book describes the events leading up to the accident and the shock and grief that it caused. The author also quotes in great detail from the report made by Lieut-Colonel E. Druit, the Inspecting Officer of the Railways Department of the Board of Trade, the inquest and the trials of the two signalmen and the fireman of the local train involved in the accident. He concludes with a summary of the disregard of elementary safety precautions and the neglect of regulations that caused the accident which the *Railway News* commented at the time must be regarded as almost impossible, and had they not actually occurred, no experienced railwayman would have thought them possible. Such lapses have, however, been the basic ingredients of many other railway disasters.

The last of the principal players in this drama died in 1967 and now only the written record remains and a tall Celtic Cross, modelled on St Martin's Cross on Iona, stands as a memorial to the memory of the officers, non-commissioned officers and men, 7th Battalion, the Royal Scots, Leith Territorial Battalion, who met their death at Gretna on 22 May 1915.

THE HISTORY OF THE ELECTRIC LOCOMOTIVE

F. J. G. Haut

(George Allen and Unwin. Price £6)

This beautifully illustrated book, giving the history of electric locomotives from the first small engine exhibited in 1879 to the present day, is a highly technical journal, with numerous line drawings and wiring and layout diagrams, of more interest to the expert than the enthusiast. Some of the colour plates are magnificent, but much of the information is above the head of the layman.

H.J.

DRESS REGULATIONS FOR THE ARMY 1900

(Reprinted by David & Charles Ltd, Price 63*s*)

This copiously illustrated book, containing a mass of detail and 79 pages of plates, is a reprint of the official War Office publication *Dress Regulations for the Officers of the Army (including the Militia)*, issued on 9 July 1900.

In the foreword to the original issue the Commander-in-Chief, Field Marshal Sir Garnet Wolseley, wrote that Her Majesty had been graciously pleased to approve the Regulations and commanded that they be strictly observed on all occasions. General Officers Commanding and Commanding Officers of units would be held responsible that no deviation from authorized patterns were permitted, and Commanding Officers would be held personally responsible for the payment of any expense which might be entailed on their officers by having to replace, or to restore to the authorized pattern, articles which might be found by General Officers to be not in conformity with the Regulations—a pretty severe warning to possible deviationists and Commanding Officers with 'mod' tendencies as far as their officers' gear was concerned.

The Regulations give complete details of uniform to be worn on all appropriate occasions by Field Marshals, General Officers and those holding staff appointments, officers of the Household Cavalry, Dragoon Guards, Dragoons, Hussars and Lancers, officers of the Royal Regiment of Artillery and the Corps of Royal Engineers, officers of the Foot Guards and Infantry of the Line and officers of the Army Service Corps, Royal Army Medical Corps, Army Chaplains, Army Ordnance, Army Pay and Army Veterinary Corps.

There is also a Section dealing with special appointments, including uniform to be worn by Retired Officers which contains a footnote which, in today's vocabulary, sounds rather surprising saying that Officers retired from the Household Cavalry with permission to wear uniform, will not wear breeches and jack boots, but will wear overalls.

Another Section deals with uniform to be worn for service abroad in India, in all other overseas stations, except Canada, and what you must wear in Canada, except British Columbia, and what to wear if you are posted there—Visions of past Imperial grandeur!

There are also Appendices covering badges, buttons, lace, swords, sword knots, scabbards and sabretaches, Webley pistols and holsters, binocular cases, water bottles, belts, saddlery, etc, and a fascinating Section on the care and preservation of uniform which gives useful hints on how to prevent uniform becoming moth-eaten, how to buff up slightly tarnished gold trimmings and lace and how to remove obstinate stains from scarlet jackets, all without the use of soap powders or detergents.

The Section dealing with the Royal Engineers laid down the dress for General and Staff Officers with a footnotes that they might continue to wear uniform in their possession till 31 December 1901, i.e. some 16 months after the publication of the Regulations. Other Sapper Officers apparently were not given this licence and the Regulations gave explicit details on full dress, undress, greatcoat and cape and Mess dress, and working dress to be worn when employed in Submarine Mining Companies and Balloon Sections. In the latter case officers had to wear undress uniform with blue puttees, lace boots, and, when actually mounted, hunting spurs. The exact moment at which their spurs had to be buckled on was not specified. Possibly it was on receipt of that now forgotten, but exciting, order: "Prepare to Mount".

The illustrations show the RE officers' tunic, collar and cuff, frock coat and Mess Dress and the Field Cap Badge (the Grenade above the Ubique scroll) and the Puggaree Badge (the forerunner of the present Sapper Cap Badge) and the design of the RE Lace which was much more gorgeous and flamboyant than the lace worn by the Gunners.

When first published these illustrated Regulations were printed for Her Majesty's Stationery Office by Harrison & Sons of St Martin's Lane, Printers in Ordinary to Her Majesty. They could be purchased, either directly or through any Bookseller, from Eyre and Spottiswood of London, John Menzies of Glasgow or Hogges, Figgis & Co of Dublin. The price was four shillings and sixpence each plain, and a bob more if interleaved. Today's price of sixty-three shillings for a reprint of the Regulations is an indication of present inflation. It is rather terrifying to contemplate what would be the present day cost of the uniform accoutrements, etc, required by a Sapper officer of 1900 if, as surely he must, he strictly observed on all occasions every detail of the Dress Regulations and equipped himself accordingly with everything to the authorized pattern.

J.L.

Technical Notes

CIVIL ENGINEERING

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

SEAFORTH DOCK, LIVERPOOL, by D. Kirby-Turner, FICE, and F. Irwin Childs, FICE. This article describes a two-stage scheme for a ten-berth dock covering an area of 500 acres for the Mersey Dock and Harbour Board. The present contract for £11 million was let to John Howard and Co (Northern) Ltd in late 1967 and includes construction of two miles of quay wall and excavation of an 80-acre dock basin.

When stage A is completed it will provide three container berths, two timber berths, a grain berth and a mechanized meat berth backed by cold-storage facilities.

The quay walls are of diaphragm design and have been built prior to excavation by employing the bentonite trench system of construction. The entrance passage is closed by sector gates which have the advantage of remaining operable under a difference of head or under conditions of flow.

The sea wall consists of stone cores with a clay seal in the centre. The clay is obtained from some of the 5·5 million cubic yards excavated from the docks. The outer face of the wall is armoured with rock from ½ ton to 6 tons in size, ascending to the degree of exposure to direct wave attack.

STRUCTURAL LIGHTWEIGHT CONCRETE—ECONOMIC ASPECTS. This abstract from the proceedings of the Sixth International Congress of the International Bureau of Precast Concrete outlines the basic properties of this material. Apart from informing engineers about the methods of production, typical strengths, heat insulation and fire resistance, the total costs are discussed fully. Those who are interested can obtain further information from the Cement and Concrete Association.

Hong Kong's New £48 Million High Island Reservoir. Anyone who has ever served on the Island or in the New Territories will welcome a further effort to provide more water. This scheme involves the construction of two dams between the Sai Kung peninsula (Site of the Battle School) and High Island. Water from the Sai Kung catchment area will be carried through a tunnel complex to the reservoir. The main tunnel of the system will link the new 50,000 million gallon reservoir to the Sha Tin treatment works.

W.G.C.

THE MILITARY ENGINEER

JULY–AUGUST 1969

In "Plowshare comes of age", the author describes progress to date in the peaceful use of nuclear explosives. In one experiment 5 × 1Kt charges produced a canal, 254 ft wide by 70 ft deep by 865 ft long. Other projects cover the recovery of natural gases and copper ore.

An interesting article covers the use of prefabricated structures in Vietnam. The Ammi pontoon 90 ft by 28 ft by 5ft weighing 55 tons, features strongly. It has been used as a floating bridge, as a fixed bridge supported on piles passing through internal wells, as a helicopter base and in a slightly modified form as a dry dock. This versatile equipment can carry 290 tons with 10 inch freeboard when floating or 275 tons when supported by piles. Other items described are a portable lightweight observation tower and prefabricated steel revetment for aircraft protecion.

Another article describes a new type of aircraft shelter which has a 24 ft radius semi-circular cross section. The main structural members are tubular arches made from ten gauge steel. Each section is bolted to its neighbour and then a concrete skin, about 2 ft thick, is poured. From the number of articles on this subject in this and previous issues aircraft protection is a major worry in Vietnam.

Surveyors might be interested in a description of a Laser-optical system for precise distance measurements.

P.W.H.

Forthcoming Events

18 February	Corps Guest Night	RE HQ Mess
14 March	RE Draghounds Point-to-Point Meeting	Charing, near Ashford
14 March	RE Drag and Beagles Hunt Ball	RE HQ Mess
24 March	REYC Dinner	RE HQ Mess
19 April	Annual RE Memorial Service	Rochester Cathedral

SPORTS AND GAMES FIXTURES 1969/70

RE RUGBY UNION FOOTBALL CLUB

11 December	RE *v.* RA	Chatham
21 January	RE *v.* RCT	Aldershot
4 February	RE *v.* XL Club	Cambridge
25 February	RE *v.* REME	Chatham
11 March	RE *v.* RAMC	Mitchett
8 April	RE *v.* RMA Sandhurst	Sandhurst

RE HOCKEY CLUB

6 December	RE *v.* Infantry	Chatham
10 December	RE *v.* RMA	Sandhurst
13 December	RE *v.* Hampstead	Chatham
20 December	RE *v.* HAC	Chatham
10 January	RE *v.* Metropolitan Police	Away
21 January	RE *v.* US Portsmouth	Aldershot
24 January	RE *v.* Surbiton	Away
31 January	RE *v.* Polytechnic	Chatham
2 February	RE *v.* Cambridge University	Cambridge
4 February	RE *v.* London University	Away
14 February	RE *v.* Blackheath	Away
21 February	RE *v.* Cliftonville	Chatham
22 February	RE *v.* Maidenhead	Away
28 February	RE *v.* Cheam	Chatham
28 February	Final England Trial	Chatham
1 March	England *v.* Kent	Chatham
5 March	RE *v.* RA	Away
8 March	RE *v.* Villagers	Chatham
15 March	RE *v.* Chimps	Chatham
18 March	RE *v.* United Hospitals	Away
4 April	RE *v.* T & AVR	Chatham
18 April	RE *v.* Southgate	Chatham
25 April	RE *v.* Spencer	Chatham

RE CRICKET CLUB

11 to 18 July	RE Cricket Week	Chatham
24 — 25 July	RE *v.* RA	Chatham
8 — 9 August	RE *v.* Band of Brothers	Chatham
12 — 13 August	RE *v.* Oxford Harlequins	Chatham

ROYAL ENGINEERS TRANSPORTATION REUNION DINNER 1970

The 1970 Royal Engineers Transportation Reunion Dinner will be held at the United Services Club, 116 Pall Mall, at 7 p.m. for 7.30 p.m. on Friday, 27 February 1970.

All officers who are on the Dinner Register will receive a notice about three months before the dinner date, and this preliminary notice is an endeavour to reach all officers who have served at any time in any capacity in the RE Transportation Service who may not be on the register.

Will any officer requiring details, or knowing of another who would wish to attend, please get in touch with the Dinner Secretary, Colonel F. J. J. Prior, OBE, CEng, FICE, Assistant Civil Engineer, British Railways, Southern Region, Southern House, Wellesley Grove, Croydon CR9 1DY (Tel: 01-696 3422, Extn. 2244).