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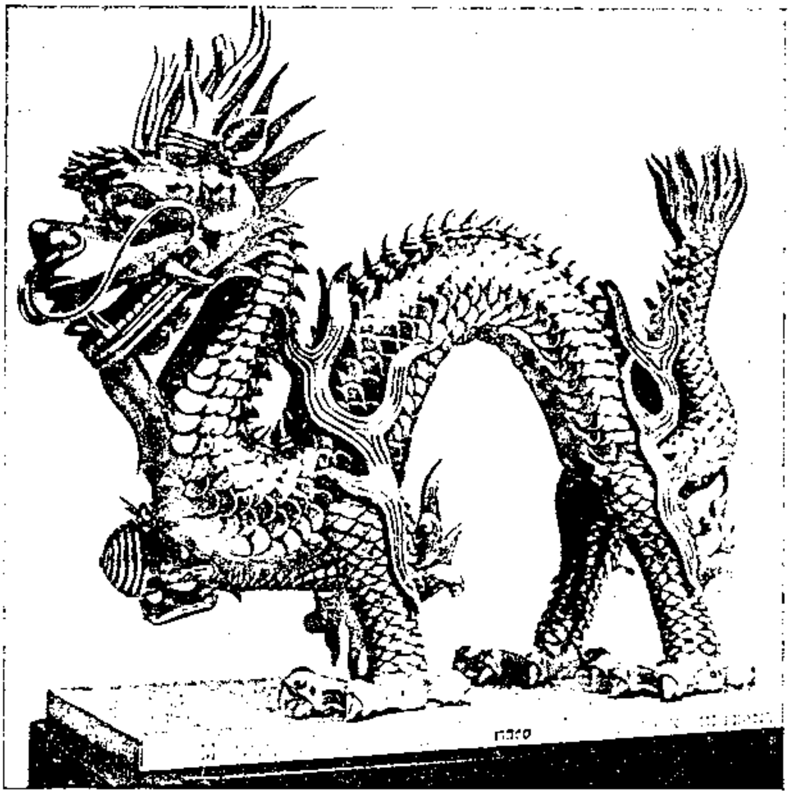

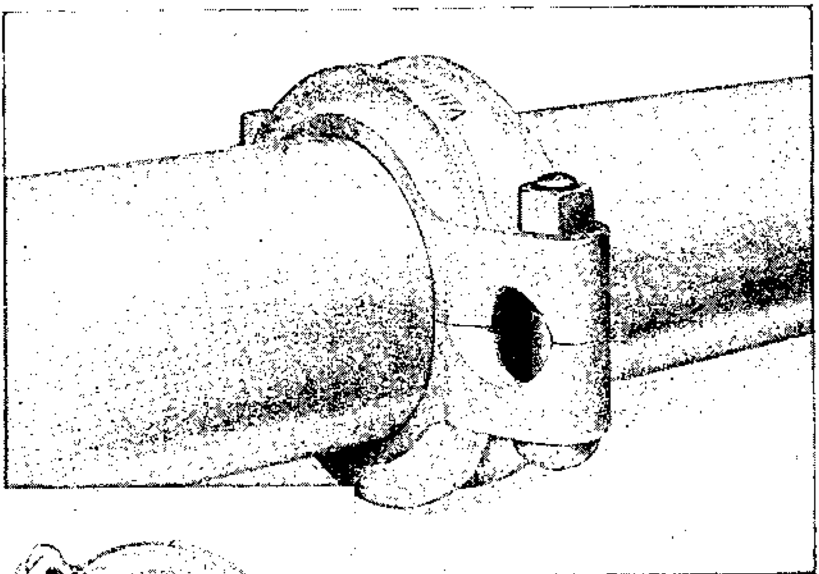

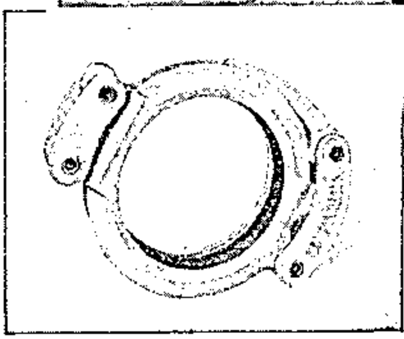

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Engineer-in-Chief's Address to the Annual General Meeting of the Corps of Royal Engineers on 23 June 1965

Introduction

Chief Royal Engineer, Gentlemen, last year I departed from the normal pattern of the Engineer-in-Chief's address to the Corps Annual General Meeting by devoting most of my time to the impending reorganization of the Army, and its effects on the Corps, and only touching briefly on the Corps activities and progress during the preceding year. This year I have reverted to the usual form, but at the end I shall say a few words on the reorganization of the Army.

General Corps Activities

As a Corps we are accustomed to having our resources fully committed, but this has been especially true in the last twelve months, when we have had difficulty in providing sufficient units to meet the demands of overseas theatres. The main cause for this has been the continuance of operations in the Borneo Territories and Aden, which has called for a sustained military engineering effort in support of the three Services. Demands have also been made on the Corps to meet the services requirements for works in areas where Ministry of Public Buildings and Works (MPBW) civilian personnel are unable to operate.

The Far East

Malaysia. The Sapper order of battle in Borneo has been built up to the equivalent of nearly four field squadrons, British, Gurkha, and Federation, as well as one Australian Field Squadron. The main task of the Australian Field Squadron has been the construction of 114 miles of road in North Borneo (Sabah). British, Gurkha and Malaysian Squadrons have been employed in support of Brigades on a wide variety of tasks, including four major road projects, eight twin pioneer airstrips, numerous helicopter landing zones, providing purified water installations at jungle patrol bases, building resettlement villages for the local Ibans and camp facilities for our troops. Many of the road building tasks have a secondary aim of opening up new areas and are contributing to the development of the country. One of the main difficulties which has had to be faced is the very heavy rainfall, in the wet season 70-ins of rain can fall in one month. This causes severe flooding and restricts plant work. The variety of engineer tasks in this theatre has given excellent training for both officers and other ranks, and has emphasised the need for a sound knowledge of basic civil engineering and organization of work and for good tradesmen in our field units.

Thailand. Work on the airfield at Loeng Nok Tha has continued and the planned progress maintained despite a major change in the specification for the airstrip. The Pierced Steel Plant surface originally planned was found to be unsatisfactory, and it has been replaced with a 6-in cement stabilized pavement with a 2-in surface of bitumen. Most of the troops were withdrawn in June 1964 as it was not expected that work could continue during the monsoon period, however the rains were not as heavy as expected and some work was possible. The main force returned to the airfield in September 1964, to be immediately faced with two heavy deluges, each of 8-in of rain in twenty-four hours. This caused a temporary diversion of effort on to restoring communications for the Thai authorities. The airfield was opened on 17 June this year, and the construction force will be withdrawn during the next few months.

Middle East

We now have a Chief Engineer in Middle East Command and a better balanced RE order of battle, including three Field Squadrons and the MELF Park Squadron. During the year additional units of the Strategic Reserve, including 516 and 521 Specialist Teams have also been involved in operations there. One of the Field Squadrons is committed to supporting the RAF in airfield construction and other tasks about which I shall say more later. The other Sapper units have been operating in support of the Radfan operations last summer, and the policing activities which are still continuing. Here the work has included road and airstrip construction, well drilling and mine clearance. Mine detection in particular has posed a difficult problem, as many miles of sand and gravel tracks are in daily use, and are wide open to nuisance mining at night. A major task is the construction and surfacing of the 36-mile long Lahej-Thumier Road. We have also been responsible for building redeployment camps in Little Aden and for carrying out irrigation and other tasks in aid of the civil population. A small RE unit has now been established expressly for this latter work.

Near East

Cyprus. 33 Field Squadron and the Cyprus Park Squadron have been occupied on internal security duties, having been used as Infantry as well as carrying out Sapper tasks. The latter have included constructing a transit camp, aircraft dispersals and a mole at Akrotiri Sovereign Base Area and building an LST ramp at Dhekelia Sovereign Base Area.

Malta and Libya. Personnel from the Fortress Squadron and Park Squadron in Malta have assisted in construction work in Cyprus, building facilities in El Adem and a barrack block, slipways and a jetty in Malta.

Gibraltar. 1st Fortress Squadron has continued to operate two power stations on behalf of the MPBW and to extend the tunnel system in the Rock. Since the deterioration of relations with Spain and the restrictions to movement over the border, the Squadron has also been engaged in supplying sand and aggregate to the MPBW.

BAOR

There has been some re-deployment in BAOR following the decision to concentrate Field Squadrons of Divisional Engineers under their CsRE; Headquarters 11 Engineer Brigade and 35 Corps Engineer Regiment moving to Hameln and 2 Armoured Engineer Squadron moving to Hohne. The equiping of all field squadrons with APCs has started and 1 and 4 Field Squardons have completed their first exercises with APCs. All units have had a busy training year, including taking part in formation exercises. The peculiar characteristics of major war in Europe have produced a problem for us, in that as the engineer units become more proficient at their specialized role in Germany, they are liable to become less easily adaptable to the sort of operations in which we are already engaged in Borneo and Southern Arabia. We are trying to offset this, as far as BAOR is concerned, by taking every opportunity of civil engineering type tasks which will give tradesmen practical experience in their trades.

United Kingdom

The high rate of arms plot and emergency moves of squadrons in the Strategic Reserve and its Support Echelon has continued, and in the first half of 1965 only four field squadrons of 12 Engineer Group were in UK. Sapper units have also taken part in exercises in Canada, Malta and Libya. The UK Bomb Disposal Unit RE has continued to be fully employed during the past year.

Survey. Survey units have once again had a busy year. Both Borneo and Aden are poorly mapped areas and survey units in the area, reinforced by Topographic troops from 42 Survey Engineer Regiment on emergency tours, have been heavily involved in all stages from initial survey to map production. The troop commander of the Aden troop, Lieut G. P. G. Robinson, was awarded the Royal Geographical Society's Cuthbert Peek Award for exploration and survey in the Radfan area. Two survey officers are participating in the American Geodetic Satellite Project, and we have survey detachments on duty in such places as Guam, Socotra, South Georgia, Sierra Leone, Malawi and Zambia.

Postal. I have been very impressed with the keenness and efficiency of the Postal and Courier Communications Units I have met around the world. There is no doubt that their efforts in keeping the mails moving, often under difficult conditions are having an excellent effect on morale wherever British troops are stationed. The Long Range Courier Service has been extended to include Cyprus and Malta and will shortly operate to Gibraltar, and a service has been introduced between Belize and San Salvador.

Recruiting. One of our greatest problems at present is the shortage of officers, particularly captains, as officers commissioned in the years of acute under-recruiting from 1956 onwards become more senior. This Army-wide shortage has made it difficult to man extra-regimental and training posts and we have had to employ some majors in captains' appointments. This deficit cannot be made up and will be with us for some time, and indeed we are still not recruiting up to our requirement of regular officers. Our post McLeod requirement is about sixty-five permanent regular officers a year. Last year we commissioned fifty regular subalterns, including our full quota of (35–37) from RMA Sandhurst, the balance being made up from transfers from short service commissions and direct entries from the Universities. We are hoping that the number of direct entries will be increased by the University Cadetship Scheme. There is no hope at present of increasing our Sandhurst quota and we are concentrating on increasing our direct entry from Universities including cadetships, and transferring to regular from short service commissions. We are continuing to commission warrant officers on short service commissions for administrative duties.

On the other rank side the position is far brighter. In August 1964 we passed our authorized ceiling of 14,850 for the first time since National Service ended and we have got off to a good start in 1965. The standard of recruits is high and we are now able to be slightly more selective in our choice. The Junior Leaders' Regiment RE is full and the standard here has also been raised. We cannot be complacent however as the period is now being reached when the first of the "six-year men" run out.

We are making great efforts to publicise the Corps at displays up and down the country, in the national press and on television, but this is something in which everyone of us can help, and the successful recruiting of officers especially can depend to a large extent on the personal efforts of serving or retired Sapper officers.

Equipment. The planning and development of combat engineer equipment now takes place alongside that of fighting vehicles, both under the Director of Army Equipment Policy in the General Staff and under the Director General of Fighting Vehicles and Equipment in the MGO's Department. This change is designed to encourage the study of all aspects of mobility with close consultation between fighting vehicles and engineer interests.

In BAOR the second squadron of 32 Armoured Engineer Regiment now has its complement of AVRE, and the 165 mm gun is operational. The squadron has also been equipped with bridge layers, and both squadrons have received their APCs. The delivery of ARK is scheduled to start this year. The re-equipment of 23 Amphibious Engineer Squadron, due to take place this year, has had to be postponed owing to delays in production of the German M2 Bridge.

Among the new equipments accepted for service during the past year are the Johnson commercial 40 hp outboard motor, with a special bracket for use on the light raft, and the 2,500 gallon collapsible water tank. Comparative trials are being arranged in BAOR shortly of various types of digging equipment, from picks to light mobile diggers.

DAEP has set up a team under a RE officer to review the holdings of "C" vehicles in all theatres and commands. I hope this will pave the way for a more realistic casting policy for "C" vehicles, by reducing the size of the fleet and thus helping to secure agreement to the automatic replacement of machines after an agreed life. This will enable us to get rid of many antiquated machines, and will of course also be a great relief to RAOC and REME.

Military Engineering Services. Since last year we have made slow but steady progress in producing proposals for the reorganization of the Engineer Special Service Establishment into the Military Engineer Services. The problem is a complex one. Whenever there is an operational situation where the MPBW are unable to operate, either because of local conditions or because of the short notice, there is an emergency demand for RE Works Staff. In the past this has been met, in the main, by the removal of ESSE personnel at short notice from static posts within the MPBW. The sudden removal of staff causes serious embarrassment and dislocation, especially where the ESSE personnel are holding key posts. MPBW have come to regard the soldier as being continually "at risk", with the result that the scope and level of responsibility of posts offered to miliary staff suffered. The situation from the military point of view is equally unsatisfactory. No Engineer Works staffs exists for planning or to form a nucleus on which units could be built up. The staffs have had to be improvised for each emergency as it arose. These factors, together with the administrative and personal problems of collecting specialist officers and senior NCOs from posts scattered through the UK and theatres overseas, made it difficult to provide speedy and efficient engineer support in emergency. To rectify these shortcomings we are proposing to form five new Works units; two CsRE (Construction) and three Specialist Teams RE (Construction). One CRE and one STRE will be stationed in the Far East, one STRE in Aden and one CRE and one STRE will be with the Strategic Reserve in England. The CRE (Construction) and STRE (Construction) organisations are very similar to the old CRE Works and Works Section. We shall continue to obtain civil, electrical and mechanical engineering experience for our officers and clerks of works by holding appointments with the MPBW. Because we can now guarantee that officers and clerks of works will serve full tours with MPBW, we have been able to establish improved terms of employment for MES personnel integrated into the MPBW. We will continue to attach officers and clerks of works to civil firms and public authorities to get specialized engineering experience which cannot be obtained with the MPBW. There is no doubt that this reorganization will improve our professional status as engineers and give much better opportunities for civil engineering in the Corps.

Organization

The main events in 1964/5 have been the take over of responsibilities for airfield construction, the completion of the Nye reorganization and implementation of McLeod reorganization.

Airfield Construction. In November 1964 the Defence Council accepted the recommendation of a joint working party, that technical responsibility for operational airfield construction and maintenance should be transferred from the Airfield Construction Branch, RAF, to E-in-C, and that four field squadrons should be formed in the Corps to take over progressively the commitments of the Airfield Construction Squadrons, RAF. It was agreed that field squadrons (Airfields) should come under operational command of the RAF, but would remain under the technical direction of the Chief Engineer of the Command concerned.

In December 1964, 60 Field Squadron moved to Aden to take over from 5004 Squadron RAF, and I am glad to say that this squadron has acquitted itself well in its new role. 10 Field Squadron (Airfields) is now forming at Maidstone to take over from 60 Squadron who will then revert to a normal field squadron. It is planned that two of the other three field squadrons (Airfields), due to start forming later this year, will take over from RAF units in the Far East and UK during 1966 and 1967. A CRE (Airfields) is being formed to command the two squadrons in UK, who will be based at Waterbeach near Cambridge, where we are taking over the RAF station. The formation of these squadrons, and the need to take over various airfield staff posts in headquarters, is causing a further strain on our officer and senior NCO resources, but I hope this will only have a short term effect.

Nye Reorganisation. The move of the Arms Directors from Whitehall has now been completed and my headquarters was established in Chatham in January this year.

McLeod Reorganisation. The McLeod Committee recommendations which I explained last year are in the process of being implemented, with the exception of the proposal to transfer responsibility for the control and handling of engineer resources from RE to RAOC. Transfer of functional responsibility for Transportation and Movement Control Service from E-in-C to DST took place on 1 January 1965, but transfer of officers and men, with recapbadging, will not take place until 15 July 1965. Officer transfers will on the whole be on a voluntary basis, but many other ranks in trades which will no longer be RE will be transferred by direction. About 199 officers and 1,129 ORs will transfer to the Royal Corps of Transport and three officers and 210 ORs to REME. I am sad to see so many members of the Sappers leaving, but it is inevitable, and I wish them the best of luck with their new Corps. We have also lost our responsibility for A and B vehicle repair, which has been taken over by REME. Some of our vehicle mechanics are transferring, but REME are having considerable difficulty in finding the balance to take on this commitment.

Engineer Support to the Royal Corps of Transport. The Royal Engineers retain their present responsibilities for the civil engineering aspects of port and railway construction, maintenance and repair. In Germany and Belgium we shall continue to provide supervision over the rail installations to Army depots, though financial control of the works may be vested in the MPBW. There will be a small RE instructional staff at the School of Transport at Longmoor, and platelayers will continue to be trained there. We are considering the formation of a Specialist Team (Railway Construction), on the general lines of the establishment of a permanent way troop, to keep the techniques alive.

Resources. As I indicated earlier the McLeod recommendation that responsibility for engineer resources should be handed over to RAOC was not accepted by the Army Board, and a Committee under Major-General Odling was set up to re-examine the proposal. The Committee have not yet published its recommendations but I have great hopes that reason will prevail and that we will be allowed to keep control of our own resources organization.

Conclusion

In conclusion I would like to thank the members of my own staff, and also Chief Engineers and unit commanders world wide for all their help and support to me over the past two years. We are living in times of great change, and it is encouraging when one is particularly depressed at the consequences of some reform to go out on the ground and see how splendidly our units and detachments are doing at their wide range of tasks all over the world. We have had more than our share of reorganization, and I hope that they and the rest of the Army will now be given a chance to get on with the job.

The Surveys of Palestine

By Major I. D. Hart, RE

Introduction

Whilst serving with the Arab Legion in 1949 I ran a simple traverse along the line of a new road which my squadron was to build southwards from Tulkarm near Nablus, and unsuspectingly became probably the last sapper officer of a long and previously famous line to survey in Palestine. Seventy-seven years before me and only a few miles away, Field Marshal Lord Kitchener had stood as a young Lieutenant on Jebel Bir Asur and carried out similar, though more accurate, observations for the production of the first one-inch map of the country; and earlier still, in 1865, Captain C. W. Wilson, RE (later Major General Sir Charles Wilson) had surveyed the City of Jerusalem at a scale of 1/2,500.

It was the success of Wilson's survey which led directly to the establishment in 1865 of an association called the Palestine Exploration Fund which is celebrating its centenary this year with an exhibition at the Victoria and Albert Museum to be opened by the Archbishop of Canterbury. The PEF was formed for the purpose of investigating the archaeology, geology, geography and natural history of Palestine and it is to its efforts over the past hundred years that we owe much if not most of our knowledge of this country. Indeed the Corps owes them even more because the famous sappers and surveyors working under its auspices have made the PEF a part of our own history.

The Institution of Royal Engineers has taken over the task of preparing a collection of items for display at this Exhibition, but two years ago when the project was in its infancy, the Director of Military Survey appointed me to sit on the Centenary Committee of the PEF to advise them on any survey matters. At that time the Committee enjoyed the services of Lieut-Colonel F. J. Salmon, CMG, MC, who had retired in 1938 at the end of a six-year appointment as Director of Lands and Surveys Palestine and, from being yet another occupational hazard of a survey staff officer, this work became absorbingly interesting as I helped him to delve into the history of past surveys. Last year, at the age of 81, Colonel Salmon died and left me his maps and notes to finish the work.

I cannot do this alone as well or as completely as we would have done it together, for Colonel Salmon had a wide and profound knowledge of a country which I knew only superficially. However, I offer the results to his memory and to the greater recognition of the work of the PEF amongst officers of the Corps.

Early Maps

The PEF Centenary Exhibition is to be called "World of the Bible", a title over which there was some dissent on the grounds that it might attract only students of religion. However, Palestine will always be the centre of the Christian World and certainly it was the hub from which many ancient cartographers compiled their maps.

Plate 1. A section of the Madaba Mosaic of AD 560 showing Jerusalem. About one-twelfth actual size. East is to the top.

The Surveys of Palestine 1

In early Christian times the Church was to the forefront in making maps and a good example can be seen in the church at Madaba, East of the Dead Sea, where a mosaic map of the Holy Land was laid about AD 560. Today there exists only a large fragment of the mosaic about 10½ metres long and 5½ metres wide which originally must have filled the whole transept of the church and have measured some 24 metres North to South and 6 metres East to West. Oriented in the true sense of the word to the East, its centre, in the centre of the transept portrays the Damascus Gate in the North wall of Jerusalem (see Plate 1). As befitted such an important centre of his world the Christian priest, who drafted the outline for the mosaicists to lay in their multicoloured cubes, exaggerated the size of Jerusalem to a scale of about 1/1,600 and by this means gave us a remarkably accurate plan of the city in those days. Indeed the whole map must have been a very good representation of the geography of Palestine as well as containing a wealth of historical information.

In England in the late thirteenth century Richard of Haldingham was inspired by traveller's accounts to draw and paint a map of the world on a calf skin which can be seen today in Hereford Cathedral. The Hereford "Mappa Mundi" also has east to the top and shows the then-known world encompassed in a circle with Jerusalem and the Holy Land greatly exaggerated in size. In common with other world maps of this period the layout is on the T-O pattern wherein Asia occupies the top half of the circle and Europe and Africa the bottom-left and bottom-right quadrants respectively, divided by the upright of the T formed by the Mediterranean Sea.

As the centre of the Christian World and a cross-roads for Islamic traders, Palestine must have been the subject of many maps and plans and it is surprising that so few have remained. According to Arabic accounts, Idrisi, a Morroccan born in AD 1100, was a prolific map-maker whose work had a lasting influence on Islamic cartographers and a copy of his zonal world map of 1154 centred on Sinai is preserved in the Bodleian Library. Ibn Haukal before him (about AD 980) drew many maps including one of the Mediterranean but these contain very little geographical information about Palestine. In more detail were Petrus Vesconte's maps of 1320 which were contained in a manuscript by Marino Sanudo who was trying to persuade the Kings of Europe to mount another Crusade against the Turks; and in 1350 Mathew Paris, a monk of St Albans, produced a schematic drawing of the Holy Land as well as other itineraries and route maps.

When glancing at these ancient maps it is too easy to assume that the cartographers allowed their artistic and romantic senses to impair their ability accurately to portray the land, and that, however, beautifully the blank spaces were filled with weird animals and flying fishes they were virtually useless as maps. However, deeper thought and careful study of them show this attitude to be rather supercilious and unfair, particularly when one realizes that they were mainly made not for the traveller but by him, compiled from the tales and drawings of his journeys and scaled according to the importance and value of his information. They were used primarily for the "Instruction of the Faithful" rather than as a means of navigation—the most important function of a modern map—for not until the fifteenth century were they reproduced in any quantity from woodcuts and copper plates and even then must have been difficult to acquire and ponderous to use in the field.

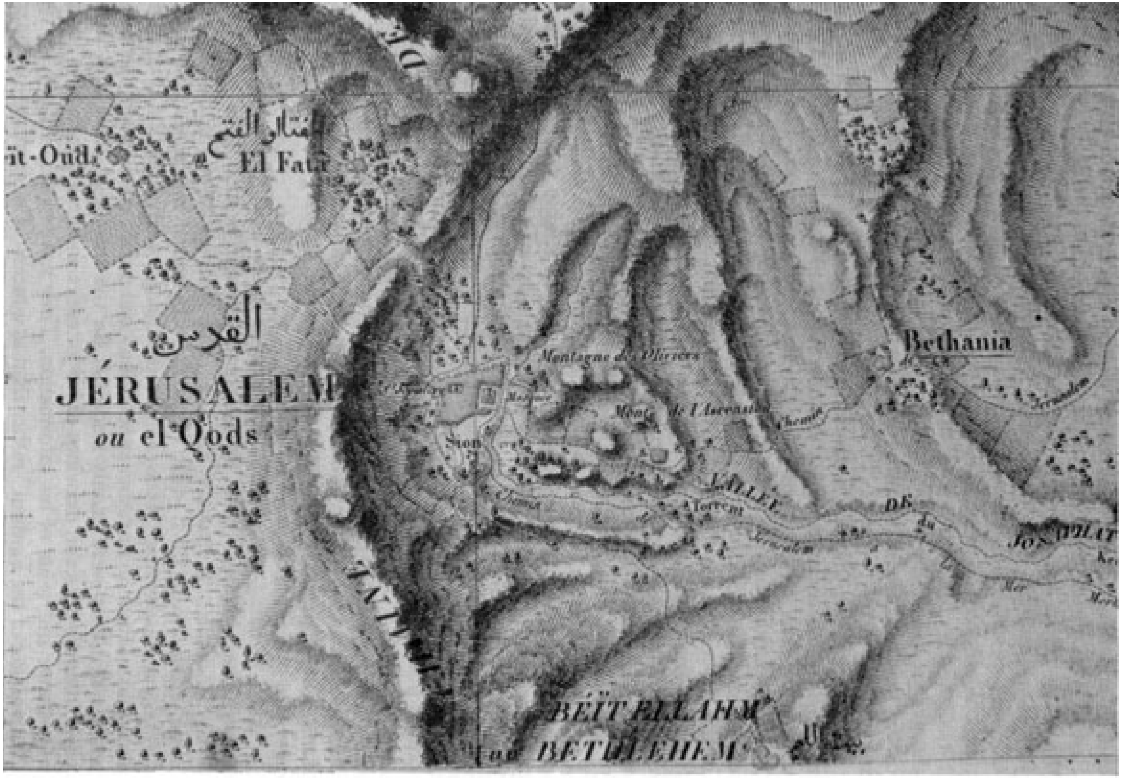


Plate 2. A section of Napoleon's 1/100,000 map surveyed in 1798.

Napoleon's Surveys

The first serious mapping of Palestine on modern lines was undertaken in 1798 by Napoleon as an extension of his survey of Egypt. A Topographic Section was formed which consisted of four officers, an astronomer and four "intelligent soldiers". It was later increased by a number of *ingénieurs géographes* and civilians from the Commission des Sciences et des Arts which was also concerned with archaeological work in Egypt. Finally Napoleon united the civil and military personnel to form the "service topographique de l'Armée d'Egypte" under the command of a Colonel Jacotin.

For the survey of Egypt bases were measured near Alexandria and Cairo and astronomical observations for latitude and longitude (East of Paris) were taken at these points. A 25 centimetre theodolite was used for the triangulation and plane tables and compasses for the detail which resulted in forty-two sheets at a scale of 1/100,000 being produced, covering the Nile Delta and as far east as the border with Palestine. Most of the sheets are 80 kilometres east to west by 40 kilometres north to south in extent and all carry a 10-kilometre grid whose origin is the Great Pyramid at Gizeh. In Palestine five sheets extend northwards to Sidon and reach from the sea to a maximum of 70 kilometres inland. Here the control was far less rigid than in Egypt and was often taken from older observations, some of which must have been very inaccurate. However, British naval charts in this area were good and were probably responsible for the coastline and its immediate hinterland being more accurate than the detail further inland. The accuracy of the topography also suffered from the fact that Napoleon's surveyors were only able to work in areas where his troops had recently fought and were thus hampered by Active Service conditions. Many areas were not surveyed on the ground and eventually had to be compiled from divers manuscripts which a report on the survey said were difficult to reconcile with one another. "A magnificent military sketch" was the description given to General Roy's one-inch map of Scotland completed some forty-three years earlier; and this too could describe Napoleon's survey of Palestine. (See Plate 2.)

Another similarity with British mapping of the time is the cartography which compares closely with the first Ordnance Survey of this country—the one-inch map of Kent surveyed by Captain Mudge in 1801. Napoleon's maps are beautifully engraved and show relief by hachuring, although the orography is very suspect and particularly around Jerusalem appears to be derived mainly from imagination. Roads and tracks, rivers and wadis are shown and a careful attempt appears to have been made to depict the correct shapes of towns and villages. Cultivation has been shown in a stylized form and the map contains many and varied symbols for trees in areas which are now bare of any vegetation. The appearance of the map is greatly enhanced by the liberal use of Arabic for place and area names, the transliteration of which caused such controversy in Paris that a special commission was eventually formed to carry out this task. Their results appear to me, as an indifferent scholar of Arabic and French, to be excellent in that they achieve what some modern transliterations fail to achieve—an identical sound of the name in either form. Another interesting feature is the marking of routes taken by Napoleon's army, and the battles which he fought are shown by large symbols of crossed sabre and musket, dated in both the Napoleonic and Gregorian Calendars.

Survey work on the ground was completed late in 1801 and by the end of

1803 compilation in Paris had reached a stage where the maps could be engraved on copper plates. It took the engraver, M. Blondeau, a little over four years and although the sheets were printed early in 1808, Napoleon ordered that they should remain under seal as state secrets. They were not finally published until about 1817.

The PEF Surveys

A number of explorations of Jerusalem and the surrounding country were carried out during the first half of the nineteenth century but little survey work is recorded. In 1841 a Lieutenant Symonds, RE "carried out a triangulation" from Jaffa to Jerusalem and the Dead Sea and in 1848 Lieutenant Lynch of the United States Navy descended the River Jordan in a boat from Galilee to the Dead Sea, taking soundings and sketching the course *en route*. These aroused public interest and led eventually to the survey of Jerusalem and the formation of the Palestine Exploration Fund.

Captain C. W. Wilson RE was serving with the Ordnance Survey in 1864 when Miss (later Baroness) Burdett-Coutts, being interested in the need for a better water supply to Jerusalem and deciding that an accurate plan was required for further study of the problems, placed £500 in the hands of Colonel Sir Henry James, then Director General of the Ordnance Survey, for this purpose. Wilson set out in June that year with a sergeant, two corporals and two sappers and by May 1865 had completed a 1/2,500 plan of the city with 10 ft contours and details of all the important buildings. They also completed a smaller scale map of the environs about three miles square at a scale of 1/10,000 with levels along the principal valleys and high ground. This plan of the city lasted for over seventy years and when a new one was required in 1937 only a revision was found to be necessary.

Controversies based on sketchy information had raged for a long time over the exact location of many buildings in the city. This new plan, together with Wilson's report which contained a large number of photographs and some plans and sections of the Mosque of Oman and the Holy Sepulchre, helped to settle some of them. It also aroused general interest in the need for further exploration, so a public appeal for funds was made and the Palestine Exploration Fund was formally constituted on 22 June 1865 under the Presidency of the Archbishop of York.

Wilson's services were again required and he returned to Palestine at the end of 1865 with Lieutenant S. Anderson, RE to make a thorough reconnaissance of the country and to recommend where the Society's first efforts should be directed. On this trip his party took astronomical observations at forty-nine points between Beirut and Hebron and surveyed some of the country east of the Jordan at a scale of 1 in to the mile. The immediate result of this reconnaissance was that two further projects were undertaken by the PEF and both were commanded by Sapper officers although their main objects were not topographical surveys. The first was under Lieutenant (later General Sir Charles) Warren RE who spent three years from February 1867 excavating and exploring the ancient buildings in Jerusalem; whilst Wilson himself had charge of the second expedition which went to Sinai for the winter of 1868–9 to discover whether Jebel Musa (the Hill of Moses) or Jebel Serbal some 20 miles to the west was the mount Sinai whereon Moses received the Law. Six inch to the mile maps and sections of these mountains accompanied his report which proved Jebel Musa to be correctly named.

By now it became apparent that a complete topographical survey of the whole of Palestine at a scale of 1-in to the mile was needed before further exploration could be considered so the PEF embarked on another appeal for funds and asked the Ordnance Survey for assistance. Captain R. W. Stewart RE, Sergeant Black and Corporal Armstrong landed at Jaffa in November 1871 to start this survey but Stewart was soon invalided home and was replaced by Mr C. F. Tyrwhitt Drake until the following July when Lieutenant C. R. Conder RE arrived to take charge. The work was carried on by that party until Tyrwhitt Drake died of fever in Jerusalem in 1874 and was succeeded by Lieutenant H. H. Kitchener RE who continued as Conder's assistant until the survey was finished in 1877. Nearly two of these six years were lost when the party was withdrawn after being attacked by the villagers of Safed in July 1875, the intervening period being used to draw up the results obtained so far.

Mounted on horseback, Conder's party all wore the Kuffeya headcloth probably more for comfort than to disguise the fact that they were foreigners and, although privately armed, they were provided with a small guard of Turkish police. A base 4 miles long near Ramleh and another of 4½ miles on the plain of Esdraleon were measured by chain, and a 7½ in transit theodolite was used to observe a rigid framework of triangles with sides from 5 to 8 miles long in the hills and from 10 to 15 miles long on the plains which controlled the survey. Triangulation stations were marked with stone or brushwood cairns and were protected against interference by the imposition of a heavy prison sentence (or a large bribe to the Turkish overlord), a deterrent which would be welcomed by many surveyors working under similar conditions. Although the country was well suited to plane-tabling for a 1-in map, this instrument was not used by Conder's men. The method employed by the Ordnance Survey at that time was to fix a number of points of detail instrumentally and then to fill in the remaining detail by measurements and alignments between those points. So the surveyors in Palestine adopted a procedure with which they were familiar and, having observed three rounds of angles to trig points, read a single round to prominent points of detail in order to fix them by intersection. The control was then traced on to field sheets and the topography sketched in from compass traverses and paced distances whilst the characteristic shapes of slopes were observed with the aid of Abney levels and drawn by hachuring. The field sheets were completed with descriptive notes, annotations and names and finally checked and signed by one of the officers.

For those who have only known Palestine since the First World War, the conditions which the surveyors encountered read like stories from a different country. Conder's report speaks of oak forests and bears, wolves, wild pig, cheetah, deer and antelope, and a great variety of game birds. In fact the fauna appeared much the same as in Biblical times and only the lion, last recorded in the twelfth century by the Crusaders, had disappeared. Conditions were very primitive and there were no roads for vehicles except a very bad one from Jaffa to Jerusalem and another, even worse, from Haifa to Nazareth. There was much sickness; cholera was prevalent in the country and the party was attacked by a severe form of malaria as well as dysentry, rheumatism and septic sores.

The area covered by this 1-in to 1 mile survey, from the Mediterranean to the Jordan and from Tyre and Banias in the north to Beersheba in the south,

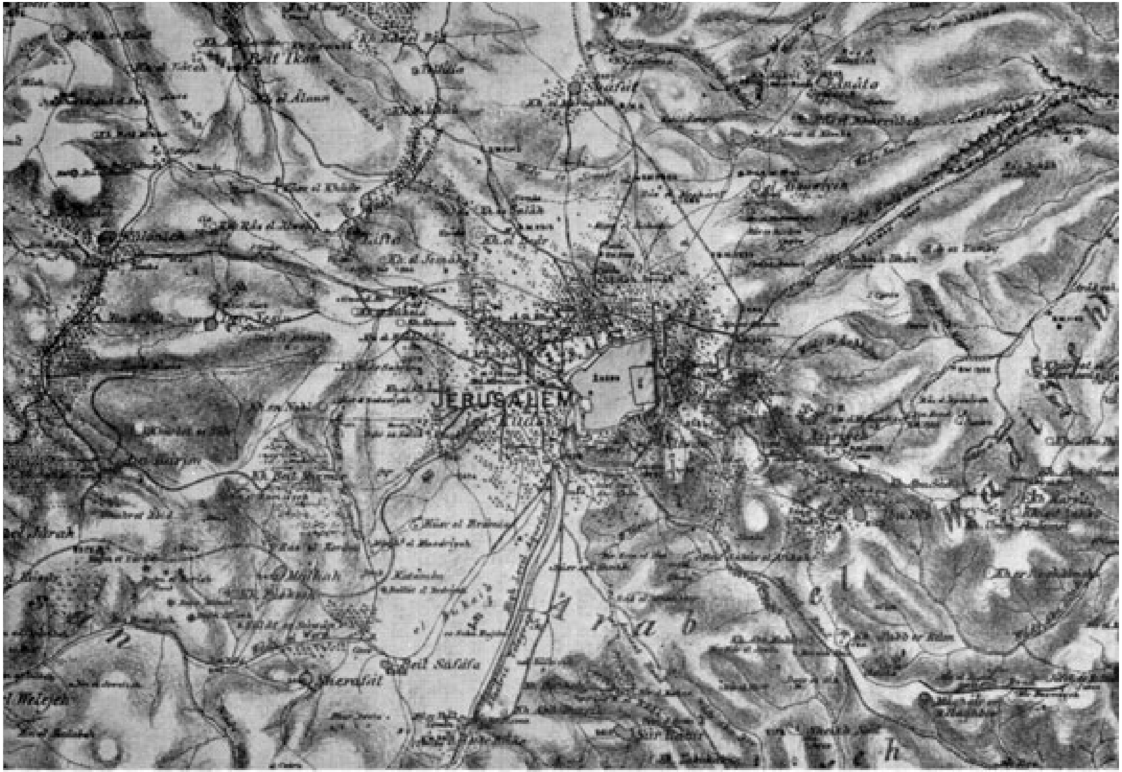


Plate 3. A section of the Palestine Exploration Fund one-inch map printed in 1879.

The Surveys of Palestine 3

enabled twenty-six sheets to be printed by the Ordnance Survey at Southampton in 1879. (See Plate 3.) Each sheet was a standard 22 minutes east-west by 15 minutes north-south, or about 22 miles by 17 miles. Printed in four colours with relief shown in brown "chalk work" hachuring they contained a wealth of detail, even to the location of wine presses in the vineyards, and became the basic topographical map of the country until 1936 when the first of a new 1/100,000 series was produced under the Mandate. The cost of the survey eventually reached £17,039 17*s* 1*d*, about £2,000 more than the original estimate made in 1865, but most of this money was soon recovered by the sale of the maps and Conder's report.

East of the River Jordan efforts were more fragmentary and were not so successful. When the PEF was first formed, the American Palestine Exploration Society had arranged to carry out similar work east of the Jordan and had commissioned one of their engineers, Rudolph Meyer, to undertake the survey of this area. Apparently the enterprise ran into financial difficulties but not until Meyer had been able to complete a large area around Banias in the north, the whole of the Jordan valley to the shores of the Dead Sea and the country east to include Amman and Zerka. Curiously these maps were printed by the Ordnance Survey in 1879 as a series of thirteen sheets at 1-in to the mile, but this was probably done on the initiative of Conder who would have wanted to use Meyer's survey when he returned to Palestine in 1881 with Lieutenant A. M. Mantel RE to extend his own work across the Jordan. Conder's party measured a base near Madaba which they connected with the West Palestine triangulation but they too ran into difficulties when, after surveying about 500 square miles of the country, the Turkish authorities refused to allow them to carry on and the project was dropped. However, a further opportunity to continue mapping this area arose in 1885 when the PEF engaged the services of Dr G. Schumacher, an engineer who was employed on the survey of the railway from Haifa to Damascus. He added a further 940 square miles to Conder's work, all of which was incorporated into a $\frac{3}{8}$-in to the mile map of Palestine published by the society in 1890.

Only Sinai now remained unmapped. In 1883–4 Kitchener had accompanied a geological expedition and had carried out a triangulation from a base at Aqabah along the Wadi Arabah to the Dead Sea, connecting it with the original framework near Beersheba. But now, in December 1913, Captain S. F. Newcomb RE was given charge of a large expedition which started from Gaza and was to cover the whole Sinai Peninsular, consisting of an archaeological party under C. L. Woolley and T. E. Lawrence and five survey parties under Lieutenant F. C. S. Greig RE. It was doubtless the experience which Lawrence gained on this expedition that justified his being commissioned into the Directorate of Military Survey in September 1914, where he was immediately involved in the compilation of the map of Sinai. Newcombe's triangulation and detail fieldwork at a scale of 1/125,000 (or about 2 miles to 1 in) was completed by the end of May 1914, in the remarkably short time of six months, and the maps were printed at this scale by the War Office in 1915 for official use only. The hurry shows in the field sheets which, though similar to the West Palestine work and probably more accurate, appear rougher and were obviously compiled in a less leisurely manner. Contours or form-lines at about 100 ft intervals appear for the first time on maps of this country, as does a grid in the form of a five minute graticule. The military nature of the survey is evident from the copious notes on water supply, local

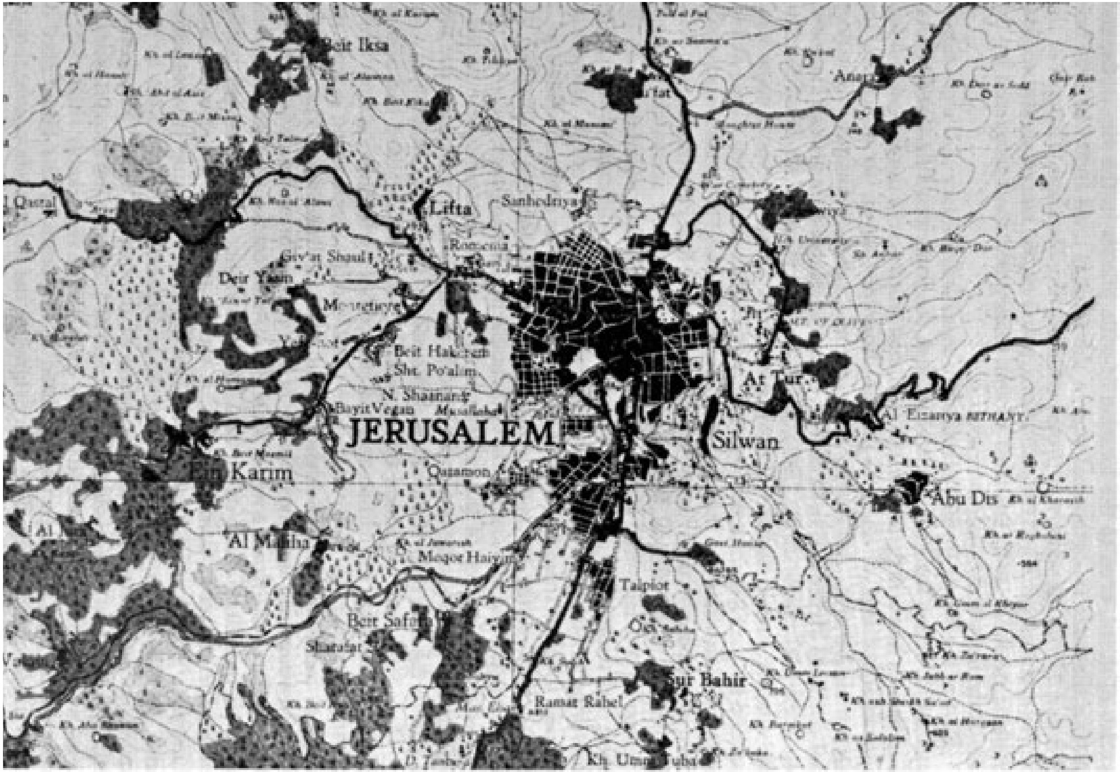


Plate 4. A section of the Survey of Palestine 1/100,000 map printed in 1937.

resources and cross country movement which cover the field sheets and which are reproduced as marginal information on the published maps. The surveyors were aware that a war was imminent and they collected whatever intelligence they could about their future enemy as this note illustrates—"Beersheba is the seat of a Turkish Kaimmaka whose district extends south to Wadi Charandal and west to the frontier. In a barrack above the town there are about 80–100 police, some 20 of whom ride camels."

Surveys Under the Mandate

Although a gridded version of Conder's one-inch survey was used by the Egyptian Expeditionary Force during the First World War, there was also a need for larger scale maps of central Palestine for artillery and tactical purposes and many sheets at scales of 1/10,000, 1/20,000 and 1/40,000 were produced during 1917–18. The new Survey of Palestine department which was established by the Occupied Enemy Territory Administration after the war therefore inherited some good topographical maps and were able to concentrate on improving the triangulation network and connecting it with the French triangulation in Syria, and on carrying out cadastral surveys for land settlement. For the first time the survey of the country had a permanent home in new offices just outside Tel Aviv and Major C. H. Ley, CBE, a retired Sapper officer, was appointed its first Director, holding this post until 1932 when Lieut-Colonel F. J. Salmon was transferred from Cyprus to replace him.

The emphasis on geodetic surveys had led to the Department being well equipped with modern calculating machines and staffed with some excellent mathematicians; but there were few surveyors trained in topographical work and there were no up-to-date town plans or road maps for the administration, the public, and the increasing number of tourists who were attracted to Palestine. Colonel Salmon, therefore, embarked on a training and recruiting programme and started work in 1933 on a new series of 1/100,000 maps which was to be published in fourteen sheets and covered almost the same area as the PEF one-inch series. A Cassini Soldner projection with a central meridian near Jerusalem was adopted for these maps which were compiled from plane-table surveys and from air photographs taken by the RAF on training flights. A photo-litho section was established with a copying camera and a flat-bed lithographic press and in 1936–7 the maps were printed at Tel Aviv. (See Plate 4.)

The Survey of Palestine had built up the equipment and personnel to carry out all the varied tasks required of a modern Survey Department and was now able to provide the public with the more sophisticated and specialized maps they wanted. A new plan of Jerusalem and of many other large towns were printed together with descriptive texts, and a 1/500,000 motor map of the country ran into ten separate revisions and provided a major source of revenue for the Department. These were followed by a series of historical maps; Palestine of the Roman Period, of the Crusades and of the Old Testament; and would doubtless have been followed by other interesting publications but for the "disturbances" of 1938 and the Second World War which turned minds to more serious problems.

Revisions and new compilations were carried out during the war by the Survey of Palestine and by RE Field Survey Companies, but the main task was one of production and supply of the maps required by the Forces stationed there. Internal troubles continued after the war and the Survey of Palestine, which employed both Jews and Arabs according to their merits, finally succumbed to the impossible situation and disbanded in 1947.

The work of surveying and mapping is never ending and since May 1948, when Palestine was divided into Israel and the Hashemite Kingdom of Jordan, these two independant countries have taken over the task of improving the mapping of their own lands. Whereas the British Army has been concerned with some surveys subsequent to that date in Jordan, its work in Israel ceased with the ending of the Mandate. Whatever surveying has been carried out in Palestine since then is at present shrouded in security and even the traverse for my road from Tulkarm can only be recorded as having closed at least on the right village.

Note by Editor

The Palestine Exploration Fund Centenary Exhibition at the Victoria and Albert Museum, will be open to the public from 1 October to 27 November 1965. The work of Royal Engineer officers and men employed in survey and other work by the PEF in the Holy Land during the latter half of the last century will be commemorated in the Exhibition.

The Radfan

By Major J. P. Groom, mbe, RE

The following is a personal story, and is by no means a complete report of the engineer activities in the Radfan, nor does it do full justice to all the personalities involved. It attempts to cover the main activities of 3 Independent Field Squadron RE and those other Sapper sub units that served in the Radfan from May to October 1964.

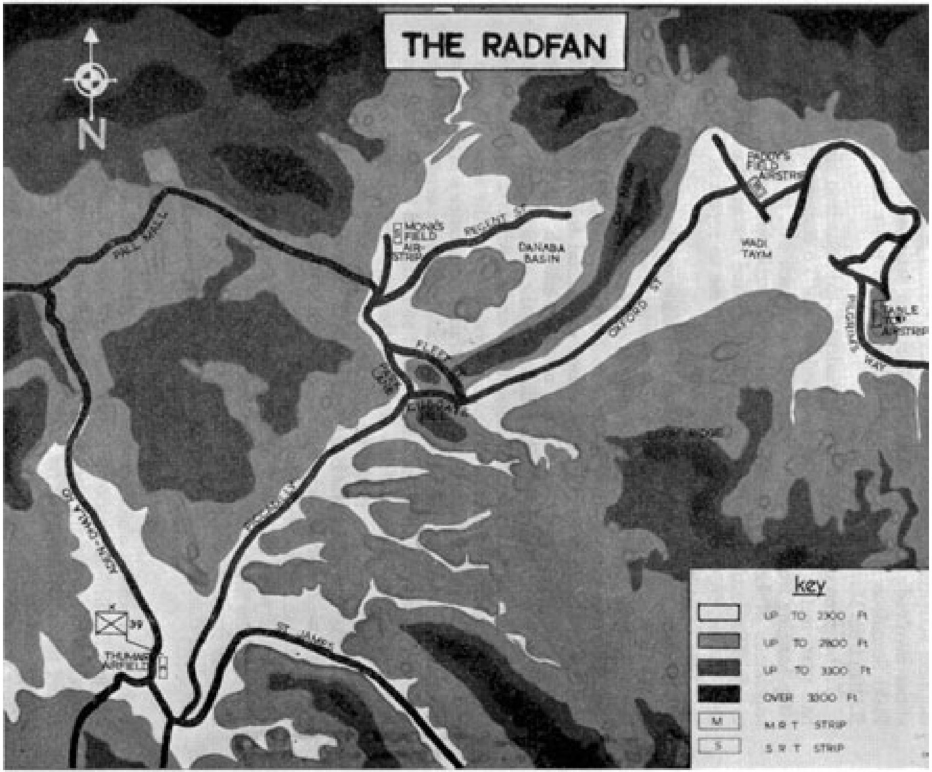
To be given command of 3 Independent Field Squadron after two and a half years in the War Office was reward indeed. To contemplate the end of strap-hanging from the suburbs for two hours each day, to escape the grime and bustle of London and to be blessed with such things as a batman and to rejoin Regimental life were prospects which had become almost unattainable dreams, so when the order came telling me to report at Tidworth in July 1963 I was more than pleased.

From my position in the War Office, working on the fringe of strategy I was aware that Strategic Reserve units were by cynical repute "UK bound" and with these thoughts in mind the move to Tidworth took place.

It didn't take long to settle in to the routine of things and to discover that I hadn't quite forgotten everything about regimental soldiering during the previous five years away. Life began normally enough with formation exercises both in and outside the UK, followed by the winter period of individual training. The welter of annual inspections ending with the Administration Inspection took place and as the routine was followed the sense of security grew. The Squadron did some adventure training in France and Scotland and as individuals returned from their higher trade training courses the Squadron came together again and went off to Wales and Stanford to knock itself into shape. By May 1964 we felt fairly confident that we could hold our own in the greater practice of war in the formation exercises to follow. By May, however, the exercise season was being somewhat abridged by affairs in the Middle East, but we replaced each cancellation with plans for some new activity. While at Stanford in early May, Anglia TV insisted on making a film of the Squadron at work since they expected us out of the country at any minute. We told them that they were wrong but they were determined fellows and the film was made. Familywise a continental camping holiday was planned—little did I then know how attached one can become to a tent!

The Move

It was about ten o'clock on the morning of 13 May that the news came, I had just finished looking over the Squadron vehicles, cleaned after Stanford when Robin Bellam the Second in Command rushed into the MT hanger saying that something was on, and that the phones were ringing like a turf accountants on Derby day. A visit to Colonel Hugh Cunningham's office, and lifting the phone which was to ring constantly for the next few days, made it fairly plain that unless something very odd happened the Squadron would be in the Middle East inside a week, and that the leave documents for Whitsun could be scrapped. A hastily called "O" Group was one of the most silent I have ever given or attended—the news was received in a great variety of ways—excitement—apprehension—annoyance at the disturbance of good


THE RADFAN
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PALL MALL
MONK'S FIELD AIR-STRIP
REGENT ST
DANABA BASIN
OXFORD ST
WADI TAYM
PADDY'S FIELD AIRSTRIP
PILGRIM'S WAY
ST JAMES
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M
S

The Radfan

order, but above all quietly. It was only half an hour later that the "O" Group returned to a man having thought of the thousand and one implications so far as each was concerned. At this stage the news was still a dreadful secret, though from the rush of Granby boxes—banding machines and air freight forms it was all clearly more than a hastily planned exercise. The secret was tenuously kept until during a Dinner Night in the Mess on the following evening the 'phone rang again, and the news became official and fact; the Squadron was to move to Aden by air on 20 May in support of 39 Inf Bde Gp operations in the Radfan.

On the following morning the news was broken to the Squadron; clearly others had also been told—people arrived from everywhere to help—and help they did, peaceful Tidworth became a riot of activity. We had thought that we were trained for such an event; the event itself showed our failings. Lesson one was that the experts exist and, without their aid, we would not have faired so well. It seemed that every depot in England stayed open to issue kit, and Workshops worked over Whitsuntide to prepare the vehicles. Everyone did everything to speed and aid the move, so much so that we began to wonder whether they weren't glad to be rid of us. By Friday night so much had been achieved that it was a fair gamble to send everyone off for three days Whitsun holiday after all.

On the following Tuesday morning the Squadron had returned to a man and the work of packing went on. By late that evening the air freight was ready, and the balance of G1098 and vehicles which were to follow by sea were all prepared, though a lot of work still had to be done before the rear party under Frank Taylor, the Squadron Quarter-master, could fly to Aden to join us.

The first Britannia took off from Lyneham at six o'clock on the Wednesday evening, and every two hours thereafter a further aircraft followed, carrying ourselves and 1st Bn Royal Scots to Aden via Cyprus and Bahrain. By early morning 22 May the Squadron, 217 of us with 3,800 lb of freight and five vehicles, were in Aden transit camp, and drawing more vehicles and equipment in readyness for our move to the Radfan, some fifty miles north of Aden.

Thumair

At about midday on the following Monday after a dawn start, our convoy arrived in the Brigade AMA area of Thumair. We were met by Sergeant-Major Hutchinson who had flown up on the previous day to set out the piece of desert which was to be our home. Setting up home was a challenge in itself, a more barren place is hard to imagine—something akin to the moon—or a nightmare of enormous slag heaps. I remember feeling particularly inadequate as home making began, but the challenge brought out the best in everyone and the Squadron lines mushroomed. Within 48 hrs the essentials had been done though during the following months improvements went on and on—it was a question of controlling enthusiasm rather than engendering it. The wealth of initiative and ability that exists in a Field Squadron displayed itself to the full and for the next five months I was utterly dependent upon it.

Up to the time of the Squadron's arrival, Sappers in the Radfan had been an "ad-hoc" force consisting of elements of 9 Parachute Field Squadron from Bahrain, 12 Field Squadron from Aden and a troop of 34 Independent Field Squadron from Kenya. These troops worked individually to begin with but just before the Squadron's arrival were placed under command of Major Charles Grey the GII from HQ RE Middle East Command. From 25 May onwards the force consisted of my Squadron with its three field troops and park troop, 2 Troop 34 Independent Field Squadron, 3 Troop 9 Para Field Squadron (up to early July) an RE Stores Section from the Command Ordnance Depot in Aden, a Topo Troop from 13 Field Survey Squadron, and from mid July until late August, Plant elements of 6 Field Park Squadron and 521 Specialist Team (Well Boring). While this gathering of Sappers all came under the Squadron's hand, inter-unit competition ran high and rivalry was as it should be. At no time was there a hint of friction and the ultimate loyalty to the "cap badge" was overriding. For this must go credit to all the troop commanders who lived with us and who did as they were asked despite 3 Squardon's ways being different from their own. (Officers who served in the Radfan are listed at Annex.)

The Tasks

The tasks which faced us were many and various but from the command point of view there were the normal problems of being middle man between Engineer HQ and the Force Commander, of being given more tasks than even my inflated resources of manpower could cope with, and of educating people in what the "Sapper" could and could not do and how long everything takes. Out of this stemmed priority tables and works programmes, which while always changing for one good reason or another, were the only means of controlling the economical deployment of effort.

This planning had to be done fairly quickly as our services were urgently needed and troops were to be deployed two days after our arrival. The work fell into fairly clear categories. There was an urgent need to build a communication system of roads into the operational area to relieve the helicopters which up to then had been the maids of all work for both troop movement and supply. Water supply was equally important and with temperatures of well over 100°F the demand for a force of some 3,000 was 20,000 gallons a day. Seven gallons per man may seem excessive and there is little doubt that the force could have managed with less but this was the demand and to a certain extent we created it. The Thumair base was basic indeed and from the start the Squadron, or part of it, was employed improving the facilities. Such things as showers and ablutions were constructed and as each was completed the demand for water increased.

Mine warfare, or the search for random-laid mines, was our most frustrating task, and conversely our most satisfying was perhaps the Agricultural Aid programme we embarked on in July. The construction of forward airstrips for aircraft up to Twin Pioneer, operational tracks for the forward movement of vehicles and guns, Sapper recce parties in support of each operation, and the construction of part of the Aden–Dhala road were amongst other jobs which came our way. In the next few paragraphs I will put some meat onto the bones of the bigger tasks I have outlined.

Road Making

The map shows the operational theatre which lies some 50 miles north of Aden and to the east of the Aden–Dhala road. The two main areas which were brought under military control were the Danaba Basin and the Wadi Taym and these areas provided the base for all other operations. The provision of 3-ton vehicle routes from the AMA at Thumair into these areas provided the principal road construction task. The geography of the area is, to say the least, rugged and the only flat bits are Wadi beds. These are as irrational as the rest of the country and change their shape with every flood. Rain water gathers in the hill water-sheds which converge in the Wadis, so that after rain a wall of water 6 to 8 ft high roars down sweeping everything in its path. Since there was no practical alternative the access route eastwards had nevertheless to follow the Wadi beds. These tracks were no more than vehicle routes from which the larger stones were removed after flood. The northerly Wadi Banah (Pall Mall) had sheer sides rising 1,000 ft from the wadi bed and with every storm boulders (some as large as 50 tons) were swept down into the track. While this was the main supply route until July and many tons of explosive were used in keeping it open, its maintenance was uneconomical once an alternative route had been completed. The alternative route lay along Wadi Rabwa (Piccadilly) which had relatively low banks and which was negotiable within twelve hours of the heaviest rain. However, at its head it reached a 500-ft escarpment which had to be climbed. Thus came into being the triangle of routes shown on the sketch map by their code names, Park Lane, Fleet Street and Ludgate Hill. Designing these routes at the end of the dry season and with no experience of the effects of rainfall, taught hard lessons of how and where not to build when the rain came. It taught the obvious that the higher up the wadi sides we built the better, and that walling which in anyway hindered the water flow was doomed to destruction, and the track with it. The work to complete these 4½ miles of road took the major engineer effort and kept at least two troops busy for five months. Using explosive and some 400 local labourers with picks, shovels and crow bars the routes were gouged out of the mountain sides; complex retaining walls were built keyed on to the bed rock and between the walls and mountain side, rocks of 4–6 ft in length and up to 2 ft in depth were manhandled into position and locked together. This fill was built to within about a foot of the top of the wall the last foot being filled with smaller stones until the final sand and gravel surface was reached. Drainage was designed so that water ran across the track and not along it. The network was taken into use in July though improvement and development went on until mid-October.

Besides this network, and the grading and surfacing of roads in the AMA area, the Squadron constructed 14 miles of road from Thumair southwards towards Aden. The existing route was a camel track which vehicles had followed. Our aim was to achieve a 20-ft roadway with minimum bends and gradients, to save vehicle damage and time on the resupply convoys from Aden on which we all depended. It also provided the alignment for part of the black top road being built by 6 Field Park Squadron from the south. The work, which was completed in nine weeks was done by the Squadron Park Troop, supplemented by plant and operators from 6 Field Park and commanded initially by Lieutenant Peter Dean the Park Squadron Plant Troop Commander.

Water Supply and AMA Amenities

I have described the effect on roads of water we didn't want. There was nevertheless a large water supply task which was the daily problem of the housekeeping troop who lived with the Squadron HQ in the base camp. Aden is somehow synonymous with heat and lack of water, but in fact it has a very good water supply. In the Radfan area the Squadron found some eighty water sources. These fell into three categories, perrenial streams, wells and cisterns. There are two streams in the area both of which supply good water to troops living near by. On the mountains which rise to 5,500 ft the local inhabitants rely on catchment water which runs into cisterns and which store up to 30,000 gallons each, but the principal source is from wells. Most of the wells are some 60–100 ft deep, are stone-lined and some 8–10 ft in diameter. Supply into the wells is by seepage through the well wall. The flow varies from well to well but a good one gives an output of 1,000 gallons per hour, it was on wells of this kind that supply to the force depended. Water was pumped into bowsers and then moved to a Braithwaite storage tank which fed the water supply point in the composite platoon from which all water issues were made. Some 12,000 gallons a day were supplied by this means and another 8,000 gallons were supplied from water points in the forward areas.

Water supply was not the only facility we were asked to provide. From the start the Squadron was heavily concerned in the improvement of living conditions and a seemingly endless number of structures were called for. When we arrived in May the force was only just settling in and little had been done to make the place habitable. By mid June there were twelve units living in the area, excluding forward units, and all were clamouring for kitchens, ablutions, showers, DTLs, ration stores, swill cages and the like. Living accommodation was basic, and concrete tent bases became fashionable once the standard had been set by our reconstruction of the CCP. Other amenity tasks included a dust free casualty evacuation helicopter pad, running a 10-ton cold store, maintaining sixty kerosene refrigerators to say nothing of turning the political officers house into a dwelling worthy of him.

Mine Warfare

As I have already written our most frustrating task was finding the mines which the dissidents laided at random in the tracks. There seemed no practical answer to their detection and, as incident followed incident, different conclusions were drawn. Eventually the dissidents laying drill became clear. The mines (Britisk Mark 5 and Mark 7 anti Tank) were being laid where track bottle necks and bends coincided and always on the outside of the bend. Initially craters 3 to 4 ft deep suggested that the mines were being laid at depths greater than 12 in and thus below detector level, but a Mark 7 mine was then discovered with a boost of 1½ lb of slab gun cotton beneath it. If this was the general practice then it could account for the crater depths made by the mines we failed to detect and which had cost us fifteen casualties. The ground is volcanic and, except for limited sandy areas the standard detector gives an almost constant warning signal, and against volcanic rock, the standard prodder gives up altogether. Searching for these mines was a matter of experiment. Eventually a sweeping system was evolved whereby sweep parties working on a converging pattern left the base and forward areas at dawn each day. Each party of four men, armed with both prodders and detectors, was accompanied by an escort and a wireless vehicle. The foot party then inspected the route and its verges for signs of disturbance in the previous days wheel tracks. Detectors and prodders were used on bottle necks and bends. While this method had some success, the airfields and twenty-odd miles of track were not cleared for the first three hours of the day, and even then one could not be sure. An attempt was made to "paint" the route by spraying with crude oil so that disturbance could be easily seen. This was successful though the quantity of oil needed was enormous and for obvious reasons could only be employed out of wadi beds.

Agricultural Aid

The flow of water in the wadis, an enemy to our road making, was the source of livelihood to the local people. Help in harnessing this flow, or part of it, was the purpose of our Agricultural Aid Programme in the friendly state of Alawi which lies to the South of the operational area. QMSI W. E. Reader was lent to me by HQ RE 3 Div and a team consisting of five or six men from each of the four field troops was put in his charge. Their work was to improve irrigation channels and to deepen and strengthen wells. We began in early July and by the end of the month the full team was at the work which went on until early October. During that time some twenty wells were deepened and their headings improved, and 1,200 Gabions each filled with about five tons of stone were constructed and set in irrigation channel walls. The Shiek of Alawi showed his appreciation by entertaining all the Sappers at one time or another, and whenever there was trouble in the Radfan sent his own tribesmen armed to the teeth to defend the various working parties. It was quite usual on such days to see up to thirty Alawi guarding two sappers working with local farmers on a well improvement or an irrigation channel wall. This was our contribution to the "Heart and Minds" war in the Western Aden Protectorate, and perhaps we had something to do with the Alawis joining the Federation in July.

Lessons

From the start there was a sense of satisfaction in all we had to do and it was this that kept everyone going and happy. To list all the lessons learned would be tedious, for the whole operation provided a wealth of experience for everyone. A mixture of peace and war accounting and the handover of all our equipment to 50 Sqn before coming home in October kept the Quartermaster busy. Communications open day and night for five months on both the Sqn and Bde net, and daily conversations with Aden on the Engr net, tested both operators and users; vehicle servicing every day taught the drivers and servicing team more than they had ever known, and the very hard going gave the fitters a real test of their skill. Cooking in temperatures of over 100°F exhausted the cooks and "variations on a compo theme" called for their ingenuity. Unlike other units the Sqn home was in the Radfan and the whole range of administration including such matters as postings, promotions, courses and pay had to go on as normal although in poor circumstances and for a unit of close on 400. The whole system was stretched and experience was gained as a result.

Conclusion

The Corps "War Cry" of helping the Army to "Fight to move and to live" adequately summarizes Sappers in the Radfan though our activities were more concerned with "moving" and "living" than with actual fighting. Perhaps this is the pattern of things to come and that Sapper Field Squadrons concerned in operations of this sort will become more and more involved in a logistic support role. If this is so, then our training must be designed to fulfill it. From my own point of view the day was saved on more than one occasion by tradesmen who were prepared to work long hours in uncomfortable conditions and have a go at anything without close supervision. That they were physically able to work as they did without taking time off for acclimatization was due to their being fit. We had put in a lot of hard training in the Spring and this certainly paid off. In the Radfan the Squadron was split into many small parties, some lead by Sappers, all responsible for their own protection as well as for their work and it was junior leadership at the troop and section level which got the work done. If lessons are to be learned from the Radfan then they are the value in this sort of operation of tradesmen, the importance of efficiency in skill at arms training in first aid and military subjects for every Sapper, reliance on junior leadership, and above all physical fitness.

In all it was a most worth-while experience. When the time came to hand-over all our equipment to 50 Squadron and return to Tidworth, a very different group of men left Aden from those who had arrived in May, and certainly we were all less cynical about the Strategic Reserve.

Officers who Served with 3 Indep Field Sqn in the Radfan

3 Indep Field Sqn

OC	Major J. P. Groom, MBE, RE
2 i/c	Major R. G. Bellam, RE
QM	Captain (QM) F. C. Taylor, RE
IO	2nd Lieut J. O. D'Arcy, RE
1 Tp	Lieut S. C. E. Weld, RE
	Lieut M. J. Hills, RE
2 Tp	Lieut M. J. Handfield-Jones, RE
	Lieut D. W. Crawford, RE
3 Tp	Lieut M. T. Whitworth, RE
Pk Tp	Captain D. Kiggell, RE
Att	2nd Lieut R. Bradbury, RE, from CRE HQ MEC

2 Tp 9 Para Field Sqn

Lieut M. Irwin, RE

Topo Tp 13 Field Svy Sqn

Lieut P. Robinson, RE

2 Tp 34 Indep Field Sqn

Captain P. Kavanah, RE
Lieut J. Prior, RE

Plant Tp 6 Field Pk Sqn

Lieut P. Dean, RE

521 Specialist Team

Captain R. Theobald, RE

Note

S/Sgt R. C. Christison was awarded the British Empire Medal for gallantry for mine clearance under conditions of great difficulty and danger on the Aden–Thumain Road, Major J. P. Groom, MBE, Warrant Officer W. E. Reader and S/Sgt D. Fox were mentioned in dispatches in recognition of gallant and distinguished services in the Radfan Area and thirteen NCOs and Sappers received the Commander-in-Chief's commendation for their work.

Editor.

Operation Flamingo

3 INDEPENDENT FIELD SQUADRON'S CENTREPIECE

By MAJOR R. G. BELLAM, RE

3RD Independent Field Squadron RE, as part of the Strategic Reserve, was flown to Aden in late May 1964 to participate in operations in the Radfan Mountains in support of 39 Infantry Brigade Group. The operations lasted until October 1964, and during this five-month period, many Engineer units and detachments were involved. To commemorate this engineer effort we decided to produce a piece of silver.

Our Officers' Mess at Thumair varied in strength from three to thirteen, thus the discussions and arguments that took place from time to time, to try to decide upon a design were many and heated. Of coures there were plenty of suggestions and much criticism. The choice was at last reduced to either a piece of rock or a flamingo, and the final decision was a compromise. The rock to symbolize the rugged barren area in which we had been working, while the flamingo (the operation's code name) was chosen for its natural beauty.

After much searching, whilst on reconnaisance or visits to field troops, an attractive piece of rock was found. This was carefully brought home and taken to Carringtons, as the basis of the centrepiece. It was agreed that a flamingo should stand upon the rock, but other than these two details, the design was left to the silversmiths. The design, submitted by Mr G. Bush of Carringtons, was accepted, and the piece, as shown in the photograph was completed by 10 March 1965.

The centrepiece, which is 12-in high, consists of a piece of whitish granular rock about the size of one's fist, standing on a silver mount upon a wooden base. Upon the rock stands a silver flamingo 3½-in tall. The ebonized base has silver plates on each side which are inscribed as follows:—

Front plate: 3 Independent Field Squadron Royal Engineers. To commemorate Engineer Operations in support of 39 Infantry Brigade Group in the Radfan Mountains of the Western Aden Protectorate. May-October 1964.

Left hand side plate: The rock was blasted from "Fleet Street" the route constructed between the Danaba Basin and the Wadi Taym.

Right hand side plate: "Operation Flamingo". The Flamingo represents the code name given to 39 Infantry Brigade Group Operation.

The rear face of the base has six small silver plates, each inscribed with the title of the various sub-units which were under command for some or all of the operation: 2 Troop 9 Indep Para Sqn RE; 2 Troop 34 Indep Field Sqn RE; Plant Troop 6 Field Park Sqn RE; Topo Troop 13 Field Svy Sqn RE; 521 Spec Team RE; RE Section Ord Depot Aden.

The centrepiece is the property of 3 Field Squadron RE. Should the Squadron disband, the piece would become Corps property and would take its place at Ghatham with the majority of the Corps Silver. Meanwhile, the piece will be kept in the Squadron lines in the Trophy cabinet. On dinner nights and for special mess occasions it will be placed in front of the OC or SSM in their respective messes.

Operation Flamingo

Sappers Inaccessible

By Lieut-Colonel F. W. E. FURSDON, MBE, RE

INACCESSIBLE Areas, because of their very nature, are often places where Sapper tasks arise. The job may be to build an airstrip on a virgin jungle site, to erect a camp on a remote plateau, to repair bridges on a mountain road, or quickly to open up patches of an existing route, blocked through natural or enemy action, working several sections simultaneously. In all these and similar cases the problems are first to reconnoitre and plan, secondly to introduce the required men, machines and stores as are not available locally to the site, thirdly to maintain each of these elements "on the job" and finally to extricate, recuperate, rehabilitate and re-brief them for the next task. There is nothing new in this, and it is all traditional Sapper teaching: often, however, the sequence proves extremely difficult and time-consuming by purely conventional means. The challenge to the Sapper of today is to make the Inaccessible accesible, and quickly so. More and more in the future it is a proper appreciation of what air effort can do to help him, that will be his biggest aid in meeting this challenge. This article aims to show in particular what can be done to introduce engineer and maintenance stores and equipment to an otherwise inaccessible site, and present some of the practical difficulties involved.

RECONNOITRE AND PLAN

Many squadron commanders, troop commanders and troop sergeants, particularly in places like Aden, East Africa, and Malaysia, have become experienced in "Sapper Recce" from Austers, Beavers, Alouettes, Scouts and, at times, Colonial Police Cessnas. Others have had to work, though usually not by choice, from Twin Pioneers: flying a hundred miles of winding low-level route recce in a wallowing "Twin Pin" is guaranteed to take the fight out of all but the most stalwart souls! Working with helicopters, one can land at critical points to take working measurements and this is very satisfactory. Provided the aim of the sortie is not just to obtain the simple answer to "Is the bridge at 644751 still there or not", fixed wing recce is more demanding, and proper training and experience is needed for it to be really effective and worthwhile. To be able to tell, for instance, whether the vertical step of a washed-away bank seat is two or six feet is very difficult, particularly if there is no adjacent reference aid to use for direct comparison.

Now, with the iminent introduction of the Bell "Sioux" helicopter into the Divisional Engineers (details of which were given in the *RE Journal* of March 1965), the time has come for every combat engineer officer and field troop senior NCO in field formations to receive proper training in engineer air recce, and for this skill to be maintained by frequent continuation training flights thereafter. Of course many officers are already very air-minded either as Army Air Corps or RE Flying Club pilots, airborne sappers, or merely, as in the Strategic Reserve, through constant practice at rapid air moves; this is excellent, for they will all automatically spread "air education".

The introduction of the Air Troop RE now gives a long awaited opportunity for others to "get off the ground" and so increase their military value as Sappers. The means has been provided. It is now the responsibility of every CRE to ensure that the best possible value is obtained from it, for not to do so would be verging on the criminal.

For planning purposes, forward engineer terrain intelligence is always essential, and in addition to normal sources, everyone is well aware of the value of air photographs for providing prior, continuous, changing or "late night final" information about either a specific area or pin-point target. Both Army and RAF aircraft will fly photographic missions, but verticals and pictures behind enemy lines are normally a RAF task. The developments now taking place in the radar, infra-red and drone fields of combat intelligence acquisition by camera are all of great help, and the military engineer today must understand their capabilities and limitations so that he makes reasonable and intelligent requests for the type of information he requires.

The Introduction of Men

Getting men on to the working site is the next part of the planning sequence for Inaccessible Areas. Parachuting is the first and obvious method of entry, and, apart from 9th Parachute Squadron RE, there are in fact many trained parachutist engineers in other units of the Corps. Many of these are still keen on parachuting, are often frustrated because they have no opportunity to do so and would gladly carry out the extra training necessary to keep them operational in the airborne role. Field squadrons could have parachute teams written into their establishment for the purposes of initial assault into Inaccessible sites. This idea is not new, and for some years has been the subject of engineer lip service in lectures and demonstrations in the context of "parachuting-in-a-team-of-men-to-clear-an-initial-rough-airstrip-in - order - to - bring - in - SRT - aircraft - with - larger - kit - with - which - a - bigger - strip - can - be - built - which - will - take - MRT - aircraft - which - will - bring - in - the - still - bigger - kit - which - will - keep - it - maintained - as - a - proper - MRT - airstrip". Whereas these teams would have a more prominent role outside Europe, they would still have possible tasks within Europe in general war. The squadron's parachutist strength might well be two officers plus one section. The obvious difficulty is continuation training, but this can be assisted by the use of SRT aircraft for jump training. An alternative solution is to increase the size of 9th Parachute Squadron, so that it can then detach teams to Field Squadrons requiring them: such a solution simplifies the training problem, but it creates other difficulties.

Air landing from SRT aircraft, particularly helicopters, provides an alternative way of introducing men to the site. Some engineer units have already had experience with the Wessex and Whirlwind in Europe, moving demolition firing parties on exercises, and in Borneo for operational movement. Certainly in the Strategic Reserve, in the Middle and Far East theatres, all field squadrons should be trained in helicopter emplaning drills, and in deplaning at rest, at the hover or by rope.

The Introduction of Equipment and Material and the Problems of Subsequent Maintenance

The majority of Sappers today have had little or no experience of the potentialities, problems or limitations of introducing stores and equipment to the ground by aerial delivery. It is not a subject covered in normal Army Department pamphlets, nor is it taught in Arms Schools. To Sappers Inaccessible, however, it is a very vital subject, and it is in order to fill in a practical background to this "vacuum" area that the greater part of this article is devoted. It is all very well to air-drop Sappers with their personal weapons and what explosive and other items they can cram into their equipment or weapons containers, but their usefulness thereafter, and possibly their very means of survival, is limited without an immediate aerial delivery of vehicles, plant and equipment, and subsequent ones of rations and material! These requirements are covered separately by Heavy Drop and Air Maintenance.

Heavy Drop

Heavy Drop is not Air Maintenance. Although employing aerial delivery techniques, it is the operation of dropping vehicles, guns and certain heavy equipment to airborne forces by parachute during the assault phase of an operation. Normally Heavy Drop is a matter for 16th Parachute Brigade Group (including of course 9th Parachute Squadron RE), but on occasions it can and must be used, as recently in Borneo, to deliver vehicles or pieces of engineer plant to Sappers Inaccessible.

Aerial Delivery Platforms are of two generic types, Stressed and Unstressed. Generally speaking, stressed ones have the parachute attached to the platform base itself and can take a high point landing. In unstressed platforms, the parachutes are attached to the load itself and the platform base becomes, in effect, a skid-board. The latter are used more for distributed loads.

The items to be dropped are loaded and lashed down on to platforms by skilled unit rigging teams, in accordance with standard load lashing diagrams. These make use of timber struts, honeycomb paper and even simple steel frames to reduce landing shock. The Heavy Drop platforms in current use are:

The Medium Stressed Platform. The dead weight of the platform, lashings, parachutes etc, accounts for between 2,700 and 3,650 lb of the maximum total load of 12,000 lb. This is the platform in common use for landrovers and trailers, and it can be dropped from Argosy or Beverley aircraft.

The Heavy Stressed Platform. This is a very large platform used primarily for the aerial delivery of engineer plant and other heavy loads. A Caterpiller D4 can be dropped satisfactorily by this means and produces a total load

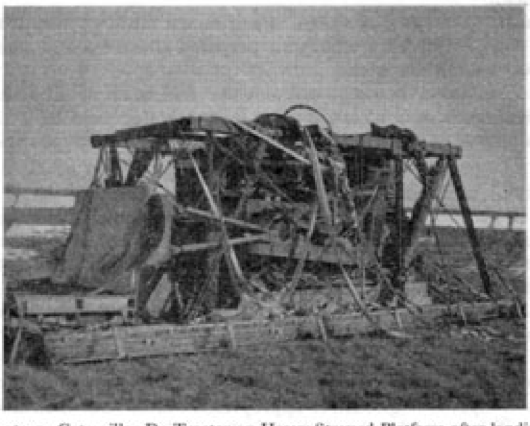

Photo 1. Caterpillar D4 Tractor on Heavy Stressed Platform after landing.

Sappers Inaccessible 1

weight, including platform and fittings, of nearly 30,000 lb. (See photograph No 1.) Graders and Mitchigans also drop satisfactorily. Because of its size, this platform can only be dropped from a Beverley.

Once the platforms are properly rigged and checked, they are loaded on to flat bed trucks by mechanical handling equipment. If no such aids are available, a vehicle pit can be dug by plant, the vehicle backed up to the face, and the load eased over the cill and on to the vehicle's rollers, but this is a laborious and exhausting technique! The platforms are then installed into the aircraft and checked. They are despatched in flight by the RAF Air Quartermaster, using automatic ejection.

Air Maintenance

Air Maintenance is the normal method of supplying an Inaccessible force by air with its needs. Its practicability depends on a favourable air situation, availability of suitable aircraft and of adequate mounting airfield facilities, the weather, the existence of a proper organization to pack and load stores for air delivery, the availability of aerial delivery equipment (parachutes etc), and the existence of suitable air landing or air dropping zones (DZs). Assuming that these conditions apply, and air maintenance has been agreed for Sappers Inaccessible, it is important for the users to appreciate the executive organization which puts the plan into operation and, in particular, to know the various Service responsibilities. These were changed as a result of recommendations arising from the McLeod Committees' Report on the Army's Q Services, and are now divided as follows:—

(*a*) The Royal Corps of Transport (RCT) is responsible for:—

(1) Providing the Army command and control organization on airfields, and is the sole Army authority with which the RAF station commander will deal.

(2) The packing, loading and despatching of all stores.

(3) Arranging transport for the move of stores to the airfield.

(*b*) The Royal Army Ordnance Corps (RAOC) is responsible for:—

(1) Holding stocks in depots or field stock-holding units within easy reach of the airfield.

(2) Primary packaging of stores, which means ensuring that stores provided for transport by air are properly prepared and are sound and safe for air transport and air despatch.

(3) The provision, holding, maintenance and issue of all Army aerial delivery equipment used within the Air Despatch Regiment RCT, and the holding and issue of parachutes and associated equipments provisioned by the RAF.

The actual unit responsible for taking all executive action is the Air Despatch Regiment. This new unit inherits all the detailed responsibilities of the previous Army Air Supply Organization (AASO), and provides the agency for moving stores through the airfield and the air transport system provided by the RAF. It is not a store-holding unit, and stores not "in transit" will normally be held in RAOC depots. Should the turn round time for vehicles travelling from the airfield to depots be considerable, it may be necessary to establish store-holding units or sub-units adjacent to the airfield. If so, these units or sub-units will be placed under command of and form part of, the Air Despatch Regiment, as appropriate. Stores once delivered to the Regiment will be considered as being "in transit".

The Regiment is established on a brick system, RHQ commanding a number of Air Despatch Squadrons RCT, which in turn command Air Despatch Troops, RCT. Each of the three sections of a Troop contains two Air Despatch Crews. The Regiments' tasks are:—

(*a*) To provide the Army command and control organization on the airfield.

(*b*) To provide the necessary transport and equipment for store handling and movement on the airfield.

(*c*) To prepare loads, and to load platforms, containers and loose freight into aircraft: to despatch and unload stores where these functions are an Army responsibility unless, in the case of unloading stores, the task is delegated to the receiving unit or formation.

The Regiment also has an Air Maintenance Platoon, RAOC, under command. The role of this sub-unit is:—

(*a*) To provide, hold, maintain and issue such a scale of Army aerial delivery equipment as may be required to be immediately available at the airfield.

(*b*) To provide technical and specialist advice on load preparation and the safety of stores in transit, particularly hazardous loads of RAOC origin.

(*c*) To ensure that ordnance loads have their proper primary packaging and are delivered to the Air Despatch Regiment sound and safe for air movement.

(*d*) If necessary, to hold a limited quantity of ordnance stores ready for loading.

In different theatres, of course, depending upon the task foreseen, there may only be a Squadron or even just a Troop of the Regiment available to deal with support for Sappers Inaccessible, but this will usually be quite enough!

Although tempting to do so, it is very dangerous to give any planning figures out of context as to what quantity of stores an Air Despatch Troop can handle a day. The principal factors affecting this total are:—

Whether the stores are for air landing or parachute dropping.

The type of container used, eg, whether 1 ton containers or harness packs.

What type of aircraft is being used, and how many.

The local conditions for work in the theatre such as climate, proper packing bay or open field, etc.

The length of the sorties being flown, and therefore how many crews are available for packing as opposed to despatching.

The state of training of the packers.

Experience has shown, however, that as a very rough guide only, an Air Despatch Troop might pack, load and, where appropriate, despatch:—

(*a*) In the air landing (or air freighting) role, up to 200 tons a day of palletized loads, or only 100 tons a day of loose freight.

(*b*) For air dropping by parachute, between 30 and 50 tons a day, depending on the type of aircraft and container.

In practice, detailed planning is needed for each situation.

Air Maintenance at the working level centres around the Air Despatch Crews. These men form an integral part of the air crew for an air drop sortie. Having been trained as air despatchers, they draw a special rate of flying pay, and having flown forty training or twenty operational air despatch sorties they qualify for their air despatch brevet or "wings". The air despatch crew commander, although normally a corporal, may be a lance corporal or even a driver RCT, provided he is suitably qualified in the appropriate category: as can be appreciated, he shoulders a great responsibility. All crew commanders are "categorized" either every six months or annually (depending on their previous category) by the Air Supply Examining Team of the RAF Transport Command Examining Staff. They are tested on all the types of aircraft used in air drop work. In addition their aircraft load checker's qualification has to be renewed every three months.

So much for the executive organization for Air Maintenance: to see how it works out in practice, consider a field squadron deployed in a jungle theatre. It is being supported by air maintenance and, therefore, makes its bids on a standard request form as laid down in the relevant formation SOPs. This request is first vetted and then consolidated into its formation HQ request for air maintenance. The various requests are considered at the daily Joint Operations Centre conference at Force HQ. As a result of this conference, executive orders go out via the Air Transport Operations Centre (ATOC) to the airfields concerned and to the HQ controlling the Air Despatch Regiment, RCT. The procedure followed and the actual sequence of events will vary in different formations and theatres of operations.

At the same time as orders go out to the Air Despatch Regiment, other orders are issued by the Army staff to the relevant RE or RAOC stores organizations and depots, etc, to provide the necessary items, complete in their primary packaging, for Air Despatch Regiment controlled transport to collect. This loaded transport drives straight from the various depots to the packing bay, preferably a large hangar. Here air despatch crews of an Air Despatch Troop, RCT prepare and pack items into the appropriate type of container for aerial delivery, and then make these up into aircraft loads. The parachutes are now checked but are not attached to the loads until later.

Aircraft loads of the smaller containers are normally loaded on to tractors and trailers for the short journey from the packing bay to the aircraft. The bigger types of container need to be lifted by crane on to flat-bed 3 ton vehicles fitted with roller conveyors. On arrival at the aircraft the air despatch crews transfer the loads into the aircraft and are responsible for lashing the load down correctly. It is at this stage that the parachutes are fitted to the large containers: in the case of small containers only, and if there are a number of DZs to be visited, the parachutes are usually fixed on in flight shortly before despatch.

Before the loaded aircraft can take off, the RAF air quartermaster and the air despatch crew commander together carry out a detailed check and inspection of all the individual loads, parachutes and lashings which have been installed in the aircraft, and both sign the appropriate certificates. With an air landing load only, this final check may be carried out by a member of the RAF Mobile Air Movements Section instead of the air quartermaster. Furthermore, in this latter case there is normally no need for an air despatch crew, since the unit manning the destination airfield or airstrip can unload the aircraft: having no despatch crew saves payload.

The aircraft flies to the DZ, perhaps just a six figure grid reference. Shortly before the drop is due, the air despatch crew unlash and position the first loads for despatch. The RAF navigator indicates by red and green lights above the aircraft doors the correct moment for the air despatch crew commander to despatch his load.

Clearance of loads from the DZ, and the very important salvage in good condition of the aerial delivery equipment used for the drop, are the responsibility of the receiving unit or formation.

Air Maintenance comprises two main techniques, Air Dropping and Air Landing, and these two aspects are described separately.

Air Dropping

The following British aircraft are normally used for air dropping:—

Single Pioneer	Beaver	Hastings	Argosy
Twin Pioneer	Valetta	Beverley	

The C 130 also has an airdrop capability.

In very general terms, any load can be dropped from an aircraft provided it:—

(*a*) Can go safely in and out of the aircraft doors.

(*b*) Is not heavier than the available aircraft payload, nor denser than the floor loading limitations of the aircraft allow.

(*c*) Can be fitted with an adequate arrangement of parachutes for descent.

(*d*) Can be automatically or manually ejected safely from the aircraft in flight.

(*e*) Does not jeopardize the aircraft's stability either during "in flight" preparation or whilst actual despatch takes place.

(*f*) Is of sufficient density, eg, weight per volume. Loads of an insufficient density will, on leaving the aircraft, fly upwards initially and may damage the aircraft. (Examples of adequate load density are 30 lb per cubic foot for Hastings, Valetta, Beverley and Beaver aircraft: 18 lb for a Twin and 15 lb for a Single Pioneer.)

(*g*) Does not violate the "Rule of Ratio", which ensures aerodynamic stability. This dictates that the longest side of a load must not exceed the shortest side by more than a ratio of 3:1.

Provided they are suitably packed, the following are examples of normal items dropped by parachute on operations: Ammunition, fuel (including drums of AVGAS, AVTUR, KERO), rations, ordnance stores, vehicles and repair assemblies, defence stores (including sandbags, dannert and barbed wire and angle iron pickets), engineer plant (in pieces: reassembled on the ground) and small live animals for service (eg, guard dogs, cats for pest clearance) or, together with poultry, for fresh rations (eg, chickens, goats). Psychological warfare leaflets are normally free dropped. Strange requests are sometimes received: one jungle patrol in Sarawak asked for a butterfly killing bottle and appropriate chemicals!

There are a variety of standard containers available in which to pack stores for air dropping. These are:—

(*a*) *Small Containers.* Currently, these have a payload range from 150 to 500 lb, but this will soon increase to 700 lb. Examples of these which are dropped with a parachute are:—

The South East Asia Command (SEAC) Pack. This is a canvas pack rather like a large kitbag, but rectangular in cross-section and it has a percussion base to reduce landing shock. (In Borneo this is usually filled with coconut fibre). Its load capacity ranges from 130–185 lb when despatching from MRT aircraft: it has a lower minimum with SRT aircraft. (See photograph No 2.)

Photo 2. The SEAC Pack.

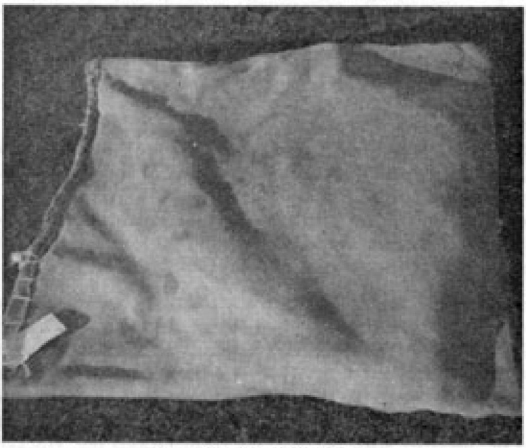

Photo 3. The Derby Sack.

Harness Pack. This consists merely of the load to be dropped, preferably regular shaped containers such as jerricans or boxes, put on to a percussion base (to reduce the landing shock) and lashed tightly together with a webbing harness. The maximum payload allowed is 500 lb, but the normal pack is about 350 lb. Fuel drums can be despatched singly by this technique, but it it used principally for dropping composite and 24-hour ration packs, small quantities of fuel and water in jerricans, and defence stores.

Universal Harness Pack. This is a new equipment, not yet in service, which will have a payload capability of up to 700 lb. It consists of a set of four webbing arms of equal length, set in cruciform pattern, each arm having a quick release buckle at its end. A parachute suspension D ring is fitted at the point of cross of the webbing arms.

Airborne Pannier. This item, looking like a large laundry basket, has done excellent service over the years, and is still in service. Its upper weight limit when despatched by roller conveyor from a Hastings aircraft is 350 lb.

Photo 4. The one ton container.

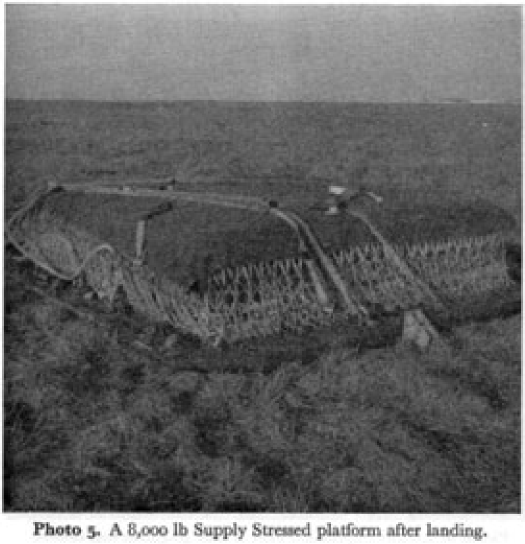

Photo 5. A 8,000 lb Supply Stressed platform after landing.

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For free dropping, *Derby Sacks* are used. These are pairs of sacks which fit one inside the other, and are used for free drops of grain, rice, etc. The commodity is packed into the inner sack, which is sewn up and placed inside the larger one, also sewn. The sacks, maximum filled weight 200 lb, are dropped from heights of up to 300 feet maximum. On impact with the ground, the inner sack may burst, whereas the larger looser sack does not do so. (See photograph No 3.)

(*b*) *The 1 ton Container*. This consists of a heavy plywood base-board on which are mounted four canvas side wall covers. First a layer of shock-absorbing material usually "honeycomb paper" is spread all over the board, the load is packed next, and then it is covered by the canvas covers (rather like wrapping up an enormous parcel) and finally the whole thing is tightly secured by an encircling webbing harness. These containers can only be despatched from rear loading aircraft. (See photograph No 4.)

(*c*) *8,000 lb Supply Stressed Platform*. This is a simple wooden platform with nylon mesh side wall nets and a canvas cover. It has a payload range of from 4,500–9,500 lb. The weight of the platform alone plus parachutes is 1,500 lb: this "dead" weight penalty is approximately twice that for a similar load packed into four 1 ton containers. (See photograph No 5.)

Where there is insufficient standard aerial delivery equipment, improvised loads, previously cleared by the Army Air Transport Development Centre (AATDC) and the Aircraft and Armament Experimental Establishment (A & AEE) may be used. However, in order to meet the operational needs of the moment, quick local improvizations jointly approved by the Army and RAF in the theatre may have to be employed. In current Borneo operations, for instance, use is being made of "roped" packs instead of standard harness packs, and of a special plywood base and rope harness, instead of a 1 ton container, to drop 40 gallon drums of fuel. (See photograph No 6.)

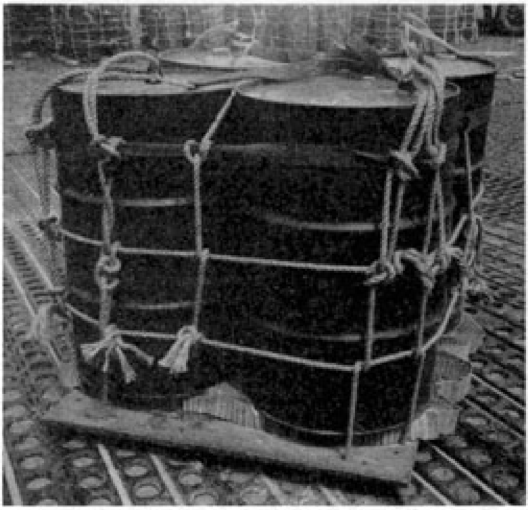


Photo 6. Locally improvised load of four 40-gallon fuel drums.

Packing is an art. Bad packing means damaged stores: not only is this wasteful but is liable to affect the morale of recipients. Any one unit or patrol (usually supplied fortnightly on internal security operations) will need a comparatively small quantity of many different items, all of which have to be packed into the minimum number of containers. This creates packing problems such as the avoidance of contamination (eg, by soap, fuel, etc); spillage; heavy (eg, ammunition) and light items (eg, eggs, medicines) to be packed side by side. Soft items like clothing can help out as packing, but nevertheless skill, care and experience are needed by the air despatch crews. Kerosene, for example, needs separation from food by some inert item like boots! Special decanting tins are provided for rum, oils, etc; plastic bags are used for watches and instruments, and items like bottles of whisky need very special attention and travel well in sawdust or coconut fibre. It *has* been known for eggs, individually wrapped and then placed in a cardboard carton, to survive an involuntary "free drop" when a parachute failed to open: a tribute to the packer!

Parachutes are supplied by the RAF to the Air Despatch Regiment's attached Air Maintenance Platoon RAOC. There are five types in service at present:—

Type	*Weight in lbs*	*For use with load weights from:*
Mark 1A (18 ft diameter)	10	50–185 lb
R type (22 ft diameter)	20	150–400 lb
U type (28 ft diameter)	20	150–400 lb
42 ft diameter (single)	120	up to 2,300 lb
66 ft diameter (single)	300	up to 3,500 lb (for use with 8,000 lb supply and medium stressed platforms)

Air despatchers are trained to pack Mark 1A, R and U type parachutes: this skill could be of importance at a forward airfield where only a limited quantity of parachutes were available.

There are three methods of despatch:—

Manual Ejection. The air despatch crew physically push the load out of the aircraft. All forms of small container, and even a "1 ton" container, provided the aircraft is fitted with floor rollers, can be despatched in this way.

Automatic Ejection (used in rear loading aircraft only). In essence, this method uses an extractor parachute (released when the RAF air quartermaster presses a switch) to pull the load, with its main parachute, out of the rear doors of the aircraft. In air maintenance, this technique is used for 1 ton and 8,000 lb supply platforms. (See photograph No 7.) Automatic ejection is helped by installation into the aircraft of "Side Guidance". This consists of two parallel rails, between which the platform can slide in and out of the aircraft, and locking hooks in the rails which engage on spigots on the platform base. This equipment gives sideways, forwards and upwards restraint to the platform whilst in the aircraft, and is much simpler to work with than numerous lashing chains. Rearward movement is restrained until the moment of despatch by a central floor fitting, incorporating a release mechanism.

Roller Conveyor. A special technique only applicable to the Hastings aircraft with airborne panniers: these come out of the side door like a train of carriages at the speed of an express!

Load Penalties are important. Three items must be subtracted from the available payload before determining the quantity of stores that can be

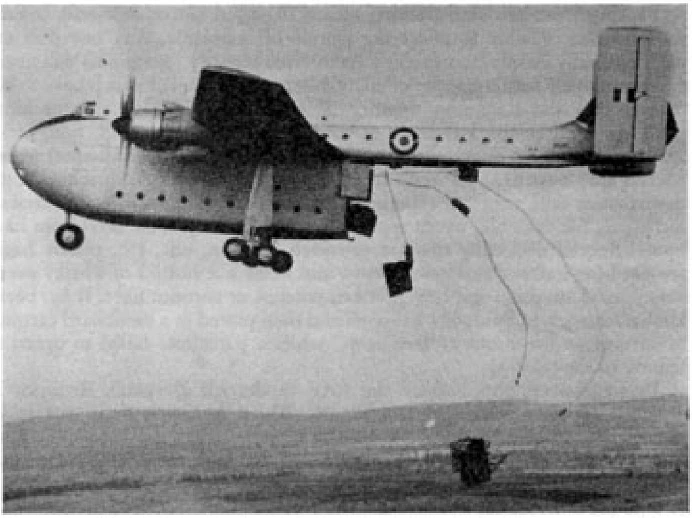


Photo 7. Supply drop of one-ton containers by automatic ejection.

carried in the aircraft: these are the weight of the air despatch crews, the weight of the aerial delivery equipment including parachutes, and the weight of the role equipment required. Combined, this "unproductive weight" normally accounts for 15 per cent of the available payload.

Unless fork lift trucks, roller equipment, etc, are available, air maintenance operations may be restricted to using small containers. Harness packs can be lifted and moved by hand, though the standard weight of 350 lb should not be underestimated! This applies particularly to jungle DZ dropping when the load often has considerable "g" added, due to the aircraft's manoeuvring to get down into the DZ at all. On the other hand, 1 ton containers and 8,000 lb platforms require proper mechanical handling aids to move them around. Flat-bedded 3 ton vehicles with rollers and hydraulic jacks, or carrying special chocks to back up on to in order to alter the bed level, are a useful alternative when loading aircraft.

Before a sortie can be flown, an aircraft has to be prepared for air dropping: this covers such things as installing the "hanging" wire to which the parachute static lines are attached, fitting load lashing points to the floor and any rollers or platform side guidance equipment. This takes time which must be allowed for in planning. For example, it takes seven and a half hours work to "role change" a Hastings from passenger to roller conveyor, or five hours to change it from the freight to the roller conveyor role.

Once airborne on an air drop sortie, there are certain operational factors which must be appreciated by the staff, the executive agency and the recipient. The principal ones are:—

Navigation. The RAF navigator has heavy responsibilities on an air drop sortie. Not only has he to locate the DZ and then direct the pilot to follow such a course that the various types of containers will land on the DZ despite wind, drift, etc, but also he has to give the order at the right instant to the air despatch crew No 1 to despatch the load to land in the centre of the DZ. This may sound comparatively easy in the UK, but when the DZ is only a six figure grid reference to a poor and inadequate map of the Borneo jungle, and with low cloud also forming in the steep valleys, the task is a little more difficult.

DZs have been known to be up to 5 miles away from their so-called map references, and have only been found thanks to the aircraft flying outwards in ever increasing circles until one of the crew spotted the vivid orange marker balloon, sent up by the patrol or platoon at the DZ to fly just above tree top level. These balloons, familiar to many Sappers who have worked in the Far East, are quite invaluable to Sappers Inaccessible. They are inflated with acetylene, made by adding water to the carbide provided with the kit, and so can be used many times over. To aid security it is normally put up by the DZ ground party only five minutes before the drop is due overhead. When trees are tall, and the DZ only 50 yds or so in diameter, the navigator will often line up the aircraft and order the despatch, taking the marker balloon as his only reference. On these occasions the air despatch crew may not catch sight of the DZ on the ground at all: by the time the No 1 looks back to check the flight of his parachutes, the moment has passed, and all he sees is his loads apparently disappearing into the tree tops.

Drop to Several DZs. Stores can be dropped to several DZs on the same sortie if required. Loads for the different DZs are loaded into the aircraft in the reverse order to that in which they will be dropped.

Abortive Sorties. In hilly jungle country, where clouds change and fill up the valleys in a matter of minutes, some sorties may well become abortive through weather or enemy interference, and this means that in Inaccessible places reserve stocks must be held. From the air despatcher's point of view, if, on a "multi-DZ" sortie, a DZ has to be missed out through weather, it is sometimes possible, depending upon which DZ it is in the order and on which actual loads are involved, to change harness pack loads around in flight and continue the sortie. This is not so, however, if the load is of 1 ton containers or 8,000 lb supply platforms, since it is quite impossible to lift these by hand, they run on the aircraft floor rollers anyway, and there would not be room for loads to pass one another.

Fresh Rations. The biggest ration problem in a hot climate is fresh meat, since once out of the supply depot refrigerator this has only a limited life before becoming unfit to eat. Remember also that a small number of sorties may become abortive through weather, the meat on board comes back to the airfield, it may prove impossible to fly again that day, and the meat will soon go "off". Whereas all other stores for an air drop can be drawn from depots and packed the day before, perishable rations like meat must be drawn from the supply depot store only the minimum time before take-off, and parked temporarily in a refrigerator kept for the purpose in the Air Despatch Squadron's packing bay. The meat is usually pre-packed in either wooden boxes, if it is a harness pack drop, or in SEAC packs for a 1 ton container drop, and so it is quite simple to mark them with the serial of the drop and the DZ. The meat is then taken out and put aboard the waiting loaded aircraft. As each DZ load is moved in flight and prepared by the air despatch crew for dropping, the meat, if in boxes, is strapped to the harness packs (with spare straps carried specially for the purpose) or attached to the 1 ton container webbing harness if a SEAC pack. Should the sortie prove abortive, it is thus a simple matter to remove just the meat containers from the aircraft and put these temporarily back into the bay's refrigerator. The meat is kept for another day and then, if it has proved impossible to fly the sortie, is condemned.

Additional Air Despatch Crew. With meat boxes to strap on in flight, the possibility of changing loads on a multi-DZ sortie and with heavy weights to move in a manoeuvring aircraft, the size of an air despatch crew, particularly in the Far East, may increase to a corporal plus six men. This of course is reflected in a corresponding reduction in stores' payload.

Recording and Accounting Procedures. It is important that the air despatch crew ensure that the right loads leave the aircraft in good order over the right DZ. Every container or harness pack is, therefore, marked with its destination and its weight. The weight ensures that the right type of parachute is attached to it. One of the air despatch crew acts as "recorder" in flight, and keeps a detailed written record of what actually is despatched at each DZ as against what should be dropped. He also records the colour of each load's parachute: the use of different coloured parachutes enables the air despatch crew to identify any particular load on its way earthwards which has become a "candle" or "lazy chute" load. Both these types of failure arise from malfunctions of the parachute, and the load will probably suffer damage on landing. A replacement for any particular load seen to be damaged, eg, AVTUR, can then be dropped at the first opportunity. A copy of the unit voucher is usually dropped with the load, duly marked if any requested items are "not available". However, stores may be damaged on arrival on the ground. Each unit on the DZ, therefore, has to complete an Air Drop Completion Report and send this in forthwith to its formation HQ. This states what has been dropped, and deals with any complaints, damages, missing items, etc, so that immediate action can be taken to remedy these. Remember that the air despatch crew keep their own record, and these two records can be easily compared and cross checked. Completion reports usually form the basis for charging for NAAFI foods received.

Recovery of Aerial Delivery Equipment. The capability to keep up the air maintenance of a force is limited by the amount of aerial delivery equipment available: containers, platforms and parachutes are all scarce and expensive, and inevitably some suffer damage.

Not only the larger containers, but the supply of straps, shackles, strops or even enough good quality rope for local improvisations may become critical at times. Emphasis must always be on the salvage of aerial delivery equipment in good condition, and arrangements must be made using Short Range Aircraft if necessary, to return it to the Air Despatch Regiment or Squadron of the Medium Range Transport Aircraft base as quickly as possible.

To assist receiving units, the empty bags of the parachutes actually used on the drop are usually tied on to the bigger load containers and go down with them. Obviously a small proportion of parachute harnesses, etc, will be genuinely damaged, but experience has shown that unless strict disciplinary control is applied, a great deal of unnecessary irrepairable damage may be done to expensive equipment. Examples are slashing open 1 ton containers (to save undoing the straps properly), ripping up parachutes for scarves or rigging lines for hammocks. Tempting though this may be, in the circumstances such actions qualify as felonies! Anyone who does not heed warnings may well be jeopardizing his next NAAFI drop!

If 60 per cent of the aerial delivery equipment used on operations is recovered in usable condition, things are good: the average is normally about 40 per cent.

Security of Air Dropping Aircraft. Aircraft in this role on operations are vulnerable to enemy fire from air defence artillery, small arms and from enemy aircraft. They will, therefore, need fighter escort on many occasions, and the air despatch crews working in the open side or tail doors of the aircraft may need to wear flak suits. RAF fighter escorts are currently provided for air drop sorties in the Indonesian border areas of Borneo.

Ultra Low Level Aerial Delivery, or ULLA, is another technique being developed for Air Maintenance. It aims principally to reduce the amount of aerial delivery equipment used in relation to the true useful payload of maintenance stores. Two variations exist. In "Cable Drag", the aircraft comes in low with a trailing hook. This engages in an arrester wire system on the ground, similar in concept to that used in naval aircraft carriers, and, as the aircraft flies on, the now anchored hook draws the load out of the aircraft's load compartment and makes it land on the ground. In "Para Drag", the load is pulled out of the aircraft by a large parachute which in turn was pulled out by an extractor parachute released from inside the aircraft.

"Cable Drag" calls for a ground party who have arrived with the necessary arrester equipment, holdfasts, etc, and had time to install it. Some officers consider that in this time the ground party could have prepared a short airstrip anyway! "Para Drag", on the other hand, appears to offer much more scope for the future. The actual load, for example 132 jerricans, is packed on to a sledge, and this runs along the ground for a short while before coming to rest.

Although important, and opening up scope for very interesting future developments, ULLA should only be considered as yet another of the family of aerial delivery techniques available. Because the "drop" height is about 30 ft, ULLA dictates a long low "run in" by the pilot. This would be impossible on jungle air dropping sorties, when the drop often takes place in a matter of a few precious seconds between coming out of one steep turn and having to do another to get out of the valley before crashing into the green "wall" ahead. (See photograph No 8.)

Air Landing

All the aircraft listed for air dropping may be used to air land stores. Long Range Transport aircraft, such as the Britannia, can also be used in this role, but remember that it is official policy not to use such aircraft in a battle area. Belvedere, Wessex, Whirlwind, Scout and Alouette helicopters may also air land stores. As with air dropping, the Air Despatch Regiment RCT provides the organization to assemble the loads, and the air despatch crews load and lash the stores in the aircraft. An organization, transport and a labour force for unloading the aircraft must be provided at the destination airstrip. Fixed wing aircraft are relatively simple to cope with, but air landing with helicopters poses some special problems.

Stores may either be loaded inside a helicopter or, in the case of Belvedere, Wessex or Whirlwind, slung externally. The former method usually takes longer since the items must be manually stowed and lashed, and subsequently unlashed and unloaded. For slung loads, either loaded nets or a system of

Photo 8. Harness pack drop on small Dz in Borneo.

slings to contain the load are used. These are attached by shackles to strops which incorporate a quick-release mechanism operated by the pilot to provide a very quick unloading technique. External loading will reduce the speed of the helicopter, possibly by as much as 20 per cent, and on long journeys in operational theatres where helicopter flying hours are scarce, the extra time necessarily spent in the air may not justify this method of loading. With Belvederes, which normally cruise at 100 knots, this cut in air speed is a very appreciable reduction. Underslung loads must be of a minimum specified weight to prevent any violent oscillation of the load in the air affecting the aircraft's stability.

The current external load carrying equipment consists of:

Helicopter supply nets, having a load capacity of 3,000 lb. They are used for carrying loose stores and are suitable for mixed commodities; they can be loaded easily up to the full available aircraft payload. There will always be a shortage of nets, and so their recovery from units is important. (See photograph No 9.)

Helicopter pallet slings, which are used to sling the standard palletised load of stores beneath the aircraft. At present these have a capacity of 2,000 lb, although some new ones with a 3,000 lb capacity are shortly becoming available. Recovery of pallets and slings from forward landing sites is important.

Helicopter slings, having a 3,000 lb capacity for slinging vehicles, guns, tractors, etc. (See photograph No 10.)

When carrying underslung loads, the Belvedere has a 20 ft nylon extension strop hung from the aircraft, to the end of which the slung load is attached. The strop aids stability in flight. The helicopter crewman has an essential part to play helping the pilot when working with underslung loads, because the pilot cannot see what is happening underneath the aircraft. The weight of the crewman must be allowed for when calculating available payload.

Photo 9. RAF Wessex with supply net load.

Just as the early Sapper aeronauts led the Services into the air, so the Royal Engineers of today must be "with it" by seizing the opportunities and exploiting the potentialities offered by the air. This must start with a ready acceptance of the unit integrated aircraft—the Sioux helicopter.

Imaginative thinking is needed about the aircraft's uses so that the most effective and beneficial use is obtained from it. If we waste this unique potential which has been placed in our grasp there is always a lurking danger that it might be taken away and given to someone else who can use it more fully, and who would then only "lend" us time on it when our priority was high enough.

Proper fixed and rotary wing "air recce" training for field formation officers and senior NCOs must be introduced now.

Each Field Squadron, or at any rate each non-BAOR Squadron, should contain a minimum of two parachute trained officers and one complete section ready for initial engineer assault on Inaccessible sites. The remainder of the

Photo 10. RAF Belvedere lifting a 105 mm gun slung load during operations in Borneo.

unit should be trained in air landing helicopter drills, and have a number of trained unit rigging teams for Heavy Drop. A proportion of officers and senior NCOs should have attended a short introductory course on air despatch, so that they can be familiar with and realistic about what loads can and cannot be delivered to them by parachute or "on the hook". Although this article has emphasised the operational aspects of aid from the air, it is very important to remember that its potential is also available for "peacetime" Inaccessible Sapper Tasks.

If only the right frame of air-mindedness can be injected into officers, both young and old alike, forward progress will be made, and our field squadrons will advance towards being practical Sappers Inaccessible, waiting more confidently than ever before for the most unusual and challenging tasks to arise. A very wise East End magistrate was lecturing recently on the problems of Modern Youth in Society to an officer audience at Camberley. In his summing up, he assessed three of its needs as "The need to be needed", "The need to be challenged", and "The need to be 'sent'." These three are not so far removed from the feelings of any Sapper unit when it reads, or hears of, an overseas government in trouble on account of a hurricane, flood, earthquake or some other major disaster in an Inaccessible area, let alone hear the early operational cries that arose in Sabah, Sarawak or the Radfan. These are certainly the needs of those young men whom we have just, or are about to, or whom we are hoping to recruit into the Corps as officers or soldiers. It is up to us, therefore, if we are to progress as the traditional live, energetic and forward-looking Corps, to give these younger Sappers the training and background experience in air matters which will help them face the challenge of Sappers Inaccessible with confidence and ability.

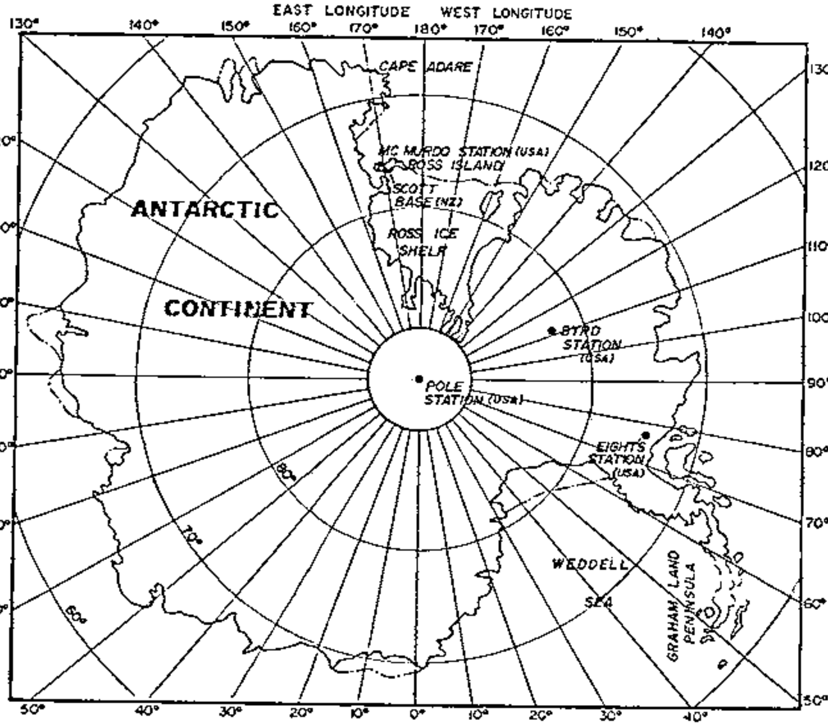
Note by Editor

The author of this article is air despatch qualified and has flown operationally as air dispatch crew in Borneo.

Antarctic 1965

By Major J. D. Isaac, RE

During my year with the US Army Nuclear Power Programme at Fort Belvoir, Virginia, I have visited reactors and nuclear laboratories in Massachusetts, California, Alabama, Wyoming, New Mexico and Idaho, but perhaps the outstanding experience during my tour of duty has been a visit to the Antarctic with a reactor inspection team. I make no claim to be at all knowledgeable on Antarctic affairs; in fact before my journey I was lamentably ignorant on the history and conditions in that vast continent which is as big as Western Europe and the United States combined. However, I did manage to see something of that part of the world during my short visit and jotted down a few rough notes on my impressions each day. These have formed the basis of this article, which should confirm that Sapper officers are apt to find themselves in all sorts of extraordinary places; it may also suggest to the junior officer that an interest in reactors and nuclear engineering will not necessarily chain him to a laboratory bench or control panel at Aldermaston or Harwell for years to come.



The Journey South

We boarded the US Navy Constellation at Andrews Air Force Base, Maryland, on a cold January morning. Rear facing seats bolted on to the cargo deck were adequate but hardly up to BOAC standards. Our travelling companions included a US Senator, several journalists, ornithologists in search of penguins and a British botanist who was attached to the New York botanical gardens for a year. We settled down for the 11-hr flight to San Francisco, the first leg of our 13,000-mile flight to McMurdo Sound. The flight was slow and bumpy but the packed lunch was excellent, and on the flight deck a patient crew explained aircraft controls and the navigation. After an overnight stop at San Francisco we droned on across the Pacific, and 10 hrs later landed at Hickham Air Force Base beside Pearl Harbour.

My impressions, in retrospect, of our 20 hrs in Hawaii are somewhat blurred. An excellent dinner, some very expensive beer, a club beside an incredibly white beach where the Tahitian dancers' grass skirts were practically smouldering, bikinis on Waikiki beach at 9 am and huge catamarans sailing gently up on to the sand, a drive into the rain forest in the mountains, the museum in Honolulu with giant squids, sub-tropical birds, Polynesian devil masks and native boats and houses—these all followed in quick succession, and then we were dashing for the airport and were almost glad to relax in the aircraft heading South for American Samoa.

It was midnight local time when we landed at Pago Pago "International Airport". The "air terminal" comprised two low buildings in contemporary native style connected by a covered walkway fringed by coconut palms. There seemed to be no other sign of human habitation. A waitress straight from a Gauguin painting in ankle-length black skirt and short white coat and with a flower in her hair (could it have been artificial?) served the inevitable hamburgers and Coca Cola.

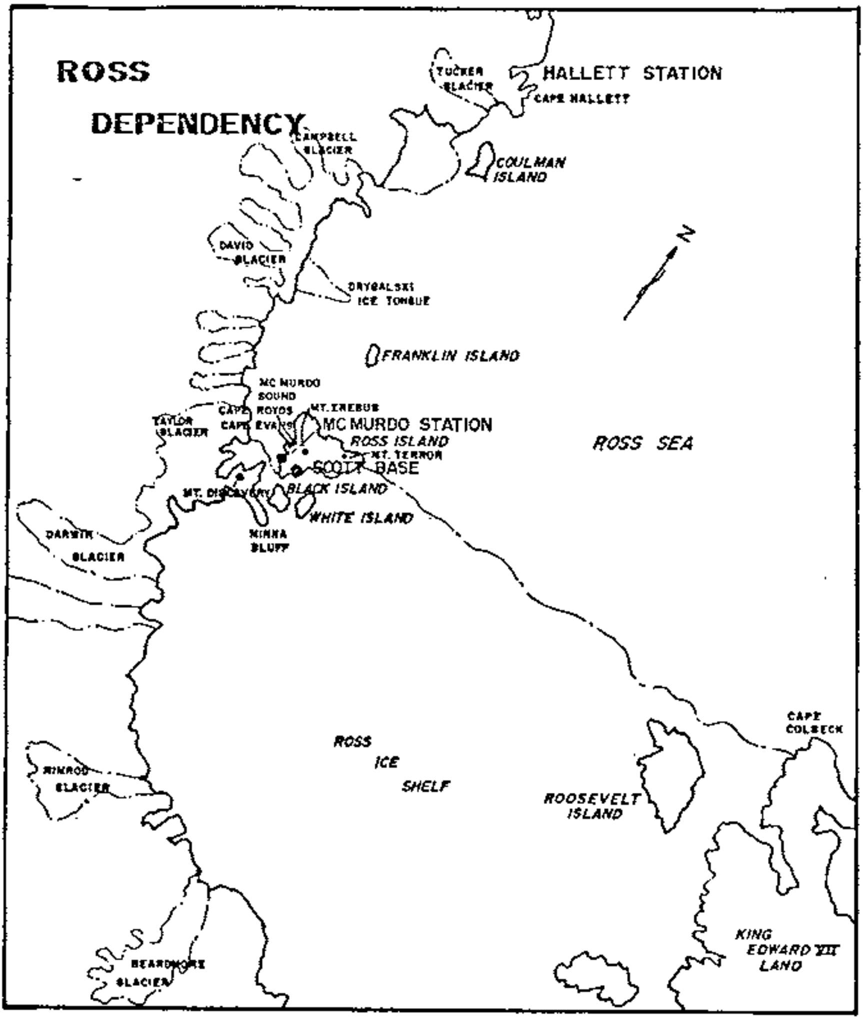
We flew on after refuelling, crossed the international dateline and lost a complete day before touching down at Christchurch for a late breakfast. The flight to the Antarctic was to depart in forty-eight hours. We were to leave all our existing clothing in New Zealand before we left and were to draw Antarctic clothing at once. Woollen shirts and trousers, "waffle weave" thermal underwear, a survival kit of parka and overtrousers with woolen liners and large white thermal boots (insulated rubber boots—cumbersome but very warm) were to be topped by that standard item of US cold weather equipment, a baseball-type hat with ear flaps. The time was now our own and we were ready to see something of New Zealand.

Christchurch is a beautiful city with a provincial English air. Ancient cars rattle through the streets and stretches of the river Avon winding through the city are reminiscent of the Isis or the Cam. Most private houses have beautifully tended gardens, and an area of 450 acres of park and magnificent botanical gardens lies within a few hundred yards of the centre of the city.

Littleton, the port of Christchurch lies across a range of hills on an inlet from the sea. It was from here that Scott and Shackleton sailed on their Antarctic expedition at the beginning of this century. Children were bathing in the small bays as we drove past. They looked extraordinarily brown and fit and many potential All Black Rugby forwards were in evidence.

Soon we were standing at the airport again but this time in our Antarctic gear and feeling distinctly self-conscious. At 9 am we were off on the last leg of our journey, the 2,300 miles to McMurdo Sound. We flew over seemingly endless seas, over the Furious Fifties and the Shrieking Sixties, down towards the Antarctic ice. At 5.10 pm there was great excitement on board. The great white continent was in sight. It was Cape Adare, the western tip of that part of the continent embracing the Ross Sea.

We flew down the coast of Victoria Land peering out of the aircraft windows at the mountains, glaciers and ice cliffs lying below. Out at sea huge icebergs glistened in the sunlight and floes of sea ice formed surrealistic patterns. The temperature inside the aircraft was gradually lowered and we began to put on our heavy outer clothing until we sat, fully clothed in our complete Antarctic gear, circling McMurdo Sound, that strip of water and ice which separates Ross Island from the mainland.



McMurdo Base

The aircraft landed on William's Field, the ice runway on the Ross Ice Shelf, and we stepped out to meet the Antarctic. Snow and ice stretched in every direction. Helicopters, tractors, sledges, huts and piles of stores dotted the ice, and in the distance magnificent mountain ranges stood sharply defined in the clear air. Some thirty men, huddled into their parkas against the

(Official US Navy Photograph)

Photo 1. *McMurdo Base*

Icebreakers and Supply Ships lie alongside the ice dock at Hut Point. Scott's hut can be seen at the extreme left of the picture opposite the nearest ship. The road mentioned in this article can be seen running from the dock to the camp.

chill wind, stood waiting to greet us, and a pale sun shone without warmth. Stumbling clumsily across the uneven ice in our thermal boots, we climbed into helicopters. The ice road to McMurdo Base was cracking up and floating out to sea and the journey via the re-routed road would have taken two hours or more. In the helicopters we were landing on the base helipads in ten minutes.

McMurdo Base, the home of some 600 summer support men and the 200 strong "winter-over" party, is a jumble of huts, sheds, oil tanks and packing cases lying in a sheltered position between Hut Point and Observation Hill. Captain Scott's store hut built in 1902 stands on Hut Point, whilst silhouetted on the peak of Observation Hill, stands the cross in memory of Scott and his four companions who died on their return from the Pole ten years later. Mount Erebus, the only active volcano in the Antarctic, lies behind the camp with a slight wisp of cloud (or smoke) hanging over it. Mount Erebus and Mount Terror, the other major peak on Ross Island, take their names from the two British sailing vessels (the Terror and the Erebus), which, under the command of Captain James Clark Ross, first sailed along this coastline in 1841.

Home during my stay at the base was the top bunk in a curtained-off cubicle inside a padded canvas "Jamesway" hut. At my elevated position it was hot, but at ground level it was quite cold. There were no windows in these sleeping quarters and therefore no insomnia problems at night despite the bright sunshine outside. An exploration of the camp area revealed a central mess hall serving excellent food, a wardroom where the standard of the martinis was very high, and ablutions where a complete lack of privacy and strong Antarctic winds emphasized the rigours of the seventh continent.

The PM-3A

The PM-3A reactor, the object of our visit, stands on a bedrock site halfway up Observation Hill overlooking the camp. This pressurized-water reactor can supply 1,500 kilowatts of electrical power to the base. A flash distillation plant using secondary reactor steam and which will produce 14,000 gallons (US) of fresh water per day from the sea is due to start up soon. The reactor's core lasts for about two years—some two million gallons of fuel oil would be required to produce the same amount of electricity.

The plant was shipped to the base and arrived on 12 December 1961. The packages were offloaded on to heavy sledges on the ice and were dragged up to the construction site. The construction season is short in these latitudes and the weather conditions during this "summer" season can be severe. The US Navy "SeaBees" (Construction Battalions) with the manufacturer's technical assistance assembled the plant very quickly and it went critical on 3 March 1962.

This is essentially a prototype plant sited in a very hostile environment. The base is cut off from all outside support from early March until the beginning of October. Not only does the plant have to contend with temperatures as low as —59°F and winds of up to 155 mph but the safety requirements are particularly stringent and, under the Antarctic Treaty, no radioactive waste of any kind can be disposed of on the continent. Not unnaturally the inevitable teething troubles of any completely new system have been magnified under these conditions and are taking some time to put right.

Details of the inspection team's work at the plant would be of little interest to the majority of readers. I spent an instructive and busy eight days going into the details of the reactor system and the operating records, talking with various members of the crew and writing a technical report. In the remaining six days I determined to see something of the Antarctic and the civil engineering work which was in progress at McMurdo. The remainder of this article describes what I saw.

The Inland Stations

The United States maintains three stations in the interior of the Antarctic. They are at the South Pole itself, Byrd station in Marie Byrd land, and Eights Station out towards the Graham Land Peninsula. All of these stations are supplied by air; in fact, it is only since the advent of the Air Age in the Antarctic that permanent inland stations have become possible. C130 aircraft fitted with ski landing gear are the main work horses in this effort, and I found myself in such an aircraft taking off from William's Field to lift supplies to the Pole. It was all too easy. We flew down over the Ross iceshelf where Scott and his companions had died eleven miles from their One-Ton Depot. From the flight deck we could see mountain ranges ahead, and then the great Beardmore Glacier glittered below. Shackleton, Adams, Wild and Marshall had first climbed this eighty-mile-long heavily crevassed route to the polar plateau in 1908. In February 1912 it was to claim the life of Petty Officer Evans, the first of Scott's four companions to-die on the "Last Expedition". In a few minutes the glacier was left behind, and we flew on over the apparently featureless plateau to land very smoothly on the snow at the Pole after a flight of some three hours.

It was a summer's day at the South Pole; the sun shone very brightly and the temperature was —40°F or °C (the scales cross here). A very large husky and two or three men greeted us and showed us around the station, which is all under the surface except for chimneys, wireless antennae and the occasional weather observation dome. Work was in progress to strengthen the snow-tunnel arch supports, and a small party of "SeaBees" was working enthusiastically in the sub-zero temperatures. After an excellent lunch, two of us declined the offer of a ride on a motor sledge out to the Pole itself and set out on a post-prandial hike. As the aircraft was due to leave the station in thirty minutes and the actual flagpole was more than a mile away, we started off at a brisk pace. The going was heavy, breath froze on moustaches and sunglasses, and at the 9,500 ft altitude the air was distinctly thin.

We were wet with perspiration on arrival at the flagpole, where the US flag flew at half-mast because of Sir Winston Churchill's death. We stood looking out at the seemingly endless white waste stretching before us, where Amundsen and his party with their dog teams had come in December 1911 and where one month later Scott and his four companions had dragged their sledges towards that small but eloquent black flag. The aircraft engines in the distance started with a roar, rudely returning us to the present. For a few moments we faced North in various directions and walked in a circle crossing every degree of longitude. Then pulling out our cameras from beneath our parkas we took two photographs and set off for the airstrip—we had been to the Pole.

A few days later I flew in another C130 to Byrd Station. Our load this time was a large tank containing 3,600 gallons of diesel oil. The tank is firmly secured to the aircraft, and the fuel load can be pumped out to storage tanks in fifteen to twenty minutes. This improves the aircraft turn-round times considerably, but the cost of one of these C130 supply flights from McMurdo to Pole or Byrd Station remains at about $6,000. Obviously a suitable nuclear power plant at either site would reduce the logistic support considerably, but present portable reactors have too great a power output and too large an operating crew to be considered. A proposed second-generation nuclear system with a smaller power output and designed to run unattended would seem to be an ideal power source for these two bases.

Byrd Station was very like the Pole station. It consisted of a snow runway and a collection of huts buried in tunnels, which had been cut in the snow by a Swiss snow-milling machine. The snow walls were bowing slightly and the floor was rising in places. This plastic flow of the snow caused trouble with the PM-2A reactor in 1962 at Camp Century, Greenland, where there was an almost identical situation. Arches collapsed and reactor piping was warped and twisted. The problem is better understood now, but the siting of any future reactor in such a base will still be complicated by this phenomenon.

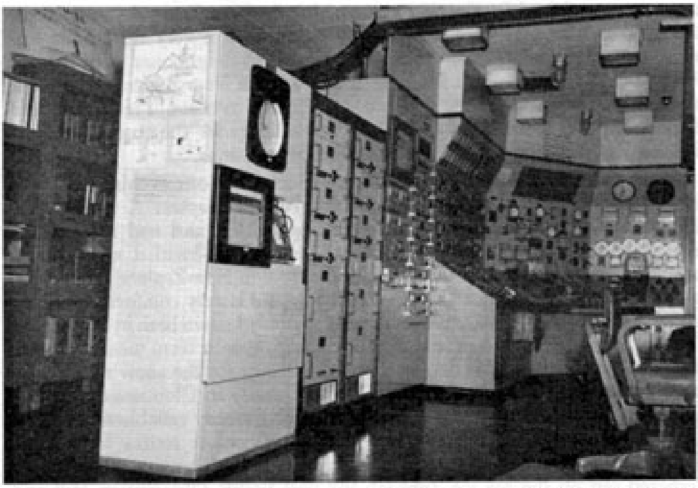
These then were the inland stations. The last aeroplanes of the season visit them at the beginning of March; the new season opens in late October with the first aircraft landing when the airstrips have been prepared. About twenty men live at each station for the "winter-over" period, spending the six-month night making scientific observations at the bottom of the world.

The New Zealand Antarctic operations are centred around a base of the same size as the US inland stations although it is only some three miles from McMurdo Base. It lies on Pram Point on the southeastern side of the Hut Point Peninsula, Ross Island. Here the Ross Shelf Ice meets sea ice and forms ice-pressure ridges and fissures. Seals abound along this part of the ice and are a source of food for the dog teams which the New Zealanders use in the field. Scott Base was most impressive; the men were very fit, morale was extremely high and relations with their American neighbours were cordial. US DC-3 (Dakota) aircraft fitted with skis lift the New Zealand dog teams to their area of operations and also drop supplies to them. This US air and logistic support is provided to the base in exchange for the staging facilities in New Zealand afforded to the US Antarctic operations.

A British botanist and I walked over to Scott Base one evening and were shown round by the team leader, Major Adrian Hayter. A native New Zealander, he had been at Sandhurst in the thirties and had reached the Antarctic via service with the Ghurkas, two single-handed sailing trips around the world, and an outward bound school in New Zealand. The camp consists of eight huts joined by a covered way and is very comfortable; many Americans envied the layout. It also boasts the only known bath in Antarctica. The water supply problem is solved by arranging each team member's bath night to coincide with the day he has to haul snow for the snow meltors. In one corner of the base British diesels from Dursley in Gloucestershire provided the power for the camp. They were giving steady reliable service and despite the high fuel costs are still the obvious power source for a small isolated base. We thanked our host and walked home past the sledge dogs tethered out on the sea ice, through the pass beside Observation Hill and down into McMurdo Base with its summer population of 800, its helicopters and nuclear reactor. We were back in the metropolis.

(Official US Navy Photograph)

Photos 2 and 3. *The Old and the New*
The interior of Scott's hut at Hut Point (above) provides a vivid contrast with the PM-3A reactor control room (below).

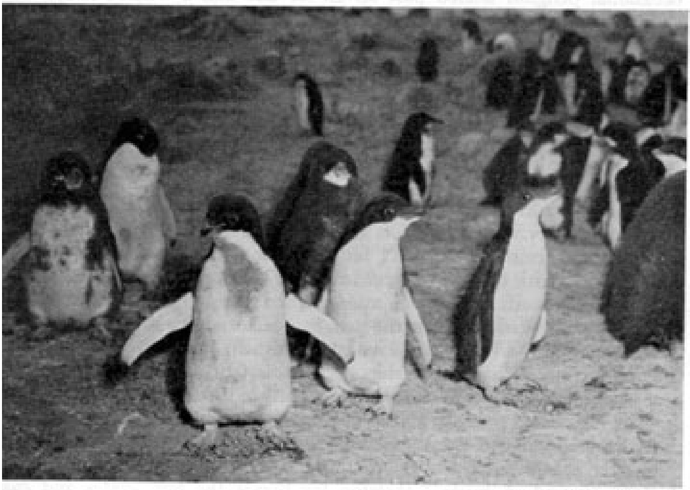


(Official US Navy Photograph)

Antarctic 1965 2 & 3

(Official US Navy Photograph)

Photo 4. *Construction at the South Pole*
Arches removed from the entrance to South Pole Station to reinforce the timber supports.



(Official US Navy Photograph)

Photo 5. *Antarctica's Natives*
Young Adelie penguins at the Cape Royds rookery.

Antarctic 1965 4 & 5

A Day With an Icebreaker

There were two icebreakers lying alongside the ice dock at McMurdo during January and early February and I was very keen to see them at work. The opportunity came when I was invited to dine with Admiral Reedy, the US Navy Task Force Commander. During the after-dinner conversation it transpired that a party of distinguished visitors was to spend a day out on the US Navy's icebreaker *Staten Island.* A judicious word in the ear of the Admiral's aide was all that was required—I could regard myself as a distinguished visitor for the day.

The *Staten Island* is some 270 ft long with a 63-ft beam. She draws 29 ft when fully loaded and displaces some 6,000 tons. Her bow has a sharply sloping forefoot which enables the vessel to slide up on to ice too heavy to break by the forward motion of the ship alone and the weight of the ship then crushes the ice. A speed of 4 knots or more can be maintained in light ice up to 5 ft thick. In heavier ice, up to 10 ft thick, forward motion is reduced to about one knot. We set off from the ice dock and ran through the pack ice. Some pieces were as big as a football field, others bigger, but the ice breaker cut through them with little trouble but much pitching and crashing. First the bow of the ship would rise slightly, and the ship would slide up on to the floe; then cracks would run out across the surface, and lumps of ice 6 ft thick, shining blue and green in the sunlight, would turn on edge and bump down the side of the vessel as we crashed down into the water again.

The ship sailed along the western coast of Ross Island. To port, Mount Discovery and the Royal Society Range stood majestically silhouetted against the sky on the mainland. To starboard, lay Mount Erebus towering above the Ross Island Coast. In the sound ahead, skuas circled lazily, the occasional penguin floated past on an ice floe and a whale's broad back showed momentarily.

Before long we were anchored off Cape Evans and were put ashore. Here in 1911 Scott's second expedition, prevented by ice from sailing on to Hut Point, built the hut which was to be their base. From here Cherry-Garand, Wilson and Bowers set out for Cape Crozier in the depth of the 1911 winter in total darkness to study the Emperor Penguin during the breeding season. Scott described their 134-mile ordeal as "the worst journey in the world". From here, too, the One-Ton Depot was laid 150 miles south of Hut Point but 31 miles short of the original planned site, and it was at this hut that the supporting party waited for Scott and his companions in vain. This hut was also the base from 1915 to 1917 for Shackleton's McMurdo Sound detachment, which, with the loss of three men, laid the depots towards the pole for Shackleton himself, who was to attempt the crossing of the Antarctic Continent from the Weddell Sea to the Ross Sea. Shackleton's ship, the *Endurance* was trapped in the Weddell Sea ice and eventually sank. The men made their way on floating ice and in the ship's boats to safety, and the McMurdo party was eventually relieved by Shackleton himself in the *Aurora* in 1917.

The hut stands today in almost its original condition. It was restored by a New Zealand party in the 1960–61 summer; penguins and skuas are hardly interested in souvenirs, and the climate has prevented any rapid decay. It is historic ground. A husky's skeleton lay beside the hut, crates and cases of food littered the ground. Huntley and Palmer biscuits, Fry's cocoa, golden syrup and oatmeal still remained, as well as engine parts from the motor sledges which Scott had tried to use. Inside the hut, stores were stacked neatly, an old copy of the *Illustrated London News* lay on the table, and scientific apparatus, sleeping bags, a draught board and other reminders of the party's work and leisure under very cramped conditions lay all around.

Outside, the skuas who obviously resented our invasion of their privacy made swoops and dives at our heads. There were skua chicks on the ice and rocks, and their parents were determined to see us off. We retreated to the shore and returned to the Staten Island.

Some seven miles to the north on the Ross Island shore, Shackleton's hut stands at Cape Royds. This was built in 1908, and from here Shackleton climbed the Beardmore Glacier and was 97 miles from the Pole when forced to turn back through lack of supplies. We landed at a beach a mile or so to the north of the Cape to avoid disturbing the penguin rookery there and walked through a desolate landscape of black and grey volcanic rocks with the occasional skua standing by a nest site. We breasted a final ridge and saw the penguin colony.

It was a fantastic sight; on the inland slopes of a small hill lying between us and the sea were hundreds of the small Adelie penguins. The hillside was stained pink with guano, an unexpected colour in the Antarctic, and there was great activity within the colony. Half-grown chicks chased adult birds for food, earnest and prolonged conversations or choral recitals were in progress, and lines of penguins trooped down to the shore to bathe and feed. They scrambled over rocks and stood in groups along the edge of the ice nervously edging one another forward. The grown penguins' major predator, the fearsome leopard seal, may be waiting beside the floe, and there is much manoeuvering and side-stepping until one of the group is nudged into the water. His fellows peer anxiously over the edge of the ice; if he reappears all is safe and the whole party dive in and rush out into the bay looking for all the world like a school of porpoises as they feed on the shrimp-like krill which abound in these waters.

The Adelie status symbol is the stone. These prevent the eggs from rolling down hillsides where they would be eaten by the predator skuas. It has been said that the whole Adelie economy is based on the stone and no self-respecting young female Adelie will consider matrimony unless her suitor has amassed a considerable pile. Even at this late stage in the season there was the occasional thief who could be seen sneaking a stone from a neighbour's nest and scurrying back to his own territory. Several battles were raging where the miscreant had been spotted. The penguin chicks were nearly old enough to leave the rookery, and in two or three weeks the entire population of this southernmost Adelie colony would leave Cape Royds and its solitary hut and swim north to the pack ice where they spend the winter.

It is then the turn of the larger Emperor penguin to return to the continent. The female lays her egg in the early winter and moves out to open water to feed. The male birds stand incubating the eggs by holding them upon their feet against their breasts for sixty days without food. A French scientist who lived for the winter beside an Emperor rookery in Adelie Land writes "The wind blows without respite at 100 to 150 km per hour, the dense blizzard reduces visibility to a metre and lets loose a ceaseless bombardment of small fragments. Man has great difficulty in breathing, is incapable of any effort and is blinded in a minute by a mask of ice. His skin freezes in 90 seconds. Twenty metres away from his hut and he will

(Official US Navy Photograph)

Photo 6. *A Jamesway Hut at Eights Station.*

(Official US Navy Photograph)

Photo 7. *Steel Erection at McMurdo*

Note the white "thermal boots" worn by the "SeaBees" and the icicles forming to the right of the picture.

Antarctic 1965 6 & 7

never find it again. In these conditions . . . the Emperor hatches his eggs." We summer visitors trudged back across the rocks and scree to the icebreaker.

Work at McMurdo Base

Two days remained before the aeroplane was due to come in to fly us back to New Zealand, and there was time to look at some of the civil engineering and construction work going on at McMurdo Base.

A special "SeaBee" construction battalion of some 250 men, formed for Antarctic support, arrives at McMurdo each October and leaves in March. The camp is the logistic base for the considerable US effort on the continent and is being improved yearly. Weather conditions during the construction season are often severe but there are twenty-four hours of daylight each day and the proportion of tradesmen in the unit is very high. Work begins in October digging out stores and construction sites from the snow, continues in surface mud during December and dust during January and February. At any time during the season the weather can deteriorate dramatically in a few hours. The wind gets up, the temperature drops and driven snow can produce "white out" conditions.

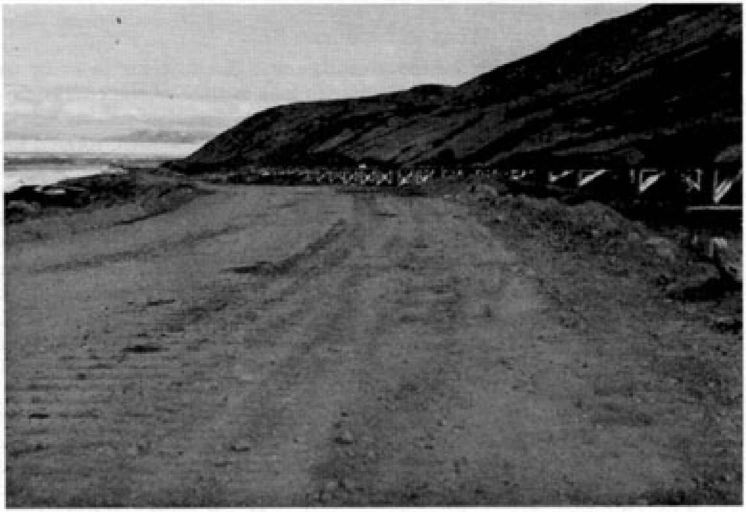
The jobs were similar to those which many engineer squadrons have tackled. During the season the battalion had built a road, laid pipelines, set up fuel-oil and water-storage tanks, and erected many prefabricated buildings.

The road, which had taken three months to build, is a two-lane "highway" 2½ miles long. It runs from the ice dock at Hut Point through the base and then on past Observation Hill to the ice shelf. The fill material, the local basalt rock, was scraped from the surrounding hillsides. A broken rock crusher and no spare parts meant that material specifications were necessarily crude. Fines were added in indiscriminate quantities, and the snow and ice scraped up with the fill added some moisture content. In fact, this crude material has compacted down to form a hard permafrost base some two to four inches below the top surface. As this will never thaw out, it would seem to be a very high grade base. Culverts were made of timber or "Armco" piping and were always at least 30 in. in diameter—when the snow does melt on the hillsides in November and December there is a short-lived but a very substantial drain-off. A timber bridge carries the road across a small gully.

A system of oil pipe lines runs from the dock beside the road to the tank farm above the base. The storage tanks are of 250,000 (US) gallon capacity and were built by the "Sea Bees" using a two-man civilian welding team from the Chicago Bridge & Iron Corporation to weld all joints. The construction times were impressive; a team of six "Sea Bees" and two civilian welders could put up one tank in five eleven-hour working days.

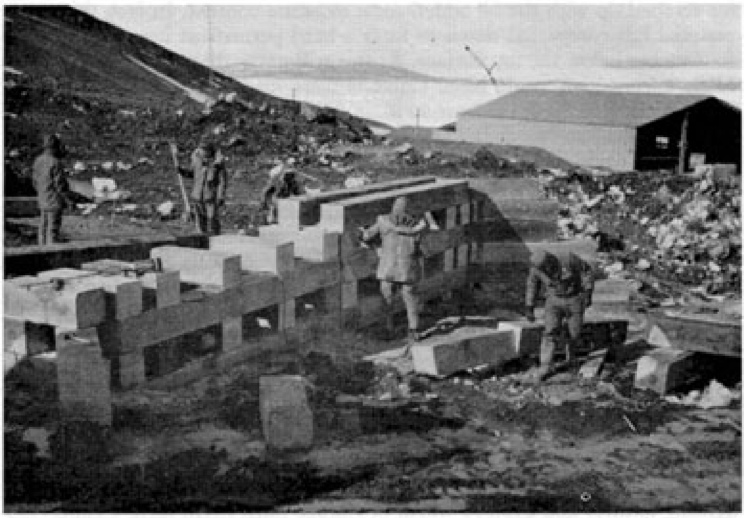
Prefabricated buildings included the Jamesway hut, a Nissen-type structure 64 ft long and costing some $5,000. Its canvas outerskin was stretched over a wooden framework and insulated by felt panels on the inside. Two men could erect one of these in five days. An interesting permanent warehouse was in the final stages of construction. This prefabricated two-story "Robertson" structure had a floor area of 100 ft by 40 ft at each level. The total cost was $130,000, which included heating and lighting fixtures and $10,000 worth of storage bins. Eight men, a supervisor and a crane had completed the structure in four weeks (10 hours per day—6½ days per week). The internal work on installing heating and lighting fittings would take six men 1½ weeks.

R.E.J.-L



(*Official US Navy Photograph*)

Photo 8. *The New Road to Hut Point.*



(*Official US Navy Photograph*)

Photo 9. *The First Bridge in Antarctica*

"Sea Bees" lay the headers for the bridge which carries the new road from Hut Point to the ice shelf.

Antarctic 1965 8 & 9

To New Zealand and Home

It was time to leave. After a round of farewells and some doubts as to whether the aircraft could fly in because of the weather conditions, we climbed aboard a Constellation at William's Field. We took the same route home. New Zealand seemed very green and the hospitality there was wonderful. In three days whilst waiting for an aircraft, I had a day's sail from Littleton in a 4-ton sloop, watched a test match, was shown the new School of Engineering of the University of Canterbury by one of the professors, and was introduced to the pleasures of the Christchurch Officers' Club. A two-day flight with very short stops for refueling brought us back to winter in Washington. We had been away for twenty-seven days, had flown 30,000 miles and had seen something of Hawaii, New Zealand and the Antarctic. Fifty years ago the journey would have taken months if not years. Perhaps it is all too easy now, but I would not have missed it for the world.

"Secor" Geodetic Satellite Tracking Project

By Major N. J. D. Prescott RE

Introduction

The surveyor has always been faced with the problem of measuring distance across oceans so that triangulation systems in different continents might be tied to one another. The arrival of artificial satellites has opened up many new methods which may be used for these long distance connections. The satellite becomes a landmark in space, which may be observed from several known stations and an unknown station. Ground stations may obtain directions by photographing the satellite, if it is a suitable target, against a star background, or ranges to the satellite may be measured electronically. There are advantages and disadvantages to both methods. However, after a careful assessment of the merits of each technique the United States Army Corps of Engineers chose to put their main effort into electronic distance measuring equipment. It was felt that all weather capabilities of an electronic system would more than compensate for the cost and trouble in developing the equipment. Army Map Service therefore ordered four prototype SECOR (Sequential Collation of Range) stations from a contractor (Cubic Corporation) in 1960. Many teething troubles were encountered, but by 1963 the majority of them had been overcome and six more stations of an improved and more rugged design had been obtained. Firm arrangements had then been made for a SECOR satellite to be launched at the end of 1963, and several American teams were undergoing training on the very complex electronic equipment in the ground stations. Meanwhile in Britain the Director of Military Survey, Brigadier L. J. Harris, CBE, had watched the development of these satellite tracking plans with close interest. An invitation to participate in the project was received from the United States Corps of Engineers and it was agreed that after receiving the necessary training a British team would man one of the tracking stations. The writer was fortunate enough to be nominated to command this team which was made up of two expert technicians from each of the three services.

The British team has now been with the SECOR project for over 18 months and all the original members have been replaced. The writer returned to Washington, DC, in September 1964 to help with operational planning and data reduction at Army Map Service, leaving Captain A. M. Bell RE commanding the team in the Pacific.

Limitations of Astronomical Observations

It has been possible to locate an isolated land mass by means of precise astronomical observations for many years. Values of latitude and longitude which have been observed astronomically in effect give the direction of gravity at the station concerned. The distance between two astronomical stations may therefore only be deduced by making some assumptions about the radius of curvature of the earth's surface between them. Unfortunately different parts of the earth's crust contain more mass than others. This results in the geoid (shape of the earth's mean sea level surface), though it approximates to an oblate spheroid, being quite irregular. Therefore the astronomical observations may be influenced by some local gravity anomaly, and this will result in an inaccurate length being calculated for the arc between the stations. There is then a definite need for a more accurate method of determing the great distances across some of the world's oceans.

Locating an Unknown Station

Range Measurement. The SECOR system was designed to enable four ground stations (one acting as master and three as slaves) to measure twenty times per second simultaneously to a transponder in a satellite. In practice the ground stations measure the range in sequence, but this is corrected for in the system so that each set of ranges will correspond to the same satellite position. Each ground station emits a phase modulated carrier signal which is received by the satellite and retransmitted with a small known phase change on two off-set carrier frequencies. The ground station receives the returning signal and compares its phase with the outgoing phase. The amount of phase shift determines the range. A combination of different modulation frequencies enables an accurate range to be determined without introducing ambiguities. One of the principal sources of error in range is caused by the retardation of the ray as it passes through the ionosphere. The amount of retardation varies with the frequency of the carrier signal. The returning signal from the satellite is transmitted on two carriers, one being half the frequency of the other. The difference in range measurement of the two is used to compute an ionospheric correction. A second correction is also made to the range for the effects of the lower atmosphere (troposphere). A general description of the electronic processes in a SECOR station is given later.

Simultaneous 4th Station Solution. For effective operational use a minimum of four SECOR stations must be deployed. Three will be placed at known points that have been previously established and the fourth station may occupy an unknown position. Ranges from the three known stations will fix a unique position for the satellite in space (Fig. 1). A known range is also available from each fixed satellite position to the unknown station. Therefore ranges from a minimum of three well chosen satellite positions will locate the

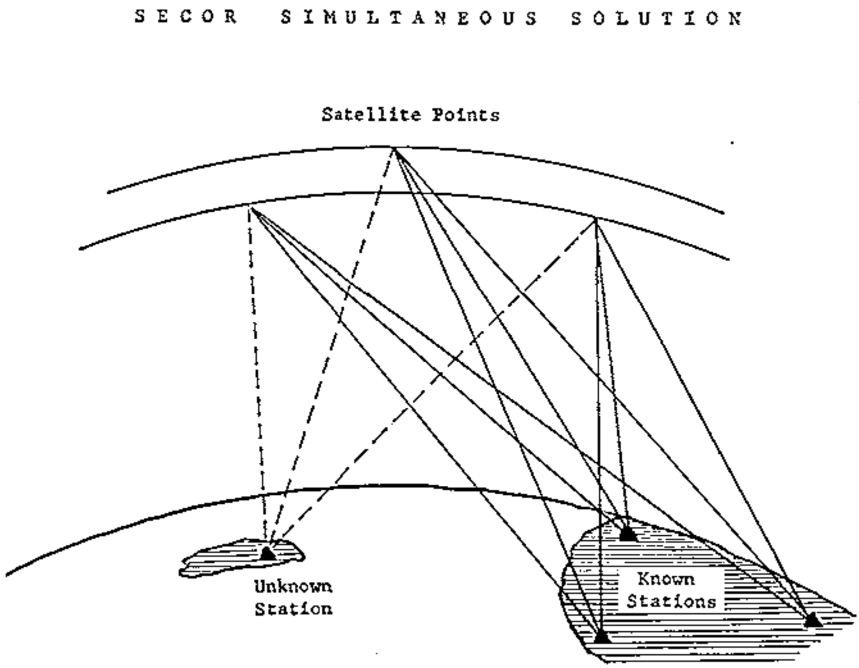


Fig. 1

unknown station. In practice, the satellite is normally tracked over a number of passes so that a variety of satellite points are fixed in a wide area above the ground stations. Several least square solutions may then be made for the position of the unknown station, with each solution using numerous satellite points. It is not proposed to go into details of the mathematics used to obtain a solution in this paper.

The accuracy of the SECOR system depends very much on the geometry. Ideally the three known stations should be selected to form an equilateral triangle with side lengths of about one to two times the satellite height. The best position for the unknown station would be in the centre of the known triangle, but in practice it will generally need to be placed some distance outside it. Another consideration is that it becomes difficult to correct a line accurately for the effects of the ionosphere if the elevation angle of the line from station to satellite is allowed to fall below 15–20 degrees. However, excellent results have been obtained using the simultaneous 4th station solution and all present Army Map Service plans are based on it, though other techniques that have been tried are discussed later. It will be noted that this method is entirely geometrical and that all assumptions on the direction or intensity of gravity are avoided.

Orbital or Semi-Orbital Solutions. Here the unknown station is too far away from the known stations for the simultaneous technique to be used. In these methods the satellite is tracked over as long a section of orbit as is possible from the known stations. This data is then used in conjunction with the orbital constants and the earth's gravity harmonic terms to extrapolate

SECOR ORBITAL SOLUTION

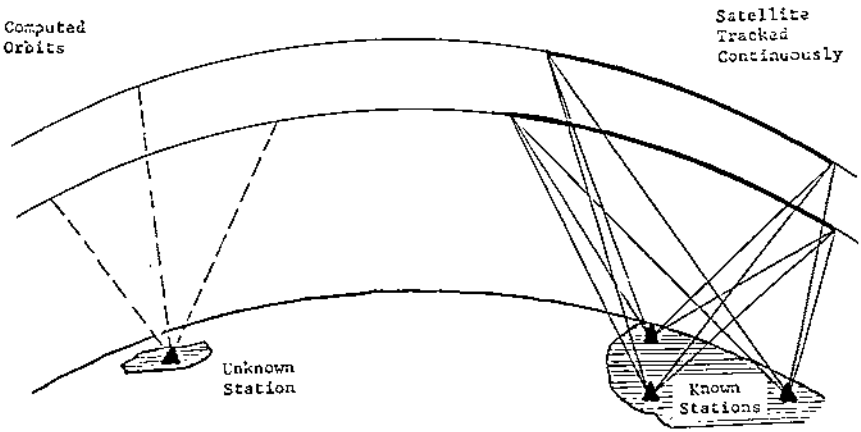


Fig. 2

the orbit until it has passed the area where it has been tracked by the unknown station (Fig. 2). The procedure is repeated for two or more orbits. The unknown station position is then computed in much the same way as in the simultaneous method using predicted satellite points instead of points that have been observed directly from the known stations. The difference between the orbital and the semi-orbital methods is that in the former the known stations finish tracking before the unknown station is able to start tracking, while in the latter there may be overlap between the observations of some of the known stations and the unknown station. One disadvantage of these methods is that minor variations in air resistance cannot be predicted, though these will not effect a small high altitude satellite very much. However, the most serious problem is that of assessing the effects of unknown local gravity anomalies beneath the span of orbit. The results obtained for Grand Forks during the USA tests (shown later) are considerably inferior to those obtained using the simultaneous method. For Grand Forks the computers at least had the advantage of knowing the survey position, information that would not be available if isolated islands were to be fixed. However, it may be that a semi-orbital technique may sometimes be used in the future to improve the geometry for a weak simultaneous fix. A particular advantage of this method is that time synchronization between the known and unknown stations takes place automatically during the track while the length of the extrapolated span of orbit is kept to the minimum.

Line Crossing Technique. This technique was designed as a method of determining the distance between two stations. The results of the experiments shown later are good only because other known stations were used in the middle of the line to obtain accurate satellite height. There are no future plans for using the technique as it is less satisfactory than a 4th station simultaneous fix, and is unsuitable for measuring lines across water.

SECOR EQUIPMENT—DESCRIPTION AND METHOD OF OPERATION

General Description of SECOR Station. The layout of Station No 6 in Guam is shown in photos 1 and 2. The three shelters each weigh under 5,000 lb and are easily air transportable. On land the shelters can be readily lifted by a crane or fork lift. A split trailer called a GOAT (Goes Over All Terrain) is provided with each station. This couples on to both ends of a shelter lifting it about 5-in from the ground. Ancillary equipment includes air conditioners for each shelter and a diesel generator. In fact all stations were provided with two 45 kW generators in the field, one being a reserve as the maximum station power requirement is only about 30 kW.

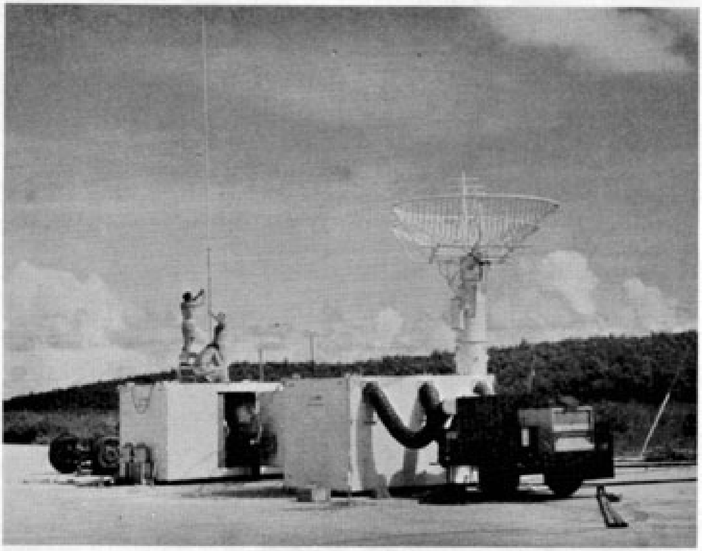


Photo 1. SECOR Station No 5, Guam. The British Team erecting the radio mast. One of the trailer mounted air conditioners can be seen on the right.

The shelter with the twin dish antenna is the radio frequency (RF) shelter, and the SECOR transmitter and receiver is housed in it. In the centre is the data handling (DH) shelter where the ranging modulations are measured and recorded on magnetic tape. Much of the electronic equipment in the DH shelter is similar to parts of an electronic computer. The left hand shelter with the radio mast on it is mainly a storage shelter, but it also houses the Collins single side band radio equipment which is used for inter-station communications. Much of the remaining space in the shelter is taken up with the numerous pieces of test equipment and spare parts. A small work table is also provided.

Secor Geodetic satellite tracking project 1

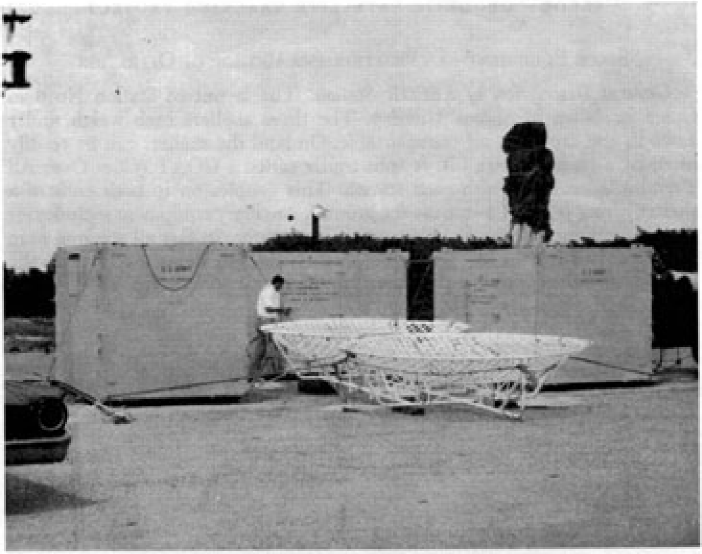


Photo 2. Station No 6, Guam, secured for Typhoon "Sally".

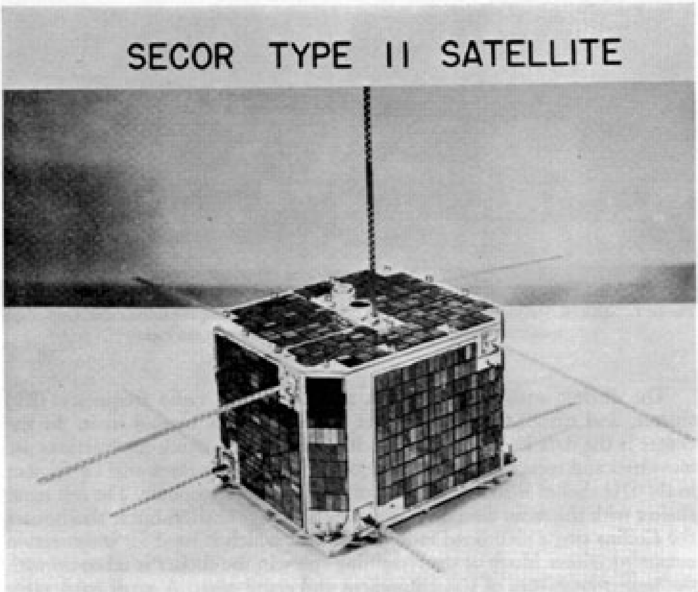


Photo 3. SECOR Type II Satellite.

Secor Geodetic satellite tracking project 2 & 3

SECOR Type II Satellite. A SECOR type II satellite, which was successfully launched in January 1964, is a box-like package of 10 × 13 × 9-in with a weight of about 40 lb (see Photo 3). The antenna system outside the satellite includes a telemetry dipole as well as eight dipoles for the SECOR transponder. The satellite surface area is covered by solar cells which recharge the nickel cadmium batteries. The telemetry system which is monitored by special receivers on the ground provides such information as battery voltage and satellite skin temperature. The SECOR transponder however occupies most of the space inside the satellite.

General Description of Electronic Processes. A general block diagram of the SECOR system is shown (Fig. 3) and the technical terms used throughout refer to this. The measuring frequencies are generated in the frequency synthesizer (DH shelter) and then pass to the RF shelter.

Transmitter. The carrier frequency is generated in the RF transmitter and modulated by the measuring frequencies. The carrier is then amplified to about 2 kW with a frequency of 420.9 Mc before being transmitted via the diplexer, which prevents feedback, and the high frequency antenna. An operator controls the pointing of the antenna to the satellite.

Transponder. The satellite transponder receives the ranging signal and re-transmits them on carrier frequencies of 449 Mc and 224.5 Mc without significant change of phase. The transponder has a power output of 1–2 watts.

Receivers. Sensitive high and low frequency receivers in the ground station (RF shelter) receive the two signals from the satellite. The measuring modulations are removed from the carrier and after amplification are fed back to the frequency synthesizer in the DH shelter.

Frequency Synthesizer. The incoming modulations then pass into mixers where each is joined by a sample of its outgoing signal. The resulting outputs are 1.144 Kc signals, each with a phase angle equal to the differences in phase of the incoming and outgoing ranging modulations.

Servos. The 1.144 Kc signals pass into the electronic servos where a measurement of phase angle is made in the analogue servos. The actual range measurements from each station are made in sequence (not simultaneously) and are repeated every 50 milliseconds. It is therefore necessary for the analogue servos to be electronically damped so that a smooth and continuous record of phase angle is kept. A digital servo monitors each analogue servo and maintains a digital representation of the phase angle in terms of range. On receipt of a *read* command from the processor the digital servo is stopped and the range reading is transmitted via the processor to the tape recorder. An analogue display of range is sent direct from the servos to the quick look strip recorders for the benefit of the tracking team. A special doppler loop circuit in the servos compensates for doppler effects on the wave length.

Processor. All data that is recorded on the magnetic tape passes through the processor. The processor has the task of calling up particular data as required and feeding it correctly on to the 7 channel tape recorder.

Extended Range Timing and Sequencing. The timing of outgoing signal bursts from the transmitter are controlled here. The returning data bursts from all stations are also fed into this section and may be viewed on an oscilloscope. The approximate range to the satellite, without ambiguity for distances of up to 3,000 kilometres, is obtained from the transit time to the satellite of a data burst. An operator controls the timing of the transmitter bursts to ensure that the signal is kept in its correct sequencing slot. The master station sends out a special pulse which is received by all stations via the satellite. This initiates the *read* pulses in all the processors so that range readings will correspond to the same time at the satellite.

VLF Timing. A frequency standard operates a time code generator. A VLF receiver is available for checking the frequency while a second receiver is available for making WWV radio time checks. The time of observations is recorded on the magnetic tape via the processor.

Testing the Secor System in the USA

Any new piece of equipment as complicated as SECOR must be carefully tested, both for electronic reliability and for survey accuracy. Engineering tests could be performed more easily in the USA, while the country's first order triangulation framework provided a convenient basis for testing the accuracy of the system over great distances. Prior to the satellite being launched the only way of checking the equipment and obtaining some idea of accuracy had been with the transponder mounted in an aircraft. Results from this and theoretical studies had indicated good potential. However, the fact that one very delicate piece of equipment, the transponder, would be beyond reach in outer space produced a tense and expectant atmosphere during the months before the first launch. In this period the British team were busy training on the ground station equipment at Herndon, Virginia.

After some delays the SECOR satellite was successfully launched into a near circular orbit about 930 kilometres above the earth's surface on 11 January 1964. The plane of the orbit had an inclination of 70 degrees to the plane of the equator. A short time after the launch a ground station successfully interrogated the satellite and the transponder appeared to be in good working order. At this time United States Army Map Service teams were occupying the following stations (Fig. 4):—

Fort Carson, Colorado (HQ), Stillwater, Oklahoma, Austin, Texas, Las Cruces, New Mexico, Grand Forks, North Dakota.

The first four of these stations formed a quadrilateral with side lengths of approximately 500 miles (this is generally referred to as the small quad). The fifth station, Grand Forks, was placed some way to the North of the small quad for tests of the orbital technique. The British team moved to Fort Carson in late January and spent the first phase of the tests alternating with an American team in operating that station. No serious difficulties arose with the equipment, though a number of minor teething troubles were overcome and everyone learned many lessons, which proved valuable in the future. The results are listed later. By March 1964, after ample data had been collected for the small quad and for a number of orbital solutions for Grand Forks, it was decided to set up a large quadrilateral to check accuracy at greater range. The British team therefore moved down to San Diego, California and took over SECOR Station No 6 which had been held there in reserve. The Las Cruces team also moved, complete with its station, to Larson Air Force Base, Washington (Fig. 4). At about the same time one of the older model stations at Herndon became operational and a number of line crossing experiments were carried out. These included the line between San Diego and Herndon, a distance of 3,628 kilometres.

SECOR BLOCK DIAGRAM

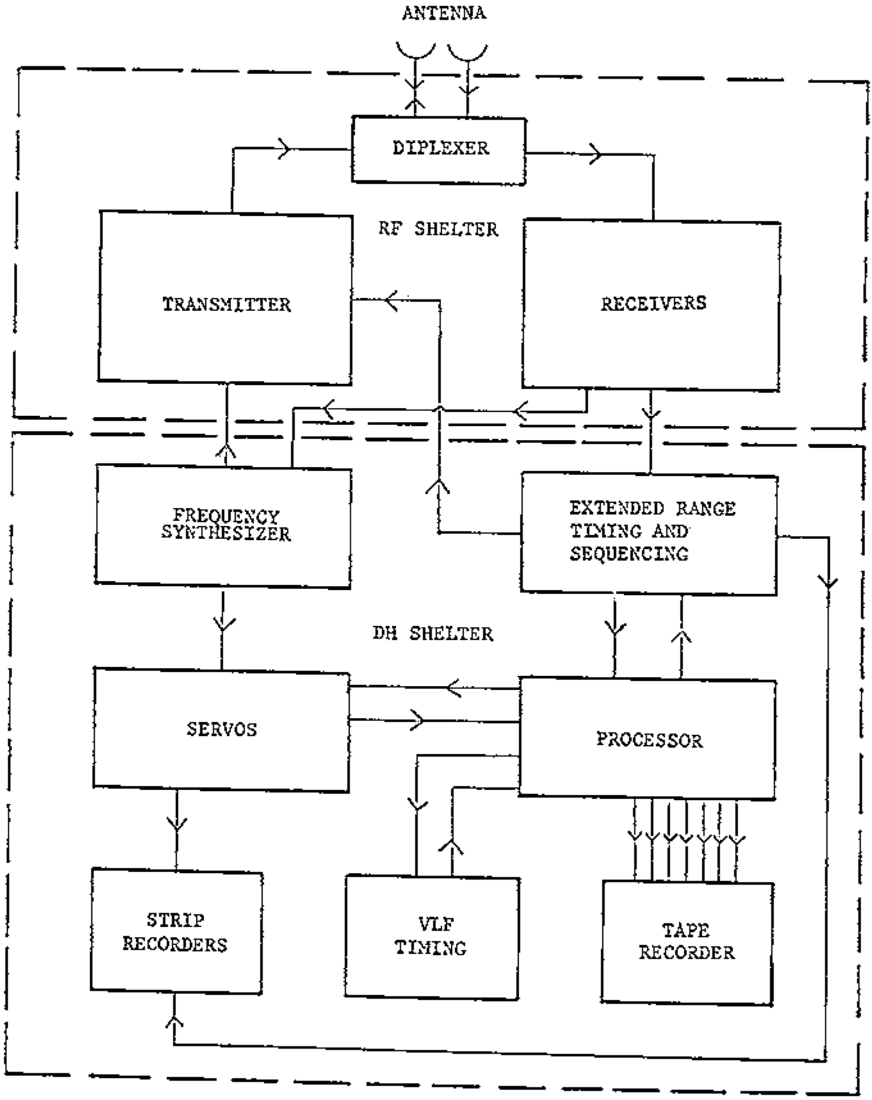


Fig. 3

Results of USA SECOR Tests

Test	No of Solutions	SECOR—Survey in Metres			Standard Deviation of SECOR in Metres		
		Latitude	Longitude	Height	Latitude	Longitude	Height
Small Quad Fort Carson Unknown	15	−0.7	+7.1	+5.7	6.0	10.1	4.8
Large Quad Larson Unknown	10	−14.4	+10.6	+9.2	8.9	15.7	24.3
Orbital Grand Forks Unknown	17	−32.5	+7.2	−17.1	44.1	61.4	17.5

A single solution in these results is obtained from about 600–1,200 individual range observations distributed between three segments of track.

The different solutions incorporate different orbits and geometric configurations. It is quite possible that about half the discrepancy between the SECOR and survey positions could be due to errors in the ground survey. Taking this into account the results for the small and large quadrilaterals are very good indeed.

Line Crossing Results. A total of seventeen line crossing solutions were produced for lengths that varied from Austin–Fort Carson (1,138 kilometres) to San Diego—Herndon (3,628 kilometres). The average disagreement between the SECOR and the survey lengths was about 1 part in 160,000. It is interesting to note that fifteen of these solutions showed the SECOR length to be greater than the survey length, which possibly indicates a small systematic error in scale either in the triangulation or the SECOR measurements.

The results quoted for the USA tests were those obtained by the contractor in San Diego, where at that time the writer was fortunate in being able to keep in close touch with the progress of the computations. Army Map Service also carried out a number of independent computations for the small quad and their results agreed closely.

Tracking Operations in the Pacific

The results from the SECOR tests in the USA had been so good that it was decided to make an immediate start on operations in the Pacific. Therefore in early July 1964 the six teams moved overseas to various tracking sites in the Western Pacific. The British team was placed in Guam, one of the Mariana Islands, where Station 6 was set up on part of a disused air strip.

Operational Difficulties. The Pacific has proved to be a more critical testing ground for the equipment than the USA. Most of the stations, to judge by their appearance, had a fairly rough voyage to the operational area. This resulted in a number of small tears in the insulation of the shelters and various minor electronic failures. Some faults that had escaped notice in the USA caused trouble. Misalignment of the tape recorder head was a source of trouble with several stations and a routine for checking this periodically was developed. To save wear and tear on the generators, Station 6 was connected to Guam's power supply. This proved to be a very sound decision as almost all the other stations had trouble with their generators, and of course spares for these took some time to arrive. Numerous other problems arose and

USA SECOR TEST AREA

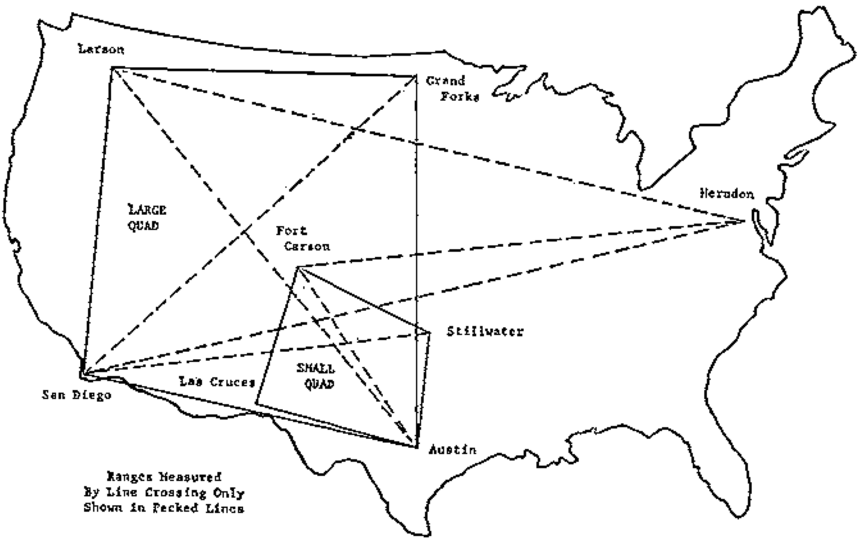


Fig. 4

were overcome during the first few months. The weather also did not help the operations and several of the stations suffered the effects of typhoons. Photo 2 shows Station 6 after withstanding typhoon "Sally" in September 1964. Note the anchor cables from the corners of the shelters, which were embedded in the ground to a depth of 6 ft.

Results in Pacific Area. Four known stations on the Tokyo datum (Bessel Spheroid) were used in different combinations to extend the SECOR network into the Pacific. By April 1965 the first three unknown stations, Minami, Iwo Jima and Guam, had been firmly fixed. The next unknown station, Marcus Island, was in the process of being fixed. The astronomical latitude and longitude (degrees and minutes omitted) and the height above mean sea level (metres) obtained for Minami are shown below. The latitude, longitude and height obtained by SECOR are based on the Tokyo datum. The discrepancies are an indication of the bad fit between this particular spheroid and the earth's shape (geoid) in this area.

Minami Daito Shima

	Latitudes	*Longitude*	*Height*
Astro	23.50 secs	53.03 secs	40.1 (metres above sea level
SECOR	12.768 secs	22.913 secs	96.6 (metres above spheroid)
Standard Deviation of SECOR	3.1 metres	2.2 metres	1.7 metres

Computations are not yet completed for Iwo Jima and Guam but preliminary solutions show satisfactory agreement.

Conclusions

The SECOR project has made great progress since it was first envisaged. The system has now demonstrated its capabilities and remarkable accuracy. The original satellite has recently been joined by others and quicker results may be expected in the future.

With some small modifications to the system it should be possible, using much higher satellites, to span distances of two or three thousand miles with improved relative accuracy. The system is therefore potentially capable of providing a world wide control framework. The SECOR simultaneous method must clearly possess more absolute accuracy than electronic systems which make use of orbital methods. For a world wide programme its all-weather measuring capacity should enable SECOR to complete such a project more speedily than any optical system.

Excellent relations have been established with the United States Corps of Engineers, and the British team has been able to make a valuable contribution towards the success of this novel project. First class support from all three Services combined with good co-operation between their technicians in the team has made this a most worthwhile entry into the field of satellite geodesy.

Three Freedoms

THE Corps of Royal Engineers has recently been singularly honoured by the granting of three Freedoms.

On Saturday 24 April the Freedom of the Borough of Stafford was conferred upon the 125th (Staffordshire) Engineer Regiment (TA); on 8 May the Mayor of Maidstone conferred the Freedom of the Borough of Maidstone on the Corps and on 20 May the Corps received the Freedom of the Borough of Aldershot. Seldom in the space of four weeks can the Corps have been so publically recognized.

This year witnessed the 350th Anniversary of the office of the Mayor of Stafford and it was fitting that the town's largest Territorial Army unit should be honoured on such an historic occasion. The 125th Corps Engineer Regiment (TA) came into being in 1952; the component Squadrons, the 213th the 214th and the 293rd Field Squadrons, however, have a longer history. The 213th Squadron stems from the 2nd (North Midland) Field Company raised in 1908 and the 214th Squadron from the 2nd/1st (North Midland) Field Company, raised in 1915. Both Companies saw heavy fighting on the Western Front throughout the First World War. In 1920 the Companies assumed the numbers they bear today. During the Second World War the 213th Field Company was nearly cut off at St Valery with the 51st Highland Division, but managed to escape capture after carrying out some fine demolitions. Later the unit saw action in Italy and took part in the crossings of the Volturno at Garrigliano. Later still it formed part of the Normandy invasion force, fought throughout the campaign in NW Europe and took part in the Rhine crossing. The 214th Company fought in North Africa, Sicily and Italy, a long, hard slogging match. In 1961 the 293rd Field Squadron was disbanded and its Drill Hall at Bailey Street, Stafford was taken over by the Regimental Headquarters of the 125th (Corps) Engineer Regiment (TA) with 213th Field Squadron at Cannock and a troop at Stafford and 214th Squadron at Meir and Tunstall. At that time a troop of "P" Battery 441st Light Anti-Aircraft Regiment (TA) was rebadged to become a troop of the 214th Squadron and the Regiment's Band rebadged to become the Band of the 125th (Corps) Engineer Regiment (TA). In 1962 the title "Staffordshire" was fittingly bestowed upon the Regiment, and in 1965 the word "Corps" was dropped from its designation.

The Regiment only had a very short time to prepare for the Freedom Ceremony, and for the official opening of its new Drill Hall, Kitchener House, Stafford due to take place three weeks before the Freedom was to be conferred. On the great day, led by the Band, Major G. H. Owen, RE, (TA), the second-in-command, marched the Regiment from Kitchener House to the Borough Hall where among the Mayor's guests were the Member of Parliament for Stafford and Stone, the Chairman of the Staffordshire Territorial and Auxiliary Forces Association, the GOC 48 Division (TA) and West Midland District, the Chief Engineer Western Command, the Commander 23 Engineer Group (TA) and the Commanding Officer of the Regiment Lieut-Colonel D. Barker, TD, RE, (TA) who then took command of the parade.

The Mayor, Alderman Miss I. H. Moseley, received a General Salute as she and the Mayoral party came out from the Borough Hall. After the inspection of the Regiment the Town Clerk read out the Resolution conferring the Freedom of Entry into the Borough. This done, Lieut-Colonel Barker signed the Roll of Freemen and Miss Moseley in her Mayoral address recalled the Regiment's long association with Stafford and the many Staffodians who had served in it. She paid tribute to the excellent training the Regiment provided which prepared its members to defend their country in time of war. She stressed that the country depended upon the volunteers of the Territorial Army, and with womanly insight she paid a special tribute to their wives and families for their tolerance and understanding without which no such voluntary service would be possible. The Mayor's Chaplain delivered the blessing. The Resolution conferring the Freedom, engrossed and illuminated on vellum and bound in book form, was then trooped, and finally borne in an open Champ, flying the Corps pennant, back to Kitchener House escorted by RMP motor cyclist outriders. The Regiment exercised its newly-acquired right and marched through the town with bands playing, drums beating and bayonets fixed passing a saluting base set up in Market Street on its way back to Kitchener House where the Mayor took the salute.

Several officers and their wives joined the Mayoral party for tea in the Borough Hall after the March Past at which a telegram from the Chief Royal Engineer was read out thanking the Borough Council on behalf of all ranks of the Corps for the honour bestowed upon the Regiment and extending their best wishes for the continued success of the Council in future years. Lieut-Colonel Barker, after thanking the Mayor and Council for the honour bestowed upon his Regiment, presented the Mayor with a silver grenade lighter engraved with the Corps monogram on behalf of all ranks.

The Mayoral party then went to Kitchener House where the Borough Council had provided tea for the members of the Regiment and their wives and spent some time talking to a number of soldiers and their families. The day closed with a cocktail party given by the officers for the Mayor and Council in the Officers' Mess of Kitchener House.

8 May 1965 saw two ceremonies at Maidstone: the official opening of the recently rebuilt Invicta Park Barracks and the presentation of the Freedom of the Borough to the Corps of Royal Engineers. His Worship the Mayor, Councillor J. E. Evans, arrived at the Main Gate of Invicta Lines at 11.15 am, accompanied by the Recorder, the Town Clerk, the Chaplain to the Corporation, the Mayor's Marshal (an ex-QMSI of 36 Engineer Regiment) and two mace bearers, robed according to ancient custom, where he was welcomed by the Engineer-in-Chief Major-General G. W. Duke, CB, CBE, DSO, and the Commanding Officer 36 Engineer Regiment, Lieut-Colonel S. A. Frosell, MC, and inspected a guard of honour. In performing the opening ceremony the Mayor referred to the long history of the Park, dating from Tudor days, and its association with the Lushington family and the poet laureate Lord Tennyson. He paid tribute to Sir Donald Gibson, responsible for the design of the new, modern barracks and said that it gave the people of Maidstone great pleasure that the foundation stone, laid in 1962, and the plaque he was about to unveil were both the work of Maidstone craftsmen. In declaring Invicta Park formally open he wished all ranks of the Corps of Royal Engineers good luck, good health and happiness wherever they might be. He then cut the tape stretched across the road to symbolise the official opening.

The presentation of the Freedom was unique in that the ceremony took the form of a Council Meeting held with all its civic solemnity on a platform specially erected within the Barracks. The reasons for this novel procedure was to enable as many soldiers as possible and the large crowd of distinguished visitors, to see the Council in session, and to confirm the close ties of friendship between the Town and the Corps by holding the Meeting on military ground within the Borough.

Alderman C. Larking moved the motion that the Honorary Freedom of the Borough be conferred upon the Corps of Royal Engineers in consideration of the gallant and distinguished services rendered by the Corps to the Country and Commonwealth. Councillor G. Kemp seconded and Councillor E. H. Rogers supported the motion which was then put to the vote and carried unanimously.

The Engineer-in-Chief took the oath on behalf of the Corps promising to serve well and truly the reigning Monarch and preserve the common peace and tranquility of the Borough. The Trumpeters of the Chatham Band sounded a Freedom Fanfare after which the Mayor handed the Engineer-in-Chief a casket containing the Certificate of Honorary Freedom.

In his reply Major-General Duke conveyed a message from the Chief Royal Engineer saying how sorry he was that he was unable to attend the ceremony due to illness. He went on to say how greatly the Corps appreciated the honour bestowed upon it by the Council. The Regular Army, operating all over the world, was very conscious of the need to maintain close touch with the civil population at home. These ties were easier to maintain in the case of County Regiments than in a Corps, such as the Royal Engineers, recruited from far and wide. When, therefore, a link had been established, as had now been forged with the ancient and historic Borough of Maidstone, it would be the more valued. As a "Man of Kent" he fully appreciated the sadness of the people of Maidstone when their old and famous Regiment—The Queen's Own Royal West Kent Regiment—was amalgamated with the East Kent Regiment to form the Queen's Own Buffs, the Royal Kent Regiment with its depôt at Canterbury, and he was sure that 36 Engineer Regiment would prove themselves worthy successors to that historic Regiment. Although their interests were nation-wide the Sappers had a close association with Kent going back over 150 years when the Royal School of Military Engineering was established at Chatham in 1812. All newly-commissioned officers, and most of the young soldiers, had since then come to do their basic military training there, and a large number of old soldiers, officers and men, had come to live in the neighbourhood on retirement from active service. Since the last War Maidstone had been the permanent station of an Engineer Regiment, although from time to time its Squadrons had been sent all over the world. The decision to retain an Engineer Regiment permanently at Maidstone had been endorsed by the building of the beautiful new Barracks so graciously opened that day by the Mayor. In closing the Engineer-in-Chief thanked the people of Maidstone for the great honour bestowed upon the Corps and hoped that the fund of affection and goodwill established between the townspeople and the Regiment would continue to flourish.

To mark the occasion he presented two silver salvers as a gift from the Corps to the Borough. The Mayor thanked the Engineer-in-Chief and concluded the Council Meeting, The Council then left in procession to the Officers' Mess where they were entertained to lunch.

After lunch a detachment of 200 men from the Regiment marched through Maidstone, led by the Chatham Band, exercising their new privilege. The Mayor took the salute outside the Town Hall. As the detachment marched back it drew, like the Pied Piper, a multitude of followers who flocked into Invicta Park for the Open Day festivities. In all some 4,000 men, women and children came. The Open Day ended with the Beating of Retreat, and the visitors slowly ebbed away leaving unclaimed only one umbrella, one set of car keys and two small boys . . . and tons of litter!

On 20 May 1965 the Freedom of the Borough of Aldershot was conferred upon the Corps at a parade held on the Aldershot Town Recreation Ground, normally the home of the Aldershot Town Football Club. The honour was accepted on behalf of the Corps by the Chief Royal Engineer, General Sir Frank Simpson, GBE, KCB, DSO, DL.

The parade consisted of five Guards—three from 1 Training Regiment RE, one from 34 Field Squadron of 3 Division RE and one from the Junior Leaders' Regiment, RE. The troops holding the ground came from 115 (Hampshire Fortress) Engineer Regiment (TA) and 1 Training Regiment RE; these later formed No 6 Guard for the march through Aldershot. For the first time, all three of the Corps Bands, from Chatham, Aldershot and the Junior Leaders' Regiment, were on parade together at Aldershot. The Parade Commander was Colonel R. F. N. Anderson, OBE, MC.

On the day of the parade the weather was bright and warm and as the troops marched onto the Football stadium they were taken aback by an enthusiastic greeting from 2,500 school children who packed the stands. These children had come from schools all over Aldershot and their attendance had been organised by the Aldershot Education Committee. Throughout the Parade their enthusiastic cheering and interest greatly added to the atmosphere of the occasion, and indeed threatened to drown the words of command from time to time.

Among the spectators were the General Officer Commanding Aldershot District, Major-General P. H. Man, CBE, DSO, MC, Lieut-General Sir Clarence A. Bird, KCIE, CB, DSO, Major-General R. W. Urquhart, CBE, DSO, the Representative Colonel Commandant RE for 1965, and Lord Porchester, Honorary Colonel of 115 (Hampshire Fortress) Engineer Regiment (TA), and eight other Sapper Major-Generals closely connected with Aldershot, namely Major-General Sir A. Douglas Campbell, KBE, CB, DSO, a previous General Officer Commanding Aldershot District, Major-General R. L. Bond, CB, CBE, DSO, MC, Major-General N. A. Coxwell-Rogers, CB, CBE, DSO, Major-General T. H. F. Foulkes, CB, OBE, Major-General G. S. Hatton, CB, DSO, OBE, Major-General A. J. H. Dove, CB, CBE, Major-General R. Llewellyn-Brown, CB, CBE and Major-General B. K. Young, CBE, MC. There were also eleven serving or retired officers of the Corps who had been members of the Aldershot Borough Council, seven of whom were former commanders of the Training Brigade RE.

While the spectators and the parade markers were assembling, waiting music was played by the Band of 115 (Hampshire Fortress) Engineer Regiment (TA). When all the soldiers had formed up, a party from the Royal Engineers Association with their standards fell in on the left flank under the command of Brigadier G. L. Galloway, DSO, OBE, GM, a previous Commander of the Training Brigade, RE.

At 11 am the Mayor and the Chief Royal Engineer, together with the

Alderman, Councillors, Chaplains and Officers of the Borough entered the football stadium and the parade gave a general salute. Then followed an inspection by the Mayor of the troops on parade, the Royal Engineers Association and eight RE Chelsea Pensioners who had come specially for the occasion. The massed bands performed a most impressive troop in slow and quick time, during which they played the tunes *Huguenot* and *Aldershot*. Prayers were said by the Mayor's Chaplain and the Church of England and Roman Catholic Chaplains to the Training Brigade. These were followed by the Corps Fanfare and the ceremony of conferring the Freedom proceeded on the dais.

After the Town Clerk had read the scroll, the Mayor made a speech during which he said that Aldershot as a Borough did not grant its Freedom lightly and in its long history had only given it but ten times. Four of these had been to Regiments or Corps of the British or Commonwealth Armies. He went on to recall that during the whole of the 112 years' association of the Army with Aldershot there had always been Royal Engineers stationed there and, in fact, the first troops in Aldershot were a small party of Royal Engineers who carried out the original survey .The Major recalled that many branches of the Corps had been born in Aldershot, including the Mounted Depot, the Telegraph Unit, the Signals Section, the Wireless Section and also that the first RE experiments in military aeronautics had taken place there. The Mayor went on to talk about the further association that the Corps had had with Aldershot and its pre-war Tattoo and mentioned that, since 1857, one of the three military members of the Aldershot Borough Council had always been an officer of the Corps; he was pleased to see many of them present at the Freedom Ceremony. It gave him personally a special pleasure to be able to present the Freedom of the Borough to the Corps as he had served in the Sappers during the last War.

The Chief Royal Engineer, General Simpson, took the oath on behalf of the Corps and signed the Roll of Honorary Freemen. The Mayor then presented the Chief Royal Engineer with the scroll and silver casket, which had been specially made to contain the scroll. During his speech of thanks General Simpson reiterated the Corps' close association with Aldershot through the years and at the end of his speech said that after this ceremony the Royal Engineer troops on parade would like to exercise their privilege as Freemen and march through the streets of the Borough with Bands playing, drums beating and bayonets fixed. "We shall do so I can assure you, Mr Mayor, with the greatest of pride," he said.

The speeches over, the Casket Party consisting of Lieutenant W. T. Van Orden, RE and three Warrant Officers from 1 Training Regiment RE, marched forward and the Chief Royal Engineer, handed over the casket on its cushion to Lieutenant Van Orden. The casket was trooped in slow time to the tune *Golden Spurs*. The parade then marched past in quick time with the Mayor and the Chief Royal Engineer taking the salute. After an advance in review order and a general salute, the National Anthem was played. The Mayor and Chief Royal Engineer, together with the Town Clerk, Alderman, Councillors and Officers of the Borough then left the ground.

Due to the narrow exits of the ground, there was a slight pause while the Parade was re-formed six deep in Victoria Street. When all was ready, the privilege of marching through the town was exercised for the first time and this was enthusiastically received by the public. The march through the streets finished on the new Montgomery Square within a stone's throw of the now demolished Gibraltar Barracks, the home of the Aldershot Sappers for many generations.

A civil lunch was given by the Council in the Victoria Hotel, Aldershot, which was attended by members of the Council and senior Royal Engineer Officers. During this lunch the Corps presented to the Council a silver fruit bowl, which had been specially made by Mr Gerald Benney, who had also made the Casket. This was the first such presentation to be made by any Regiment or Corps who were Freemen of the Borough. In his speech of thanks, the Mayor assured the Chief Royal Engineer that the Borough would treasure this valuable addition to their collection of silver, and would use it with pride on every possible occasion.

In the evening there was a reception given by the Officers of the Corps to the members of the Council and other personalities of Aldershot at the Officers' Club. At the same time the Warrant Officers' and Sergeants' Mess held a reception in the pavilion of the sports ground. At the end of these receptions the Massed Bands Beat Retreat on the Aldershot Services sports ground, a fitting end to a memorable day in the history of the Corps and in particular of the Royal Engineers in Aldershot.

The Mines at Messines

By Captain Lawrence E. Mullins, United States Army[1]

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Historians tell us that the medieval period of history ushered in the ascendancy of the defence over the offence as a form of combat. After fruitless assaults against the battlements of the strong castles of that era, the wise commander soon resorted to an attack by stratagem and turned to an unusual group of men who in later days bore the proud title of Sappers and Miners. These men—the Sappers and Miners—would then undertake the extremely hazardous job of undermining the castle walls to a point where the fortification would collapse of its own weight.

With the advent of gunpowder the efficiency of these mineworks was enhanced by adding a charge of gunpowder beneath the walls at a critical point. With the passage of time underground techniques were developed to such a high state of effectiveness that by the 17th century an attack by sap and mine was tantamount to eventual defeat. The fall of the fortress was just a question of the time and of the persistence of the diggers to complete the required earthworks.

In a more modern age, at Port Arthur during the Russo-Japanese War, the efficiency of barbed wire and the murderous firepower of the machine gun were amply demonstrated when used to bolster defensive positions. In Europe, quick-firing artillery pieces like the famous "French 75" also indicated that the defence had gained a definite upper hand over the offence.

Despite these indications, a majority of the general staffs of the early 20th century armies held to the spirit of the offensive, a feeling fully shown during the opening battles of World War I. It was not until late 1914, when the warring powers had settled down in Western Europe in essentially parallel lines of opposing trenches which stretched unbroken from the North Sea to the Swiss Alps, that the realization came that infantry assaults above ground could only result in astronomical casualty rates.

Qualified Personnel

To counter the strength of the defence, each side began to resort to the classical patterns of the Sapper and Miner in attempts to undermine and emplace high explosives under the frontline trenches of the opponent.

Initially, both sides had difficulty obtaining personnel who were qualified for this unusual work. The British, for example, had only five tunnelling companies in 1915. By the end of June 1916, however, they had 32 companies, a force of almost 25,000 men working on frontline mining projects.

Most of the men in these companies had been experienced miners before they entered military service. Despite this, many lives were lost in the early

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mining and countermining battles because of enemy action, cave-ins, and underground gas. Most of the early mines were fairly shallow affairs; a few were that supreme effort of the tunnellers' art—the deep mine (over 22 metres).

Contested Area

Flanders, an area of western Belgium and northwestern France, the scene of innumerable battles since the Middle Ages, gradually became one of the most bitterly contested areas in the underground battle. Here, both the British and the Germans strove mightily to crack the other's defensive positions by undermining—and this despite the unusual geographic conditions found in the region (Fig. 1).

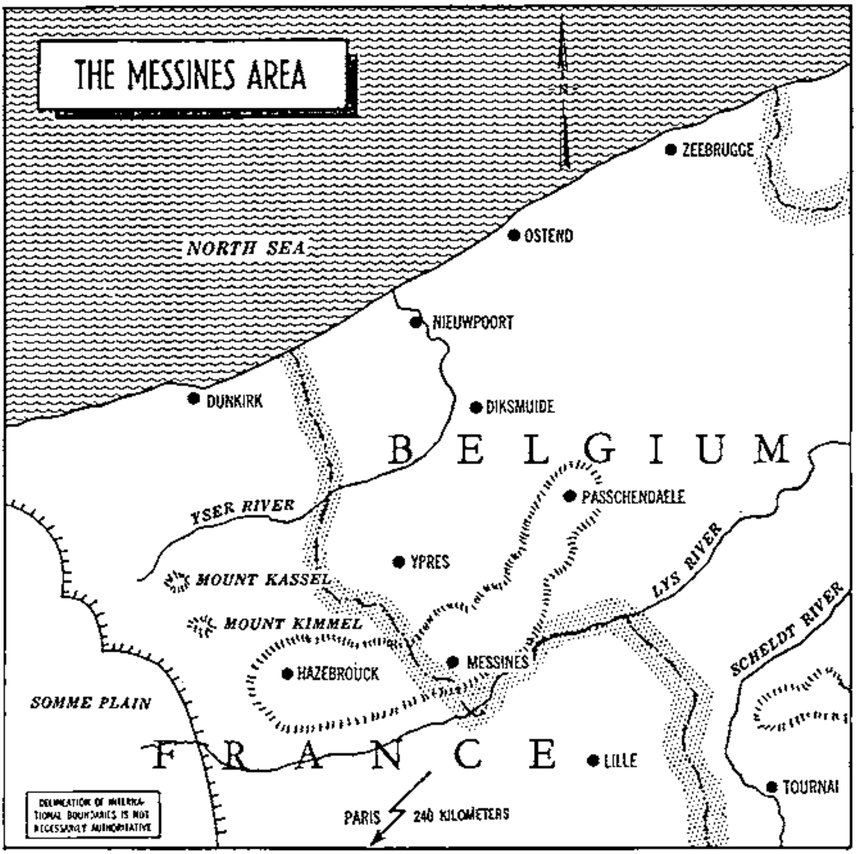

Fig. 1

The Flanders plain is extraordinarily flat, and consists of almost table-like terrain similar to parts of Kansas. It is cut by several extremely sluggish streams, the most important being the Yser, the Lys, and the Scheldt. Hundreds of smaller natural tributaries and man-made canals are present.

Throughout, there is no topographic feature of significance except for a chain of low hills and intervening highlands. These higher elevations run in an arc from a point north of Passchendaele south to Messines and then west toward Hazebrouck. The average elevation is about 45 metres with the highest point (82 metres) reached at Wytschaete, which overlooked the entire British positions at Ypres.

The relatively low hills were Everest-like prominences of inestimable value to their German defenders who, for over two years, had been emplaced on the high ground in secure defensive positions where they could note every move of the British. For two years they had easily repulsed numerous and savage British attacks.

But the German possession of the high ground was not all advantageous. Because the German positions were on higher ground than those occupied by the British, they were especially vulnerable to an underground mining assault.

The surface layer of the Flanders soil formation consists of a thin veneer of sand or sandy loam immediately underlain by a layer of water saturated, semi-liquid sand, or sand and clay. Beneath these surface soil zones is a thick seam of blue clay, found on both sides of the Channel and referred to as the "London Clay".

As a result of the underground clays, the constant rains which fall in Flanders cannot be absorbed into the ground. Since the stream gradients are low, little water is carried away by the rivers; most of it remains as stagnant swamps and ponds. In essence, then, the water table is the ground surface; trenches and fortifications constructed below ground level can be manned with only the greatest hardship and difficulty.

In addition, the problems of the attacking British troops had been further compounded by their own supportinga rtillery. The cannonades had created thousands of shell holes which soon filled with water; these impeded rather than assisted the British attacks.

Deep Layers

The earliest mines in the area had been driven by the Germans with great difficulty and little success because they had been dug in the wet, unconsolidated upper layers. The chief British geologist, Lieutenant-Colonel T. Edgeworth David, by a careful measurement of ground water levels and a detailed study of the clay formations, found that the deeper layers were more suitable and could be kept water free. Since these layers were at a greater depth, they would also provide more security from artillery fire.

The clay was an easy medium for tunnelling, and could be cut with the spade or bayonet. Because of the nature of the topography, a gallery driven from the British side through the blue clay from shafts 275 to 365 metres behind the lines would mean that when the gallery reached the German front-line trenches it would be at a depth of 25 to 30 metres. At that great depth, the Germans would find it difficult to detect; surprise would be more easily gained.

When tunnelling in the clay, however, the miners had to take great care to dispose of the spoil from their diggings. The presence of the deeply buried blue clay at the surface would immediately betray the mining effort to inquisitive German airmen. All of the spoil had to be hidden under sandbag parapets or disposed of in far distant areas.

Both sides went to extreme lengths to ensure the secrecy of their mining operations, but occasionally things did go awry. H. Standish Ball, a Canadian officer with one of the tunnelling companies, had told the pathetic tale of the fate of a canary used in the mines to detect the odor of deadly carbon monoxide gas. During the course of one mining operation only a few hundred metres from the enemy, the canary escaped from its cage and flew between the opposing positions, landing upon a bush where it immediately burst into song. Discovery of the bird by the Germans would surely indicate the presence of the hitherto secret mining operations and place in ruin the work of weeks.

The infantry in the trenches immediately opened fire on the canary, but it continued to sing, heedless of the bullets which whistled around it. It was not until the mortars were called on to assist that a well-placed round wiped out the bird, the bush, and the song. The fate of canaries notwithstanding, British mining operations continued at a feverish pace, 750 mines being exploded with varying success in 1916.

Grand Design

None of these mines, or any mine in the history of warfare, though, could compare with the system of 19 deep mines simultaneously detonated in support of the all-out British attack on the German salient at Messines on 7 June 1917. General G. H. Fowke, Engineer in Chief of the British Armies, first conceived the grand design for the mines in 1915. But it was not until Field Marshal Douglas Haig appeared as Commander in Chief in January 1916 that Fowke's scheme received the necessary high-level approval. Colonel David supplied the critical know-how to keep the galleries out of the water-bearing formations. From that time on the deep mining in the blue clay formations continued unabated. Fowke's plan was to use the mines in conjunction with a massive infantry assault by Lieutenant-General Herbert Plummer's 2nd Army against the German positions atop the ridge.

Detection Devices

Mechanical diggers were tried but soon abandoned—they made too much noise. Crude seismic detection devices had been developed by the Germans and were capable of determining the magnitude and direction of mining work. Experiments showed that the sound of picking and shovelling would carry at least 15 metres through the underground clay. In one case the sound of a pile being driven into the blue clay was detected 518 metres away. Therefore, as a normal practice, it became necessary to keep the miners working quietly at the face with a spade, bayonet, and, on occasion, with their bare hands. An average day pushed the subterranean galleries six to nine metres closer to the German lines.

There has been a great deal of discussion as to whether the Germans knew of the British mining attempts. Apparently, the lackadaisical German attitude can be traced to their mining officer, Lieutenant-Colonel Fusellein, who stated to his Commander in Chief, Crown Prince Rupert, that geological conditions would prevent the British from mining the critical high ground positions. In any event, so saturated with water were the underground formations, and so much trouble did the Germans themselves encounter during their own tunnelling, that they had no idea of the tremendous scope of the British operations.

Unique Place

The 19 British mines occupy a unique place in military history. Many of the mines were dug, loaded, and fuzed for well over a year. Since they had been so long in place, their effect on the critical infantry operations against

Messines could not be accurately gauged, especially in view of the ground water conditions. Even if they would explode, there was no recorded precedent from which the surface or underground effects of the earth waves resulting from the simultaneous detonation of a number of concentrated mines could even be approximately computed.

The mines of the Messines area were also unusual due to the extreme length of their galleries, the Kruisstraat gallery, for instance, being 670 metres long. However, the main characteristic which sets this operation apart from previous mines known in history was the enormous aggregate of explosive used—one million pounds. No less than 500,000 pounds were concentrated under 4,115 metres of the frontlines from Hollandscheschuur to Ontario Farm (Fig. 2).

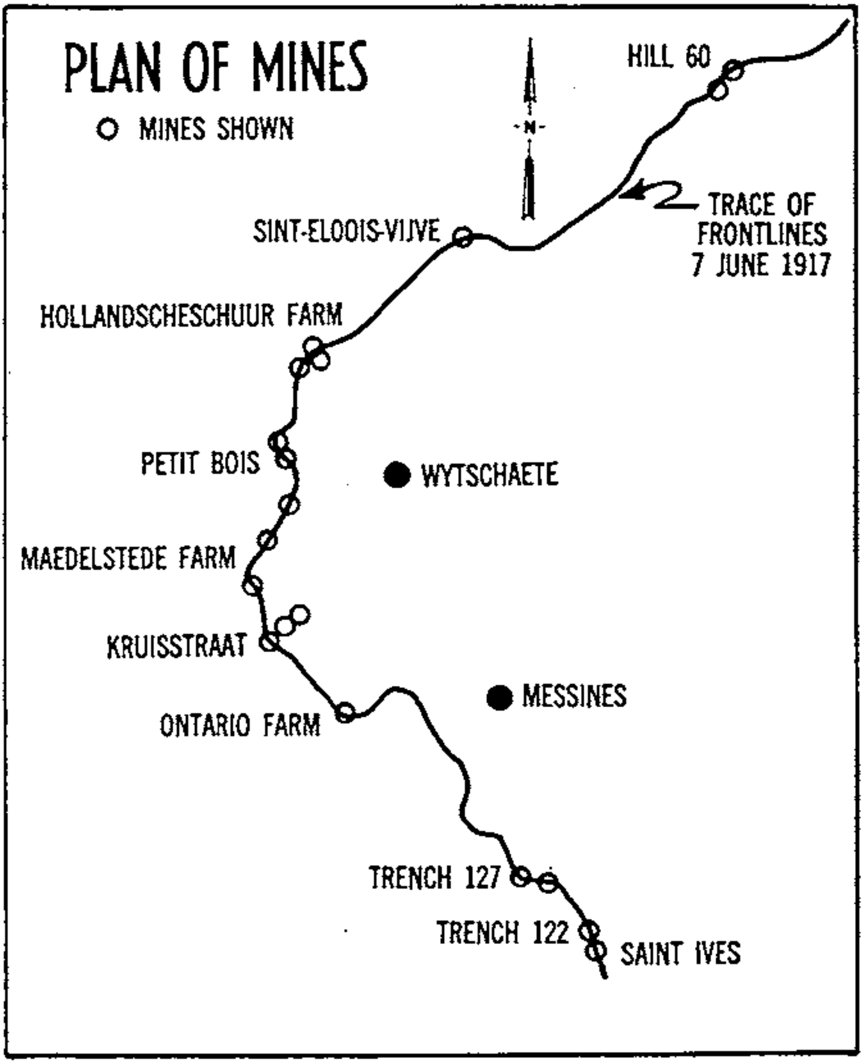

Fig. 2

This was to be no mere mining operation alone. British Empire troops numbering 80,000, supported by 300 aircraft and 72 tanks, would begin the assault on the ridge with the simultaneous detonation of the 19 huge mines. The planned preparatory artillery fire in support of the attack was breathtaking even for an age which was accustomed to tremendous bombardment. Prior to the zero hour, 165 trains had dumped 144,000 tons of ammunition for the 2,400 artillery pieces which would be used. Between 26 May and 6 June 1917, 3.5 million shells were hurled at the Germans. On the day scheduled for the attack, one gun was ready to fire for every six metres of front.

The novelty of the plan of attack was heightened by typical British thoroughness. Exact terrain models showing every natural detail of the ridge, as well as the enemy emplacements, were constructed well to the rear of the British lines. All commanders and staffs down to platoon commanders were repeatedly required to rehearse their part in the forthcoming operation until they fully understood their individual task.

For the British command, in spite of the tremendous preparations and fantastic determination which had stayed them for over a year in this arduous venture, there were tremendous doubts. These grew as H-hour drew closer. What if the Germans had discovered the mine system and somehow had emplaced deeper countermines of their own? Would the Germans have a premonition and withdraw to their second-line trenches leaving only a token small guard to be destroyed? Would the mines explode at all? What if even one single soldier, of the thousands who knew of the magnitude of the project, was captured and made to talk?

Attack Rumours

Persistent rumours of a German attack required the Commander in Chief to exercise great willpower and restraint to prevent a premature launching of his own assault. Although the British commanders were worried, and the outcome of the attack could not be predetermined, the British Chief of Staff did not need to summon power of clairvoyance when he made the following statement to Newsmen prior to the battle: "Although I don't know if the attack will make history, the explosion of one million pounds of powder will surely change the local geography."

Several days before the scheduled attack, the British artillery opened up against the German positions. By the evening of 6 June, effective counterbattery fire had almost completely silenced the German guns. As a further discomfort gas shells had been mixed in with the rain of high explosive. German morale was dangerously low—so low, in fact, that the Crown Prince was in the process of relieving his frontline divisions with rested troops just as the attack began. On the British side the results of long, careful planning began to pay off.

Guide tapes had been carefully laid out for the highly drilled British troops to assist them in moving up at night to their assault positions. When all the troops had moved up, the supporting fires stopped. From their vantage points atop the ridge, the Germans had seen almost all of these British massive preparations. They did not know of the mines.

At last, all was in readiness. At the word of command, and almost in unison, the 19 mines were detonated. Actually, about 10 seconds elapsed between the explosion of the first and the last. But to the German infantry atop Messines Ridge, the million pounds of explosive blended into a single catastrophic roar. The villages of Messines and Wytschaete totally vanished. The entire ridge appeared to be in volcanic eruption as the tremendous charges spewed horses, houses, cannon, and human beings into the dawn sky.

The British troops were momentarily awestruck by a vision of hell in which the 3d Bavarian and the 24th Saxon Divisions were virtually annihilated in impregnable positions. The explosion which rocked their ears rolled over the plain of Flanders to Lille about 20 kilometres away, where the citizens ran into the streets thinking an earthquake had occurred. The sound was clearly heard by an awake Prime Minister who was intently listening in England 160 kilometres away. Just as suddenly, a withering British artillery barrage 640 metres deep opened up on a front of 14,630 metres.

Recovering from the spectacle they had seen, British infantry and tanks rapidly moved up and secured the blood-stained ridge. Their fears that the Germans might move out of the frontline trenches proved groundless. Thousands of German soldiers were in positions over the mines; they never lived to see the full dawn on 7 June. Those who remained alive were in such a state of shock they offered little resistance and were quickly killed or taken prisoner; over 7,000 were captured.

Only when the British infantry stood on the top of the ridge and saw the magnitude of the craters did the average soldier comprehend what had taken place. The crater at Hill 60 was 91 metres in diameter and about 23 metres deep; in other areas, though, some of the mines exploded in soft, water saturated areas and left little or no crater. In those places the sides had flowed into the holes in the manner of quicksand.

The British quickly and easily secured the Messines ridgetop, but after a gain of 4,572 metres the German resistance appreciably stiffened. Ground conditions made it impossible for the tanks to keep up with the infantry, and the attack soon lost momentum. But the prize, the ridge, was now in British hands after two and one-half years.

Although the Battle of Messines took place long ago in an era of vastly different warfare, it still is acclaimed by many critics as a masterpiece and model of tactics which shows staff planning and execution of the highest order. Valid techniques for the modern commander—persistence with a good plan and thorough preparations to ensure success—are evident. But above all, the successful British assault shows that a concept of operations, in this case the underground mines, which had been tried and rejected by the Germans as unsuitable, created a mental block or complacency in their minds which was exploited by their enemy who brought to bear his verve, imagination, and intelligence.

Memoirs

LIEUT-GENERAL SIR MAURICE GROVE-WHITE, KBE, CB, DSO, COLONEL COMMANDANT RE (RTD)

Lieut-General Sir Maurice Grove-White, the Commander of II Anti-Aircraft Corps during the early part of the 1939–45 War and who was the senior British military adviser at the Dumbarton Oaks conversations in 1944, at which the plan for the United Nations Organization was formulated, died on 3 April 1965, aged 77 years.

Maurice Fitz Gibbon Grove-White was born on 7 January 1887, the son of Colonel James Grove White, CMG, JP, DL, of Kilbryne Doneraile, co Cork. He was educated at Wellington and the Royal Military Academy, Woolwich where he was awarded the King's Gold Medal. He was commissioned into the Royal Engineers on 18 December 1907.

At the conclusion of his young officer training at Chatham he attended a Coast Defence Electric Light Course at Plymouth from where he was posted to 44 (Fortress) Company, Jamaica and later to 39 (Fortress) Company at Sheerness.

In May 1915 he joined 54 Field Company in Flanders and he served with that unit until being given his first staff appointment as GSO 3 XIII Corps in January 1916. A year later he was promoted to become a GSO 2 at the General Headquarters of the British Expeditionary Force. For his outstanding war-time achievements he received a brevet majority and was awarded the DSO, the OBE and the French Legion of Honour 5th Class. He was mentioned in despatches four times.

In May 1919 he was posted to the War Office as GSO 2 in the Staff Duties Branch and, after a short tour in Scotland to obtain Works experience, he was selected to attend the Staff College in 1922. On graduating from Camberley in 1924 he served in the Military Operations Branch of the War Office for a year before becoming, from December 1925 to July 1929, Staff Officer Local Forces Straits Settlements and Federated Malay States. This appointment also carried the responsibility of overseeing the training of the Volunteer Forces of the Unfederated Malay States of Johore, Kedah, Perlis, Kelantan and Trengganu. He was made brevet Lieut-Colonel in 1928.

On returning to the home establishment he was given command of 38 Field Company, then one of the three field companies of the 2nd Division at Aldershot. Under his inspiring command, ably assisted by CSM "Buck" Spary (later Lieut-Colonel F. L. Spary, MBE) and the "sporting gladiators" Mudford and the Croston brothers, the "Three Eight" were invincible in everything they put their hand to. During his tour in command he attended the Senior Officers' School at Sheerness.

In June 1932 he moved from Aldershot to Blackdown to take over command of the 1st Anti-Aircraft Battalion RE, an appointment he held for four years. This unit, the largest on the peace establishment of the Corps, was very much in the public eye during the famous Aldershot Tattoo, held each year in Rushmoor Arena, for which it provided the illuminations. In a more serious vein, however, the 1st AASL Bn RE was responsible for the initial training and the organization of the system that was later to expand into the elaborate AA Searchlight layout of the Air Defence of Great Britain.

In 1936 Grove-White was promoted Colonel, with seniority back-dated five years, and was posted to the Military Training Directorate of the War Office in charge of the training of units allotted to the Air Defence of Great Britain at a time when both the Regular and Territorial Gunners and RE Searchlight units were being greatly expanded. In the case of the Territorial Army many long-established Infantry units were rebadged to the Corps for searchlight duties. By the end of 1938 some 50,000 officers and men of the British Army were held on the strength of searchlight units or employed extra-regimentally on searchlight duties.

In May 1939 he was promoted Major-General and given command of the 2nd AA Division, raised to extend the air defence of the country further north. The Division contained, in addition to a multiplicity of Gunner AA units and attached services, eleven TA AA Battalions including the Tyne Electrical Engineers and rebadged TA units of the Duke of Wellington's Regiment, The Lincolnshire Regiment, The Sherwood Foresters, the Leicestershire Regiment, the Royal Warwickshire Regiment, the King's Regiment, the Lancashire Fusiliers and the North Staffordshire Regiment. Many of these units were later to become Gunners as the gradual transfer of responsibility for Anti-Aircraft and Coast Defence Electric Lights duties from the Royal Engineers to the Royal Artillery took place. For the first time in the history of the British Army "mixed units", containing ATS, were raised for AA duties in the Division.

Grove-White was in command of this AA Division during mobilization on to a war footing and during the early German air raids on this country. In November 1940, as a Lieut-General, he became General Officer Commanding II Anti-Aircraft Corps when he found himself in command of more than 100,000 men and women in isolated gun detachments and searchlight positions, and in the auxiliary services needed to keep these operational, scattered over the whole of the central half of England and Wales. It took an officer with the Corps Motto *Ubique* deeply ingrained in his heart to keep a close, fatherly eye on this wide parish, and the supervision never faltered.

The Battle of Britain being won and the role of the AA Corps reduced, Grove-White was posted in 1943 to command North Wales District, and after eight months there he was made Major-General General Staff and War Office representative on Post War Hostilities planning Sub-Committee of the Chiefs of Staff Committee. In 1944 he took part in the conversations, attended by representatives of the four Great Powers, at Dumbarton Oaks Estate near Washington, DC, USA, where the spade work was done to prepare a plan to set up a United Nations Organization and the creation of an "international police force" to prevent aggression anywhere in the world. The Dumbarton Oaks plan, with only slight amendments, was accepted by the forty-six national delegations assembled in San Francisco in 1945 a few days after the surrender of Germany.

For his war services Grove-White was created CB in 1941 and KBE in 1945. He retired in March 1945.

On 20 March 1946 he was appointed Colonel Commandant, Royal Engineers. His tenure expired in December 1953. He was from 1947 to 1950 Honorary Colonel of 571 (Middlesex) Searchlight Regiment, RA.

In July 1919 he married Bernice Agnes, only child of Mr and Mrs Duncan Parlane of Upton Lodge, Edinburgh. They had two sons. The eldest was killed in action in May 1940. The second is a Lieut-Colonel in the Royal Artillery. His wife died in 1945.

BRIGADIER A. MASON, MC

ALEC MASON was born in London on 19 November 1891, the son of John Martin Mason. He was named after his uncle Lieut-Colonel Alexander H. Mason, CB, DSO, a famous Sapper officer who distinguished himself in countless campaigns on the NW Frontier of India and who died of typhoid during an official tour of inspection on the Frontier in 1896. Even during his lifetime his name had become almost legendary and after his death his brother officers, headed by General Sir George Stewart White, VC, GCIE, KCB, opened the Mason Memorial Fund, the proceeds of which founded an endowment in connexion with the Mayo Orphanage, Simla in the welfare of which school Mason was much interested. A memorial tablet to him was placed in Holy Trinity Brompton Parish Church, and when that church was demolished the tablet was placed in the Garrison Church and rededicated on 26 April 1959, a service attended by the late Brigadier A. Mason and other members of the Mason family.

From boyhood he was told that he should follow his uncle's footsteps and continue the work he began; and that he always strove to do.

Commissioned into the Royal Engineers in July 1911, he was posted to India after his Young Officer training at Chatham. His first appointment was with the Military Works Service, but on the outbreak of the 1914-18 War he went with the India Expeditionary Force to the Western Front and in January 1916 he accompanied the Expeditionary Force to Mesopotamia. In March of that year he was awarded the Military Cross for gallantry and devotion to duty in the field. In September he was invalided out of the theatre of operations and went back to India where he took part in the 1919 Afghan War. The following year he was appointed Deputy Assistant Director General of Military Works at Simla and in 1922 he reverted to the home establishment.

After Works appointments at Oswestry and then North Wales he went in April 1924 to the SME, Chatham, as an Assistant Instructor in the Construction School. He then attended a course on Administrative Training at the London School of Economics and in 1928 he was attached to the Quarter Master General's Branch of the War Office.

In 1929 he was posted to the Far East and held the appointment, with the rank of major, of Officer Commanding Royal Engineers Shanghai, for over three years.

On returning home he was given command of 56 Field Company, then stationed at Bulford. On promotion to Lieut-Colonel in April 1935 he became CRE Lancashire Area, but shortly afterwards he was sent out to Egypt to take up the appointment of CRE 5th Division, deployed to meet a possible Italian threat from Lybia at the time of Mussolini's invasion of Abyssinia. When this threat receded Mason was sent to Palestine at that time troubled by Jewish-Arab disturbances.

In 1937 he was once again posted to the Far East where for two years he commanded the Fortress RE, Malaya.

On promotion to Colonel in 1939 he returned home to become Deputy Chief Engineer, Eastern Command. On the outbreak of war he became Chief Engineer with the rank of Brigadier and he held that appointment until being sent out to India where in March 1942, as Chief Engineer to General (later Field Marshal) Sir Harold Alexander he took part in the withdrawal of British

Brigadier A Mason MC.

and Indian troops through Burma, and his operation of the famous Irrawadi Flotilla, comprised of patched-up river craft, working from rough, hastily-constructed jetties, and commanded by RE Staff and Works officers who knew something about sailing and navigation did much to make the withdrawal possible. In September of that year, as Chief Engineer IV Corps, composed of the 31st, 6th and 10th Indian Divisions, he joined the Persian and Iraq Command where the formation, less the 10th Division which was sent to Egypt, built defences in the wild, mountainous passes of North Persia. In April 1943 he returned to India to become Chief Engineer Southern Army. He returned home in June 1944 to take up his last appointment as Chief Engineer Scottish Command. He retired in 1946 after thirty-five year's service during which he had fought as a young officer in France, Flanders and Mesopotamia in the First World War, between the wars he had seen active service in Egypt and in Palestine and in the Second World War he had served with distinction in the withdrawal through Burma and in Persia.

On 19 July 1917 at Naini Tal, India, he married Mabel Caroline Dyson. They had a daughter Dawn, now married to Wing-Commander Hugh Chater. Later there was a divorce. On 2 May 1930, in Hong Kong, he married Eva, second daughter of Karl Alexander Malmberg of Stockholm, Sweden. They had a son and a daughter.

After leaving the service Mason retired to his farm near Battle, Sussex, where he bred pedigree Guernseys. Early in 1958 he became convinced that his Uncle, Alexander H. Mason, was the original of "Colonel Creighton" in Kipling's famous book *Kim*. He joined the Kipling Society and became a member of its council and, until early 1962, gave all his time to help write a Reader's Guide of the works of Rudyard Kipling. He then went to live at Vensberg Gárd, Tösse, and travelled widely in Sweden. He returned home, due to failing health, on 19 January 1965 and he died on 5 February in his seventy-fourth year.

BRIGADIER W. C. H. PRITCHARD, CB, CBE, DSO

BRIGADIER W. C. H. PRITCHARD, Inspector of the Anti-Aircraft Searchlight Service on the Western Front during the First World War, and Director of Engineer Stores in the Second, died on 3 May 1965 in his eighty second year.

Walter Calvert Herbert Pritchard was born on 10 November 1883, the younger son of Walter Sennett Pritchard Esq, of Woking, Surrey. He was educated at Clifton and the Royal Military Academy, Woolwich and commissioned into the Royal Engineers on 21 December 1901.

On completing his young officer training at Chatham he attended a Submarine Mining Course at Plymouth, after which he was posted to Ceylon in 1904 where he served in the Submarine Mining Company at Trincomali and was also responsible for certain Works duties. In 1906 he was posted to Malta and whilst on the Island he spent some time with 28 (Fortress) Company and later he became Adjutant, RE Companies.

On returning from Malta he was posted to 30 (Fortress) Company at Plymouth and later he went on a Long Engineering Course at Manchester. In June 1911 he joined 4 (Fortress) Company at Fort Monkton, Gosport to become an Instructor at the School of Electric Lighting, and he remained in that appointment for the first year of the 1914-18 War. In August 1915 it was decided to reform 50 Field Searchlight Company, partly from the Territorials who had relieved Regular Fortress units and partly from the instructional staff of the School of Electric Lighting, and Pritchard was selected to command the unit which was originally earmarked for the Western Front. He adapted coast defence lights for an anti-aircraft role by the provision of special U shaped arms, fabricated in the Gosport Workshops, to enable the lights to elevate and traverse mounted on motor transport. As soon as his unit was fully operational it was employed in the Anti-Aircraft Defence of London against Zeppelin raids. In April 1916, at the request of the C-in-C BEF, his unit was transferred to France. The Headquarter Section of the unit was stationed at GHQ, BEF and Pritchard became the Searchlight adviser to the Engineer-in-Chief. In January 1917, as a Lieut-Colonel, he was appointed Inspector Anti-Aircraft Searchlight Service in control of some eighty anti-aircraft sections working under him. For his services he was made a brevet Lieut-Colonel and he was awarded the DSO.

Returning home in 1919, he was employed at the War Office under the Director of Fortifications and Works, and in 1924 he became Chief Inspector of RE Stores with his headquarters at Woolwich. Four years later he was posted to Headquarters Eastern Command at the Horse Guards as Senior Staff Officer for E and M duties. He attended a course at the Senior Officers' School, Sheerness in 1928 and the following year he retired, remaining on the Reserve of Officers.

Recalled for service in September 1939, he joined the Stores Branch of the Directorate of Fortifications and Works in Romney House. In peace time the Branch dealing with engineer stores consisted of three officers (one retired), a technical assistant and 17 clerks. On mobilization the staff was slightly increased and a small movements section added, and in March 1940, Pritchard's appointment was upgraded to Deputy Director. In July 1943, when the procurement, holding and distribution of engineer stores had grown beyond the wildest imagination and worldwide needs of RE field units came to exceed those for Works projects, a Stores Directorate, independent of the Director of Fortifications and Works, was set up and Pritchard was made Director of Engineer Stores responsible directly to the Engineer-in-Chief. His most efficient and infectiously-happy mixed staff, accommodated in Great Smith Street, worked wonders and were not put out even when a flying bomb removed an outside wall of the building, once the young lady responsible for them found that the Bailey Bridging records had not been destroyed. Vast engineer stores depots and workshops were set up in this country—the largest being at Long Marston near Stratford-upon-Avon which from 1940 to 1943 grew from a virgin site to a depot with almost half a million foot super of covered storage, nearly 200 acres of open stacking space, 45 miles of railway sidings, some 6 miles of roadway and a vast workshop area. It continued to grow and during 1943 over 10,000 stores wagons were handled at the Depot. Pritchard kept a ever-watchful eye over his great empire. Everyone recognised and loved the short, stocky figure of their Director, always with an equally short, stocky pipe in his mouth which to those under him was as famous as Mr Churchill's cigar.

HGH, a former Director of Fortifications and Works, who knew Pritchard well during the war years, writes of him:

"My first meeting with Pritchard was on the day I returned from Dunkirk. From then on he befriended me and I always enjoyed his company. He persuaded me to join the 'Rag' and he was my sponsor.

In the management of Engineer Stores he had a remarkable facility for thinking big and quickly. When the War Office decided in 1939 that the Channel ports might become untenable he requisitioned the Channel Train Ferry and, I believe, shipped more engineer stores to the BEF by her than by the Q (Movements) Staff chosen route to Brittany. When later there was a requirement to build a trans-continental pipeline across India, Pritchard ordered all the stores required for it in forty eight hours. He also revived the Nissen Hut in a big way at a time when the Army had no standard hutting design at all. He appeared to disregard all forms of red tape and convention and get away with it.

In the 'Rag' there used to be a small group which 'Q' Martel (the late Lieut-General Sir Giffard le Q Martel, KCB, KBE, DSO, MC) called the TOG (The Old Gang) with Pritchard always at its centre."

For his outstanding war services Pritchard was created CBE in 1941 and CB in 1945.

After his second retirement when the war was over he became a Director of Withers and Co a post he held until 1962. His interests were gardening and visiting his old friends at the "Rag".

In May 1912 he married Catherine Marion, daughter of Captain C. Underwood, Royal Navy of Ryde, Isle of Wight. They had a son, who became a Lieut-Colonel in the Royal Armoured Corps, and a daughter.

Book Reviews

HISTORY OF THE SECOND WORLD WAR
THE WAR AGAINST JAPAN VOLUME IV

By Major-General S. W. Kirby, CB, CMG, CIE, OBE, MC

(Published by HMSO. Price 85*s* net)

This volume of the History of the Second World War by Major-General S. W. Kirby covers the operations of all the Allied Forces in South East Asia and the Pacific from August 1944 to May 1945, but it is primarily a story of the 14th Army's relentless advance into Burma, supported by 221 Group RAF. This advance against a stubborn enemy across the grain of jungle-covered mountains and wide, fast-flowing rivers, carried out under most adverse climatic conditions, was only made possible by flexibility in planning, administrative improvisation, the utmost use of air supply and a most sustained engineer effort to preserve the mobility of the operations. The construction of jungle tracks and roads, airfields and dropping zones was a never-ending Sapper task. Water transport was used as never before. A boat-building industry on the banks of the Chindwin was established and engines and parts for river-craft delivered by air. Locomotives and stores for railways were brought in by road and by air. Bridging, ferrying often in face of the enemy and the demolition of Japanese bunkers were the constant tasks of the field companies. The Ledo Road and the pipeline from Calcutta to Kunming were among the many outstanding engineer achievements of the British and Indian Sappers of General Slim's Army.

The volume describes the great difficulties under which the Supreme Allied Commander, Admiral Mountbatten, worked—the shortage of necessary resources from home and the conflicting requirements of his American and Chinese allies. But overcome they were by his perseverance and tact. The laconic statement in the preface that the volume provides many lessons for those who may be faced with inter-Allied co-operation in any future war is a masterpiece of under-statement.

The outstanding gallantry, remarkable endurance and fortitude of Lieut C. Raymond, RE, when leading a Special Force raid near Taungup, which won him a Victoria Cross, does not pass unquoted in the book.

MEMOIRS OF LIDDELL HART—VOLUME I

By Captain B. H. Liddell Hart

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

This, the first volume of Liddell Hart's autobiography, starts with a description of his early life, his short, but eventful period of active service in the King's Own Yorkshire Light Infantry on the Western Front during the 1914–18 War and, after being severely wounded and gassed, his employment as a junior staff officer, as an Adjutant of Volunteers and as an author of training publications.

His name first become one to conjure with in January 1921 when, still a junior serving infantry captain, he delivered what was to become a famous lecture at the RUSI to a large audience composed of many influential senior officers among whom was Major-General H. F. Thuillier, then Commandant of the School of Military Engineering. The title of the lecture was "A Science of Infantry Tactics" and it was the first lecture on that subject to be given at the RUSI since the end of the First World War. Liddell Hart's provocative and original concept of an "expanding torrent" system of attack against defence distributed in depth so greatly impressed General Thuillier that he invited the young captain to repeat his lecture at Chatham. This was done, and the text of the lecture was published in two parts in the April and May 1921 issues of the *RE Journal*. Not everyone, however, was convinced by this provocative doctrine. The September 1922 issue of the *RE Journal* contained an article by Lieut-Colonel (later Lieut-General Sir Lionel) Bond, then an Instructor at the Senior Officers' School in India, which criticised Liddell Hart's system on two points, firstly that it took no account of the human factors involved and secondly that it was based solely on the conditions prevailing in 1918 on the Western Front and, therefore, not universally applicable. It would certainly fail in his opinion, for instance, if applied to operations on the NW Frontier of India.

This was not the last time that Liddell Hart's pronouncements were challenged, nor was General Bond to be his only Sapper critic.

Later, invalided out of the service, Liddell Hart became successively military correspondent of the *Morning Post*, *The Daily Telegraph* and *The Times* and with each change his influence in the corridors of power grew stronger. He also wrote many widely-read works on military history and doctrine. Together with those of Major-General J. F. C. Fuller, his teachings between the two World Wars made this country a recognised centre of progressive military thought—if not its application. In his recent book "The Education of an Army" Professor Jay Luvass referred to Liddell Hart as "the Captain who taught Generals". There were, however, many generals to whom the name Liddell Hart was anathema.

The first volume of these Memoirs takes the reader up to 1937 and spans a period of transition in the British Army from the horsed cavalry to the Experimental Armoured Force, a transition comparable in many respects to an earlier change in the Royal Navy from sail to steam and accompanied by similar caution and reaction. It saw the consolidation of the Royal Air Force as an independent entity despite the entrenched jealousies of the two older Fighting Services, and the emergence of air-power as a victory-producing weapon in a total war. It witnessed the rise of Mussolini and Hitler and the formation of the Rome-Berlin Axis and the Spanish Civil War—a testing ground for the French Maginot Line concept and the German employment of the dive-bomber. It was indeed a period of flux in the political and military arena and Liddell Hart has much to say on each inflexion of that kaleidoscopic scene.

Many famous Royal Engineer names appear in his book, among them being General Sir Bindon Blood, General Lord Robertson of Oakridge and Lieut-General Sir George Macdonogh, Lieut-General Sir Ronald Charles and Lieut-General Sir Hugh Elles, both in their time Master-General of the Ordnance, and such armour experts as Lieut-General Sir Giffard Martel, Major-General Sir Ernest Swinton and Major-General P. C. S. Hobart and the two Directors of Mechanization, Major-Generals A. E. Davidson and A. Brough. The author is not always complimentary to these officers, particularly if their views differed from his beliefs in how things should have been done. However, as Lord Chalfont wrote in a review of the volume, published recently in *The Times*, some readers may become infuriated by the author's assumption that he was always right. Perhaps to accentuate this assumption the Captain has seen fit to have reproduced on the dust sheet of his autobiography eulogies, pronounced by such diverse personalities as General Chassin, General Von Millenthin, General Guderian, President Kennedy, Field Marshal Sir Claude Auchinleck, and Field Marshal Viscount Montgomery of Alamein, to proclaim like Cassius Clay, that: "I am the Greatest!"

GENERAL SIR ARTHUR COTTON

By LADY HOPE

(Reprinted by the Institution of Engineers (India), 8 Gokhale Road, Calcutta 20. First published in 1900 by Hodder and Stoughton, 27 Paternoster Row, London)

This is a book of great interest to engineers. To Royal Engineers it will also bring a sense of pride. To a much wider circle of the British people its timely republication will bring satisfaction. In these days of de-colonisation it is not fashionable to talk of the "white man's burden". We can, therefore, feel gratified that it is the Indian people themselves who, through the aegis of the Council of the Institution of

Engineers (India), have caused this book to be re-published in order to further honour the memory of a famous Engineer of the British Raj who spent his whole life working for the people of India.

This biography of General Sir Arthur Cotton was written by his daughter and first published in 1900, at a time when famine once more raged in India. It was not written primarily to commemorate his life, great though his achievements were, but to stress its purpose which was only partially fulfilled in his life time, in the hopes that the narrative of his work and teaching might inspire others to complete what he began.

Many Royal Engineers have spent most of their service in India, but few of recent years can emulate the record of Sir Arthur Cotton. He arrived in India in 1821 at the age of 18 and served there continuously until 1860 when he reverted home. He was knighted for his Indian services in 1861, made KCSI in 1866, and promoted General in 1876 retiring a year later. He died in 1899 at the age of 96.

Arthur Cotton's claim to fame is as the pioneer of canals in India—for irrigation and also for navigation. From his first employment in the Cauvery delta in 1827 he was obsessed by the thought of mighty rivers running to waste in the sea while the whole land cried out for irrigating water for the crops on which its existence depended—an existence which could cease altogether if lack of rainfall caused crops to fail, or worse still if too much caused floods which carried away not only the crops but the people themselves. He saw the necessity of harnessing the great rivers and storing their waters. With great moral courage as well as technical skill he designed and built the Upper and Lower Coleroon Anicuts on the Cauvery in 1835, and later (1847–49) the great Anicut across the Godaveri at Dowlaishweram where the river is four miles wide. Here owing to shortage of masons he boldly based his design on an ancient Indian anicut of packed boulders surfaced only with lime concrete. This was completely successful, and together with the connected system of locks, sluices and canals was executed at a capital cost which paid for itself many times over by the great increase in the land revenue. But Sir Arthur Cotton's greater justification, not calculable in rupees, was the vast improvement in the living standard of the ryots. The ryots, however, could not have sold their increased crops without cheap means of transport. This Sir Arthur also achieved by making the canals navigable.

Further schemes he had also designed for the Kistna were ably carried out by his successors, and his fertile mind produced others for all parts of India for the execution of which he continued to press energetically after his return to England. Here he ran into much opposition, but remained the ardent advocate of canals until his death. If anyone should still think that Sir Arthur Cotton had "water on the brain" I would draw attention to the terrible record of famines which continued to ravage India, as given on page 312 of this book.

In describing her father's life work, the author stresses that the main spring of all Sir Arthur Cotton's efforts for the people of India, and indeed of everything he did, was his strong Christian faith. He was not only a talented Engineer, but a fearless Crusader. The writing of this book was a dedicated work for Lady Hope. She has amassed and logically arranged a vast amount of detail, and has illustrated it with some excellent photographs, and two very good maps.

H.E.M.C.

THE FORGOTTEN MEN

By Ian Adamson

(Published by G. Bell & Sons, 21*s* net)

This book tells the story of the British 204 Military Mission to China reconstructed by the author from letters and diaries of members of that Mission.

Originally there were five cadres of British and Australian troops trained in jungle warfare and demolitions whose task was to move into China should Japan declare war to act as sabotage experts to five Chinese battalions said to be operating behind the Japanese lines. Three of these cadres, each about fifty strong, set out along the

Burma Road and travelled by lorry, by junk and sampan and on foot over two thousand miles deep into China where they set up a guerilla training centre. The results obtained were disappointing—the Chinese sent for training were of poor quality and there was a considerable language problem due to the many dialects spoken. The Mission then set out on a seven week march to Chu Chia Kai, some hundred miles South of Hankow. By the time they reached their destination many had succumbed due to fatigue, malnutrition, fever, dysentry and typhus. The only action they experienced against the Japanese was a small one on a reconnaissance patrol with Chinese troops. It was finally decided that the depleted Mission could achieve no useful purpose and it was withdrawn after nine arduous and frustrating months.

This was not one of the glorious episodes of the Second World War, but it is a story of fortitude of sick men staggering on until they died and of China and its people in the agony of Japanese occupation.

STATICS OF GRANULAR MEDIA

By V. V. Sokolovskii. Translated by J. K. Lusher, edited by A. W. T. Daniel

(Published by Pergammon Press. Price 80*s*)

The book summarises the theoretical background to the more advanced theories concerning soil mechanics problems. The classical approaches of Coulomb and Rankine, while widely used, are limited in assuming the simplest of boundary conditions and a plane surface of rupture. The analysis of soil mechanics problems taking into account the curvilinear planes of failure which occur in practice has, in the main, been limited to specific simple cases. As the analysis of general problems involves tedious mathematical approximation processes or computer programmes, much research is being directed towards the possibility of simpler methods of calculation.

The book outlines the mathematical basis of the main problems in soil mechanics and develops the differential equations which specify the stress conditions in the soil. Examples are given where the differential equations have been solved for specific cases.

While this book will be of interest to research workers and, occasionally, to designers faced with particular problems, it is unlikely to be of any immediate practical use to the average engineer.

D.F.M.

WATER TOWERS, BUNKERS, SILOS AND OTHER ELEVATED STRUCTURES

Fourth Edition *by* W. S. Gray, *revised by* G. P. Manning

(Published by Concrete Publications Limited. Price 36*s*)

This book has been most successful since it was first published in 1933. In the present edition, it has been extended by one third, the main additions being a large number of excellent illustrations. The book now includes nearly 250 figures, a large number of which are photographs of structures in course of construction.

The range of subjects covered includes tanks and towers, storage bunkers and silos for granular materials and the ancillary discharge and handling equipment and the design and construction of gantries and towers. A wide variety of each type of structure in reinforced concrete is covered but little is included on pre-stressed concrete.

Appendix I contains four useful reinforced concrete design charts for the steel and concrete stresses commonly met in the design of water retaining structures. Appendix III, another new addition to the book, outlines a method of assessing the maximum bending moments in square and rectangular silos, including multiple compartment silos.

The book should continue to be a firm favourite for those involved in the design of this type of structure.

D.F.M.

SIX-FIGURE TRIGONOMETRICAL FUNCTIONS OF ANGLES IN DEGREES AND MINUTES

By C. Attwood. Principal, Apprentice Training, Ford Motor Co, Ltd

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 7*s* 6*d*)

This soft-covered book has been compiled to meet the requirements of designers and others who need reliable tables for the solution of practical problems.

The contents include: The tables of the six natural trigonometrical functions of angles in degrees and minutes; Proportional parts in tenths of a minute and twelfths (ie for 5 seconds); Functions of π; Conversion tables of minutes to degrees, radians to degrees, etc; Comprehensive notes on linear and non-linear interpolation; Tables of auxiliary functions.

The main tables provide at least six significant figures for all trigonometrical functions over the whole range of the quadrant.

Of interest are the notes provided on the work done by those 16th century computers of natural trigonometrical functions—Christopher Clavius and George Joachim Rheticus.

F.T.S.

SIX-FIGURE LOGARITHMIC TRIGONOMETRICAL FUNCTIONS OF HUNDREDTHS OF A DEGREE

By C. Attwood, Principal, Apprentice Training, Ford Motor Co, Ltd

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 12*s* 6*d*)

This soft-covered book, *No 2 of the Practical Tables Series* compiled by C. Attwood, gives the trigonometrical functions of angles at interval 0.01 degree, plus tables of proportional parts, functions of π, and the conversion of degrees to radians and vice-versa. Notes on the use of interpolation and a selected bibliography are also included.

Every entry in the main tables was taken from Henry Briggs table book *Trigonometria Britannica* of 1633 that was edited by Henry Gellibrand. The entries were then rounded off to the appropriate number of significant figures. Every entry close or equal to the termination 5,000 was checked by deriving additional figures by interpolation from Andoyer's 15-decimal sexagesimal (degrees, minutes and seconds) table books.

To ensure complete accuracy the tables were then compared with two other works recently published by the bureau of Standards, Washington, DC, USA.

Of interest is a short summary of the ways by which Briggs (1560–1630) and Gellibrand (1597–1637) constructed their tables, which have not yet been superseded.

F.T.S.

SIX-FIGURE LOGARITHMIC TRIGONOMETRICAL FUNCTIONS OF ANGLES IN HUNDREDTHS OF A DEGREE

By C. Attwood, Principal, Apprentice Training, Ford Motor Co Ltd

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 7*s* 6*d*)

This work is a companion to *Practical Tables Series No* 2, which is also reviewed in this issue of the *Journal*. Every entry has been given in full and each logarithm has been printed complete with its characteristic.

Checks for accuracy of the entries were made, except that logarithmic secants and logarithmic cosecants could not be checked against other works because none exist. Consequently, the process of derivation was reversed and the functions checked by deriving from them logarithmic cosines and logarithmic sines.

The usual information on proportional parts, conversion tables and interpolation are included, together with the auxiliary functions S and T to enable six-figure accuracy to be maintained over the range 0 to 3 degree for those functions for which linear interpolation is inadvisable.

F.T.S.

ELECTRICAL MACHINES

By J. HINDMASH, BSc (ENG), AMIEE

Lecturer in the Faculty of Technology of the University of Manchester

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 35*s*)

This soft-covered book is included in the Applied Electricity and Electronics Division of The Commonwealth and International Library.

The text of its 500 pages presents the principles of magnetism, and the electrical circuits utilized in the design of transformers and DC or AC rotary machinery. It is concise and does not resort to advanced mathematics in the explanatory detail. With the result that, academically, it fits in midway between the primer and the specialist handbook—a boom to those who are faced with the need to grasp the techniques of the vast present day range of electrical developments.

Students of electrical engineering will, however, find its scope suitable for the Machines portions of the Electrical Power and Machines syllabus for the External BSc (Eng) degree of London University and for the Higher National Certificate.

Each chapter deals individually with the theory of operation, construction, winding, starting, and testing of transformers, DC commutator machines, induction motors, synchronous machines, and AC commutator machines. Each is well illustrated with excellent diagrams and photographs and include a number of worked examples of circuit calculations. Other problems with answers are provided in an appendix.

This text book would be suitable for study by officers of the Corps wishing to qualify as E or M.

THE MEASUREMENT OF MECHANICAL PARAMETERS IN MACHINES

By PROFESSOR N. P. RAYEVSKII, Institute of Machine Construction, USSR Academy of Sciences

Translated from the Russian by D. P. BARRETT

Translation edited by L. MAUNDER, Professor of Applied Mechanics, University of Newcastle-upon-Tyne

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 80*s*)

The first edition of this book entitled *Experimental Methods for Investigating the Mechanical Parameters of Machines* was published in 1952. Since then, however, many of the experimental devices described in the first edition have been widely adopted by the laboratories of machine building institutes and factories of the USSR for experimental research on machines and mechanisms to help solve complex problems in applied mechanics. The present edition includes many additions and revisions.

The text is divided into three parts. Part 1 describes the electrical methods of measuring highly dissimilar mechanical, physical, chemical and other quantities by the use of a variety of pick-ups (electrical devices or elements which convert non-electrical quantities into electrical ones at a constant relation over an adequate measuring range). These usually comprise sub-elements which pick-up, amplify, register or record. A large number of various types are described for sundry applications.

Part 2 covers the measurement of: Displacements large, micro and angle; Linear velocities; Accelerations; Forces; Torque; Rotating parts; and Vibrations.

Part 3 is devoted to experimental problems in research on machines and includes: Recording paths in plane motion; the measurement of non-uniform rotation of shafts; the determination of effective inertia in machinery. Plus a short appendix dealing with amplifying equipment; recording instruments; and the processing of oscillograms. A host of other reading references is given at the end of the book.

The very detailed text is only suitable for machine designers and students of instrumentation in colleges of technology.

F.T.S.

DICTIONARY OF ENGINEERING MECHANICS

By CHARLES O. HELLER

(Assistant Professor of Engineering, US Naval Academy, Annapolis MD, USA)

(Published by Elsevier Publishing Company Ltd, Barking Essex. Price 30*s*)

This collection of 1,500 Russian words and their English equivalents present some of the terminology of aeromechanics, elasticity, fluid mechanics, plasticity, rigid body mechanics, theory of structures, and vibrations. It was compiled by the author over a period when he was preparing to sit for a Russian language examination that was part of his study toward a doctorate.

At first it was arranged and typed for use by himself and a few professional colleagues, but the demand for it became so great that the author decided to publish it for general use.

To assist readers to extend their list of Russian technical words the author has include the following aids to transliterations: The Russian alphabet for capitals and the lower case with English letter and sound equivalents: The cardinal and ordinal numbers: Notes on the translation of technical titles and abstracts: An introduction to Russian grammar-nouns and verbs: And a short summary of some of the more common abbreviations used in Soviet scientific and technical literature as printed in Russia.

Obviously a most useful book for the military engineer.

Incidentally, the publishers have produced many multi- and bi-lingual technical dictionaries, and a detailed catalogue of these can be obtained from them on request.

F.T.S.

MECHANICAL SYSTEM DESIGN

By ING W. E. EDER, Lecturer in Mechanical Engineering, and W. GOSLING, BSc, ARCS, AINSTP, MIEEE, Lecturer in Electrical Engineering and Warden of Neuadd Gilbertson, University of Wales

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 21*s*)

This soft-covered book is included in the Applied Mechanics Division of the Commonwealth and International Library published by Pergamon Press Ltd, and students are advised to read it in conjunction with No 129 of the same series *Problems of Product Design and Development* by C. Hearn Buck to which it is complementary.

System engineering is concerned with the design of those engineering products which consist of an assembly of individual components put together to obtain certain emergent properties which the individual components do not possess. It embraces the majority of modern industrial products such as aircraft, automobiles, mechanical handling plant and the like. *System engineering* does not cover major civil engineering products such as bridges, although road systems can be included. The book gives fundamental information on the properties of systems, techniques of design, selection of materials, fabrication methods, and serves as an introduction to more advanced studies. In this way the student is helped to select the right components, and assemble them in the correct relationship, in order to achieve the best results from any system he designs.

Universities and colleges of technology are now devoting considerable time to this subject.

The text explains in some detail the various theoretical forms of systems and their layout, the use of models and representations such as block schematic diagrams, and the various processes of design. In a section titled Element Design various considerations of detail are discussed which includes limits, factors of deterioration, and strength and fatigue calculations. The principles of ergonomics and the various factors, such an environment, which effect the efficiency and reliability of human operators, and the assembly controls they are expected to use, are highlighted in a chapter called the Human Element.

The book has a number of appendices in the form of tables and diagrams which give information on: Specification check-lists; Selection of materials; Ranges of machine tolerances and finishes; A selection chart of limits and fits; And a series of diagrams giving stress curves for a variety of steel shapes used in industry.

The text "puts in a nutshell" the principles to be observed for correct assembly design that engineers normally learn through experience, often bitter. F.T.S.

LINEAR ELASTIC THEORY OF THIN SHELLS

By J. E. Gibson, MSc, PhD, AMICE

Reader in Engineering, University of Manchester

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 21*s*)

Thin shells may be defined as those structures which contain solid material enclosed between two closely spaced doubly curved surfaces, in which the thickness of the material between the surfaces is small compared with the overall dimensions of the bonding surfaces. Such structures include containers, aircraft fuselages, submarine hulls and roofing made from a variety of materials such as steel, light alloy, plastics, wood and reinforced concrete.

The text of this book follows a course of lectures given to final year engineering and post-graduate students by the author at Manchester University. Its aim is to present the membrane and bending theories for thin shells in a manner that limits the use of mathematics to an elementary knowledge of differential and integral calculus.

In order to simplify the presentation of the theories the author has assumed that shell materials are homogeneous, isotropic and perfectly elastic. Some steels and, within certain stress limitations, reinforced concrete have these properties, hence the use of the latter for shell roofs.

The general introduction in Chapter 1 defines reference axes, membrane and bending stress resultants, and the membrane theory for circular cylindrical shells with special reference to the following examples: horizontal cylindrical tank supported at ends: vertical cylindrical tank filled with liquid: cantilever cylindrical shell subjected to gravitational load, a typical roofing application.

The subsequent Chapters 2–6 analyse, with derived examples, the bending and membrane theories of open and closed circular cylindrical shells, and those of general shape, under load.

The more complicated types of shell and their boundary conditions, which are used in practice for pressure vessels and roofing structures, involve the solution of simultaneous equations of higher order, and it is now usual to resort to the use of antomatic electronic digital computers for their analysis. Chapter 7, therefore, gives a brief introduction to the operation of these machines and outlines the analyses than can be obtained from various multi-shell programmes.

A short chapter is also devoted to the experimental investigation of shells.

This soft-covered book is included in Structures and Solid Body Mechanics Division of Pergamon's Commonwealth and International Library. F.T.S.

FLIGHT TEST INSTRUMENTATION VOLUME 3

Proceedings of the Third International Symposium, 1964

Edited by M. A. Perry

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price £5)

This book is Volume 6 of the Cranfield International Symposium Series published by Pergamon Press and supplements the two volumes already published in the series on the subject matter.

It contains an edited collection of fourteen papers presented at the Symposium held under the sponsorship of the Department of Flight of the College of Aeronautics, Cranfield.

Whilst the papers are mainly of interest to those employed in the field of aeronautical and aerospace engineering, some of the papers are of obvious interest to military engineers concerned with the operation and efficient flight of guided missiles. Most engineers who are entranced by recent rocketry and space flight successes will find much to interest them in the paper that describes the instrumentation systems utilized in the Saturn rocket launch vehicle that will place the Apollo space craft into a lunar projectory, and in the paper that describes the data conditioning of the UK3 scientific satellite for telemetry transmissions.

The text is descriptive, contains only a few mathematical derivations, and is well illustrated with diagrams, reference charts and photographs.

F.T.S.

PRACTICAL DOWSING

Edited by A. H. Bell

(Published by G. Bell & Sons Ltd, Price 24*s*)

This symposium, edited by Colonel A. H. Bell, the Founder and First President of the British Society of Dowsers, makes fascinating reading. In the introduction Colonel Bell traces the development of water divining, dowsing or radiesthesia, as it is now termed, from early days to the modern methods practised not only for the detection of underground flows of water, but also for dowsing for water or minerals on maps and plans and the methods employed in Medical Radiesthesia for diagnosis and treatment.

The symposium contains, in addition to Colonel Bell's most interesting introduction and a postscript, fourteen papers all written by experts in the various branches of radiesthesia, equally divided in subject matter between the traditionally accepted use of the divining rod for the location of water, etc and the finding of lost objects and the lesser-known medical uses to which this strange, and as yet unexplained, physical phenomenon have been successfully applied. There appears to be a close affinity between these two branches of the art and the book explains that many dowsers possess the power of healing.

The papers most likely to interest the readers of this *Journal* are three written by retired RE officers. Colonel K. W. Merrylees tells of successful locations of water in India, Pakistan, Kenya, Kuwait, and in this country. A recent location by him of 9 million gallons of artesian water a day in Lincolnshire in an area quite unpredictable on geological grounds occured too late to be included in his paper. Colonel H. Gratton's paper describes how in 1952, contrary to the opinions of the German water engineers, he discovered by dowsing on foot, in a car and on horseback sufficient water locally to meet the 700,000 gallons a day needed for the Headquarters of the Northern Army Group and 2nd Tactical Air Force at München Gladbach when he was Chief Engineer of the project for building the headquarters. Lieut-Colonel C. D. A. Fenwick explains in his paper how he successfully dowsed for water in military cantonments in India and in Army camp sites in this country during the last war. Other articles describe distant detection, dowsing from a map, methods for estimating the depth of flow aquifers and their yield and the instruments used by dowsers. In a paper on Dowsing and Archaeology, Major-General J. Scott-Elliot defines in a terse manner the full treatment sequence: "Map dowse; ground dowse; dig to test". The Rev H. W. Lea Wilson describes successful dowsing operations in India, Ceylon and Uganda. He also quotes a case of how he was able, successfully, to indicate by post to a retired lady doctor, living in a remote part of Aurungabad District, where she could find water in her compound having dowsed a plan of the compound sent him. He has, however, had no success in dowsing for missing persons or objects, but he hopes that perhaps one day he will be able to find children missing from their homes or locate the whereabouts of the money of the Great Train Robbery.

Those who have served at Ripon will know what the motto of the book, taken from Fountain's Abbey, "Benedicite fontes Domino" signifies.

SQUARES AND SQUARE ROOTS

By C. Attwood

(Principal, Apprentice Training, Ford Motor Company Ltd.)

(Published by Pergamon Press Ltd., Headington Hill Hall, Oxford. Price 12*s* 6*d*)

These tables are No 6 of the series included in the Commonwealth and International Library of Science Technology Engineering and Liberal Studies published by Pergamon Press.

The three main tables in this work are:—

Squares, 1.000 to 10.000 at 0.001 interval (exact values)

Square roots, 1.000 to 10.000 to seven figures, at 0.001 interval

Square roots, 10.00 to 100.00 to seven figures.

These are supplemented by:—

Square roots and reciprocal square roots from 1 to 100.

Notes on using the tables which cover: Correction for mean proportional parts used with squares. Square roots to extended accuracy; Products obtained from a table of squares; Short history of tables of squares and square roots.

The tables are published in pocket size with a soft cover. F.T.S.

THERMAL STRESS ANALYSIS

By D. J. Johns, MSc (Eng), AFRAeS, AFAIAA.

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 21*s*)

The author, a Reader in Aeronautical Engineering, Loughborough College of Technology, was formerly Lecturer in Aircraft Design, College of Aeronautics, Cranfield, Bletchley, Bucks.

The text, 200 pages, deals with the category of thermal stress problems produced by large variations in temperature and thermal expansion which produce thermal stresses (elastic or plastic) in materials whose properties are time-independent. It does not cover the problems brought about by small uniform rises in temperature, or those complex problems and considerations that must be given in any structural analysis to such effects as the redistribution of stress due to creep, creep buckling, etc.

A brief summary of the fundamentals of thermal stress analysis is given in the first twenty pages and comprises, the definition of strain components, equations of state and equilibrium, boundary conditions, thermodynamic considerations, minimal principles of thermoelasticity, and the solution of the three-dimensional thermoelastic equations. The other chapters cover:— Two-dimensional formulations and solutions; Membrane and bending thermal stresses in thin plates; Thermal stresses in beams, circular cylinders and shells; Thermal buckling; and Sundry design problems.

An appendix summarises the principal means of heat transfer in structures.

The text is largely presented in the form of a number of mathematical derivations and is only suited to senior under-graduates and aeronautical designers.

F.T.S.

Technical Notes

CIVIL ENGINEERING

Note from *Civil Engineering and Public Works Review*, May/June 1965

STANDARD MIXES FOR CONCRETE. The May issue includes an article commenting on the introduction of Standard Mixes in the new and revised Codes of Practice for reinforced and precast concrete. Although most concrete is now batched by weight it is still common to see mix proportions specified by nominal volumes (e.g. 1 : 2 : 4). This situation stems from the fact that until now "nominal mixes" have been given in the Codes of Practice as the only alternative to a designed mix. The new Standard Mixes are based on proportions specified precisely by dry weights and therefore allow no room for dispute regarding interpretation. They may be used as direct replacements for the nominal volume mixes, as a preliminary stage in the use of designed mixes on large works (thus eliminating the need for trial mixes) or possibly in place of designed mixes altogether. Specification of the new mixes will quote nominal 28 day strength, maximum size of aggregate, and workability. For example, a Standard Mix to replace the old 1 : 2 : 4 nominal mix might be specified as: CP 114–3,000–$\frac{3}{4}$–high.

ENGINEERING DEVELOPMENTS IN THE U.S.S.R. An interesting article in the June issue includes a mention of the use of airships by Russian engineers for the movement and erection of structures and equipment. It is stated that airships cost one-tenth of the price of equivalent helicopters, and that the load capacity is higher than most cranes. Airships are silent, stable, and do not have the problem of wind created in the working area by helicopter blades. They have been used successfully for the erection of power transmission towers, and for cable laying across rivers.

THE COLLECTION OF OVERSEAS ROAD MATERIALS AT THE R.R.L. This article describes a classified collection of some 2,200 samples of road-making materials from all over the world held at the Road Research Laboratory. Examples vary from naturally occurring sand-bitumen mixtures from Barbados to lateritic gravels from Africa. A punch-card system is used to record information about the samples held, and the results of tests carried out on many of the materials are available on request.

MANAGEMENT AND THE RESIDENT ENGINEER. The application of management techniques to civil engineering is a "coming thing". This article, of direct interest to officers and Clerks of Works attached to civil firms, is a thoughtful analysis of the position of the Resident Engineer.

TUNNELS. The June issue includes a splendid feature on Tunnels. Eleven papers are included, ranging from an historical review of tunnelling to the construction of the new Victoria line underground.

A "must" for anyone concerned with, or interested in tunnels.

Notes from *Civil Engineering and Public Works Review*—July 1965

METRIC MEASUREMENT. The changeover to metric measurement will bring problems to the civil engineering world. Drawings, calculations, quantity surveying procedures, sizes of standard components ("how big is a metric brick"?) will all alter. To assess the implications of the changeover a metric advisory panel has been set up by the Building Divisional Council of the British Standards Institution. As a first step the panel will send out a questionnaire to all appropriate organizations to sound views on the methods and timings of the changeover.

EPOXY RESIN FOR ROAD REPAIRS. A short article describes the use of epoxy resins for the rapid repair of concrete road surfaces which have cracked or spalled. The resin is used in combination with metal reinforced neoprene strip. Setting and curing takes between three and four hours, after which the repair is stronger than the original concrete.

CANTILEVER RETAINING WALLS. The height of a retaining wall is usually dictated by the change in ground elevation. The dimensions of the base, however, have to satisfy conditions of soil pressure, and stability against overturning and sliding. Normally these base dimensions are determined by a trial and error procedure; a section is assumed and then checked against the various criteria. In the first of two articles an investigation is made of the relationship between all the factors influencing the size of base, and data is derived suitable for solution by computor. The second article will give design tables based on this analysis.

MARINE PIPELINES. An interesting article describes the manufacture and installation of a new type of marine pipeline. This is formed of outer and inner plastic pipes, the gap between containing a steel reinforcement cage with spacers to keep the pipes apart. In this state the pipe is flexible and can be towed out to sea. The annular space between the outer and inner pipes is then filled with cement grout to produce a strong, rigid submerged pipeline. Although designed primarily for marine effluent pipes the principle has possible applications to other forms of submerged pipeline.

C.F.R.

THE MILITARY ENGINEER

MAY–JUNE 1965

LUNAR STRUCTURAL DESIGN by Captain Richard J. Polo, Corps of Engineers. The Corps of Engineers has been actively engaged in planning for extraterrestrial construction since 1958. In this article the author describes the factors, geological, gravitational, metereological, etc., which influence the design of structures on the Moon in which men can live and in which materials can be stored protected from extremes of temperature and the possibility of bombardments by meteors and radiation. For instance the atmosphere deficiency on the Moon produces a state of high vacuum which gives no protection against meteorites, the smaller of which would burn out before reaching the surface in a denser atmosphere. Harmful and penetrating infra-red and ultraviolet rays reach the surface undiminished. There are interesting pictures of the type of structures being considered but no details of construction. The article, however, gives a very good idea of the extreme difficulty of deciding what the conditions will in fact turn out to be and of the big differences which will exist between Earth and Moon construction practice.

ARMY DISASTER RELIEF AT SKOPJE by Major John P. Angstadt, Corps of Engineers. A clear description of the work of 39th Engineer Group, stationed in Germany in connection with the provision of semi-permanent accommodation in Skopje after the earthquake in 1963. Two hundred and fifty prefabricated 20 ft by 48 ft round roof Butler buildings were erected—distributed between eleven widely dispersed sites. The first reconnaissance was carried out on 21 October and the work, which included transporting most of the materials from Germany was completed on 10 February.

N.A.W.A.P.A. NORTH AMERICAN WATER AND POWER ALLIANCE. WATER FOR THE NEXT ONE HUNDRED YEARS by Roland P. Kelly. Even now there is a water shortage in half of the United States and also in parts of Canada and Mexico. For these reasons a continental water concept has been developed by the Ralph M. Parsons Company of Los Angeles which is being studied by a special sub-committee of the Senate Committee on Public Works. The article is an outline description of the plan which involves practically all the river systems originating in the Rocky Mountains right down to the Rio Grande in Mexico. It is estimated that to carry out the project in its entirety will take thirty years and cost about 100 billion dollars but the benefits to the three countries in North America would be immense.

CALCULATING GAMMA-RAY SHIELDING PROPERTIES OF SHELTER ENTRANCE WAYS by C. M. Huddleston. This is of interest to anyone who has to design a personnel shelter to give protection against radiation. Formulas and examples of their use are given.

MILITARY-CIVIC ACTION IN PERU by Lieut-Colonel Herbert H. Haar, Corps of Engineers. An account of how the Army in Peru is helping to improve the living conditions of the people by education, road construction and industrial training. Help is being given by the US. The potential of the military for conducting projects that will contribute to socio-economic development is brought out.

FROST DEPTH ESTIMATION by Douglas W. Evans. The freezing of water and sewer lines has been a costly and recurring problem in cold regions. While such problems can be solved by setting water lines at the proper depth there are many factors, season, prevailing climate, snow cover and natural protection, if any, which determine the average frost depths to be counted on. This article describes the effect of these varying factors and gives methods of calculating the probable frost depths under different conditions.

THE FAST RAFT SET by Captain David L. Johnson, Corps of Engineers. This article describes a modification of the normal raft assembly which much shortens the time of a completed turnround. The conventional method is to push the raft with the power boats at right angles to the roadway of the raft. This tends to bring the raft obliquely up to the bank and this makes delay in wedging the shore bay on to the bank. The modification consists in equipment which allows the boats to be fastened in line with the treadway making it possible to approach the bank at right angles so that the ramp can be forced on to even a poor landing site and held there by the power boats while loading and unloading takes place. There are other advantages described and the system has been extensively tested and it works.

A CHRONICLE OF MAPPING. PART III by Kenneth R. Stunkel. This brings the history up to the end of the 19th century by which time France had been completely mapped by genuine topographic surveys. There is a reproduction of a map of the country round Paris which is amazingly modern except for the fact that Paris was so much smaller than it is now.

KHLEDIA BAILEY RAILROAD BRIDGE by Lieut-Colonel Yasuro Komoto and Captain William F. Carroll, Corps of Engineers. This is an account, in considerable detail and well illustrated with photographs, of the design and construction of a Bailey bridge providing a temporary replacement for a railway bridge in Tunisia which had been swept away by exceptionally high floods. The railway carried large quantities of iron and phosphate ore and interruption of the traffic while a permanent bridge was being constructed would have had serious consequences to Tunisian economy. The government of Tunisia appealed to the US for assistance which was provided by moving engineer troops and stores from Germany.

MILITARY ENGINEER FIELD NOTES

AIR DELIVERY OF THE M6 BRIDGE by Captain Richard S. Krolak, US Marine Corps. This is an account of an experiment in which a 15 ft section of the M6 highway bridge was transported and delivered to site by parachute drop from a C-130 Marine aircraft. The trial was completely successful. The total load in the drop weighed 7,500 pounds.

MINUTEMAN SHAFTING OPERATIONS by Clifford C. McMillan. A well illustrated description of how the problem of lining the 52 ft deep shafts required for this project with steel sheeting was solved. This note amplifies the information given in "Minuteman Augured in" in the November–December 1964 number of M.E.

CABLEWAY SYSTEM ON HILL 651 by Captain Fletcher H. Griffs, Corps of Engineers. A description of the design and erection of a cableway to supply a radio relay station on a peak in Korea. There are good illustrations.

J.S.W.S.