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THE ROYAL ENGINEERS JOURNAL

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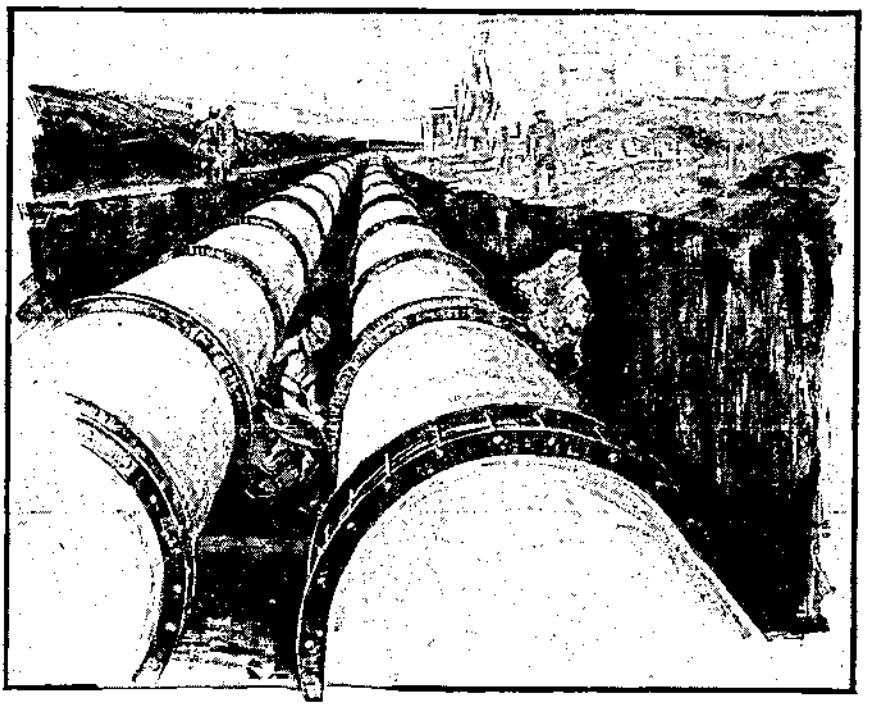

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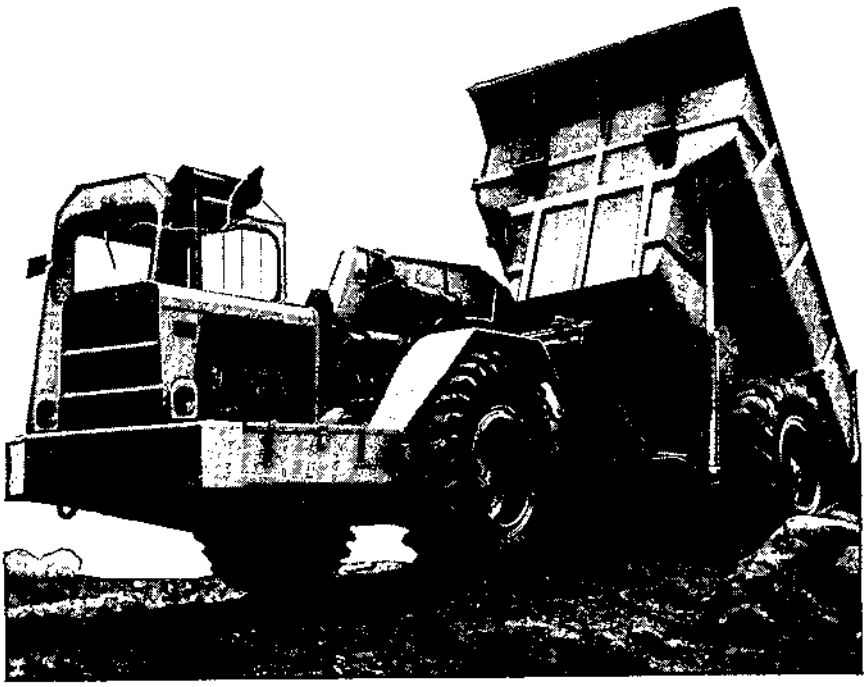

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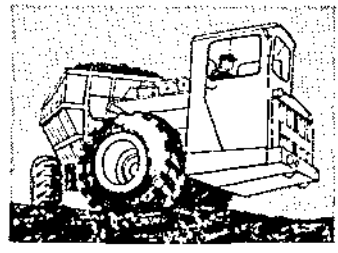

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Royal Memorial Chapel, Sandhurst

DEDICATION OF RMA WOOLWICH MEMORIAL

THE following is a brief description of the memorial and how it came to be planned, written by Lieut-General Sir William Pike, KCB, CBE, DSO, the representative of the former Royal Military Academy, Woolwich, on the Chapel Council of the Royal Memorial Chapel, Sandhurst.

"The Council of the Royal Memorial Chapel, Sandhurst, have for some time been seeking ways of making the Chapel as representative as possible of both the pre-war Royal Military Academy, Woolwich and Royal Military College, Sandhurst, so that the rising generation of Army Officers may inherit and benefit from the spirit and traditions of Woolwich as well as those of Sandhurst.

"Such memorial tablets as could be moved from the Woolwich Chapel were brought to Sandhurst some years ago, but the panels inscribed with the names of 'Shop' Cadets killed in the 1914–18 War cannot be moved and, whereas the names of all such Cadets from the Royal Military College are carved into the pillars of the Sandhurst Chapel, there is unfortunately no space to add those from 'The Shop'. The names of Officers killed in the Second World War are, of course, included in the Roll of Honour of Officers of the Commonwealth Armies 1939–46 already placed in the Chapel.

"The proposal, initially drawn up by Sir William Penney, who was my predecessor as 'The Shop' representative on the Chapel Council, was to have a 'Woolwich Corner' prominently sited in the Chapel to commemorate the whole history of 'The Shop' and of the Honourable East Indian Company's Military College at Addiscombe with which it united in 1861.

"A Roll of Honour containing the names of Cadets killed in the Great War, inscribed and suitably bound, is displayed in a glass-covered case resting on a pedestal and step, behind which are three large oaken panels. The central panel carries an inscription covering the entire life of 'The Shop' with, above it, the Board of Ordnance Arms used by Woolwich. On the two side panels are inscribed the names and crests of the thirteen Field-Marshals and one Marshal of the Royal Air Force who were at 'The Shop' or Addiscombe. Above the panels are the carved and coloured crests of the Royal Artillery, Royal Engineers and Royal Signals.

"On each side of the pedestal are two silver-plated torches, carrying the badge of the Royal Tank Regiment to which some Officers were also directly commissioned between the wars. Overall hangs a finely-made chandelier.

The cost of the memorial has been subscribed by the Royal Regiment of Artillery, the Corps of Royal Engineers, the Royal Corps of Signals and the Royal Tank Regiment, and by nearly eleven hundred individuals, officers educated at the Royal Military Academy, Woolwich, their widows and relations and others closely connected with "The Shop".

The Dedication Service was held in the Royal Memorial Chapel, Sandhurst, on Sunday, 24 September 1967. The service was conducted by the Rev. G. F. Grobecker, MBE, MA, CF, Chaplain, The Royal Military Academy, Sandhurst. The Memorial was dedicated by the Bishop of Sherborne, the Rt Rev V. J. Pike, CB, CBE, MA, DD, formerly Chaplain-General to the Forces and one-time Chaplain of the Royal Military Academy, Sandhurst, augmented by trumpeters from the four Corps and Regiments, was under the Director of Music, Royal Military Academy, Sandhurst, Captain D. Snowden, ARCM, RGJ; the Organist was Mr W. Bean.

The congregation included senior representatives of the four Corps and Regiments, officers, relatives and others subscribing to the Memorial, the Commandants of the Royal Military Academy, Sandhurst, and the Staff College, with representatives from the Directing Staff and Student Body of the Staff College and of the Staff and Senior Term of the Royal Military Academy, Sandhurst, together with members of the Chapel Council, Royal Memorial Chapel, Sandhurst.

Photograph by Mr R. B. Goodall, Senior, photographer of the National Army Museum.

Royal Memorial Chapel, Sandhurst.

The memorial is sited in the south-west corner of the Chapel and has been executed to the design of Mr John Hayward. The joinery and woodwork is by Messrs Ryder of Reading and the metalwork by Messrs Hurst, Franklin and Co under the direction of Mr John Bridges. Heraldic carving and decoration is by Mr Gordon Beningfield and lettering and decoration by Mr Alan Collins.

Mr Hayward writes:

"The Roll of Honour rests on the deep plinth of a bookcase designed with curving sections to front and sides and made in fumed English Oak. The plinth itself is covered in gold leather and the book is covered by a glazed case held out from the plinth on dull brass mounts.

"The bookcase is flanked by two torches carrying candles. The torches have a stainless steel finish and are ringed by mounts on which two badges of the Royal Tank Regiment are incised on silver. They are held out from the case by curved brass brackets.

"Behind are three large panels in black oak, with deeply incised lettering decorated in blue and gold. The centre panel carries an inscription setting out the purpose of the memorial and is headed by the Arms of the Royal Military Academy, Woolwich, modelled in low relief and decorated in full heraldic colour on a metal base. The panels to left and right list the names of those thirteen Gentleman Cadets who rose to the rank of Field-Marshal, each name preceded by a crest carved in wood and decorated on metal leaf.

"Above, on the cornice, are three large badges of the Royal Regiment of Artillery, the Corps of Royal Engineers and the Royal Corps of Signals, each mounted on a curved projecting bracket. These badges are also modelled in low relief and decorated on metal leaf.

"Over all hangs a large six-light chandelier, each light designed as a torch held out from a broken central ring on curved brass brackets.

"The golden colour of the carpet reinforces the general colour scheme of black blue and gold, 'The Shop' colours."

The inscription on the central panel reads:

TO THE GLORY OF GOD AND IN MEMORY OF ALL GENTLEMAN CADETS AND OF THE STAFF OF THE ROYAL MILITARY ACADEMY WOOLWICH 1741–1939 AND OF THE HONOURABLE EAST INDIA COMPANY'S MILITARY COLLEGE OF ADDISCOMBE 1809–1861 WHICH AMALGAMATED IN 1861

*

THE SIDE PANELS COMMEMORATE THOSE GENTLEMAN CADETS WHO ROSE TO THE RANK OF FIELD-MARSHAL

*

THE BOOK OF REMEMBRANCE CONTAINS THE NAMES OF THOSE GENTLEMAN CADETS WHO GAVE THEIR LIVES IN THE GREAT WAR 1914–1918

The names of the thirteen Field-Marshals are as follows:

Sir Hew Dalrymple Ross	1779–1868
*Sir John Fox Burgoyne, Bart	1782–1871
Sir George Pollock	1786–1872
Sir Richard Dacres	1799–1886
*Lord Napier	1810–1890
*Sir John Lintorn Simmons	1821–1903
Earl Roberts, VC	1832–1914
*Lord Nicholson	1845–1918
*Earl Kitchener	1850–1916
Lord Milne	1866–1948
Sir Archibald Montgomery-Massingberd	1871–1947
Marshal of the Royal Air Force Sir Edward Ellington	1877–1967
Lord Ironside	1880–1959
Viscount Alanbrooke	1883–1963

* All Royal Engineers.

The work of compilation and checking the RMA Woolwich Book of Remembrance 1914–18 started in April 1962 and was based on the names carved into the memorial panels of the Royal Military Academy Chapel, now Woolwich Garrison Church. The additional details of date and place of death were obtained through the Commonwealth War Graves Commission, the India Office Library, the Royal Artillery Institution and the Institution of Royal Engineers. Details as to rank, awards and decoration have been checked in the Official Roll of Officers who Died in the Great War, His Majesty's Stationery Office 1920, Army Lists and, where necessary, Regimental and Corps records. The Roll has been compiled in the office of the Librarian, RMA Sandhurst. The Book was designed and written by Miss Elizabeth Friedlander between November 1965 and April 1967. The binding was designed and made by Mr Roger Powell, MA, ARCA.

The Argentine-Chile Frontier Case, 1965-7

MAJOR W. D. RUSHWORTH, BSc, RE

"BOUNDARY Commissions are not of frequent occurrence and the personnel employed on any one commission is very limited. Consequently the number of officers with experience of them is small and the lessons learnt are liable to be lost."[1]

As our colonial empire is scattered by the wind of change, the frequency of boundary commissions manned by British personnel becomes even less. This article records my personal experiences in connexion with a recent boundary settlement in the hope that they may be of general interest and of use to anyone faced with similar problems in the future. It is not intended to be a complete history of the case.

The settlement of international boundaries is a matter for diplomats, usually assisted by lawyers and geographers. However, to convert their decisions into a frontier, marked on the ground, they require the services of practical engineers and surveyors. The two stages are generally known as delimitation and demarcation. The stages overlap and the terms are frequently misused, but by defining them the overall process of creating a frontier becomes clearer. Delimitation means the choice of a boundary site and its definition in a treaty or other formal document.[2] Demarcation is the marking of the boundary on the ground and the description of that boundary by surveys and other methods. Royal Engineer officers have often been required to demarcate frontiers and at times have been called upon as advisers during delimitation.

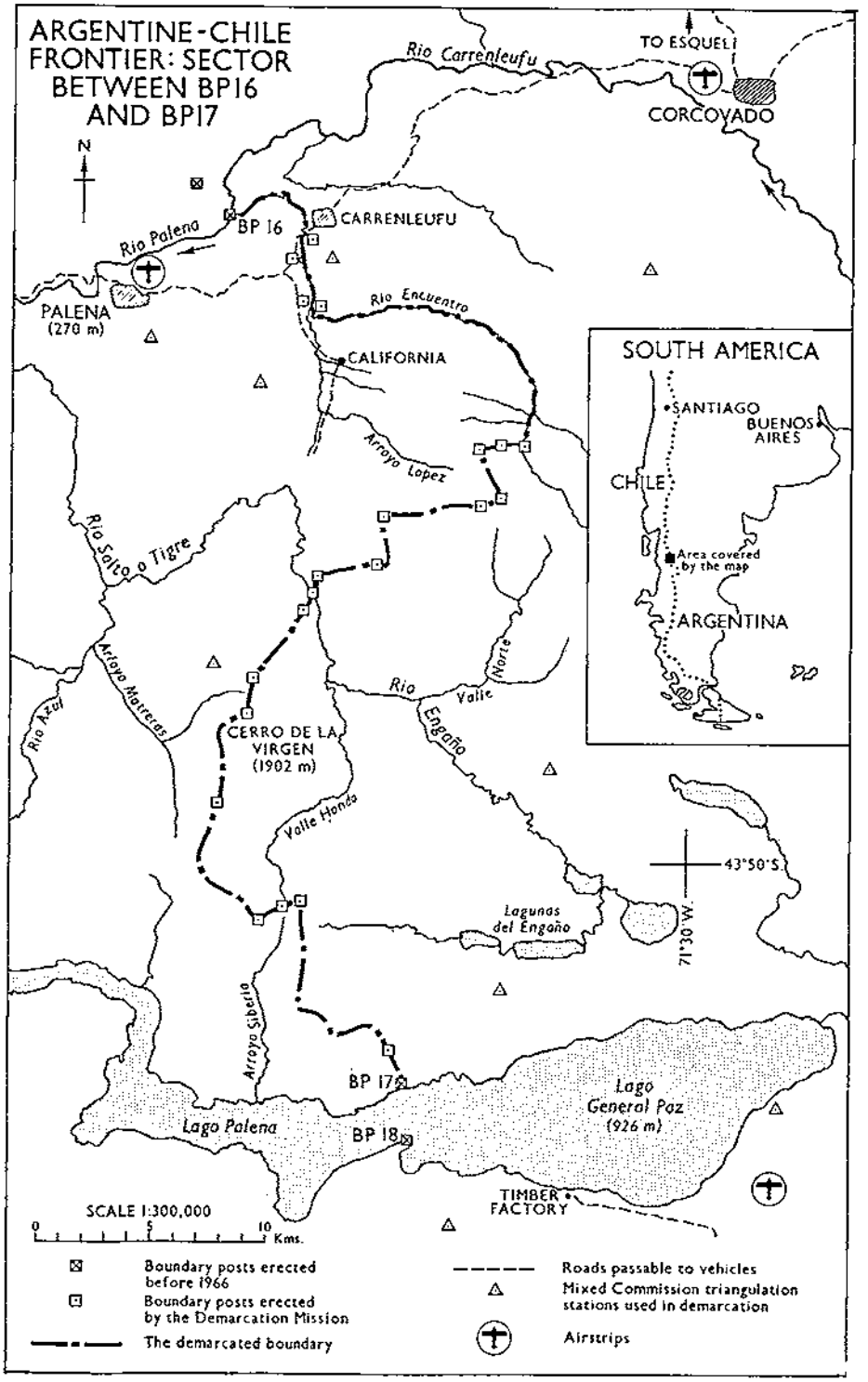
The Argentine-Chile Frontier Case differed from most boundary settlements in that a third country, Britain, acting as arbitrator, not only delimited, but also supervised the demarcation of the boundary in question. In the past, arbitration by a third neutral party was not unusual (e.g. by the King of Italy between Brazil and Britain on the British Guiana frontier), but demarcation was usually left to the two countries concerned. In future it will probably be less usual for a neutral country to act in this way, but it is probable that international organizations may be required to do this work and the experience gained in this case could be useful.

GEOGRAPHICAL BACKGROUND

The area that was in dispute lies in Patagonia between latitudes 43° and 44° South on the eastern slopes of the Andes (see map). The landscape is composed of numerous and mostly north-south mountain ranges and river valleys. The disputed area lies

[1] Clifford, Major E. H. M., RE, "Boundary Commissions", *RE Journal*, September 1937.

[2] Jones, Stephen B., "Boundary Making", p. 57.


ARGENTINE-CHILE FRONTIER: SECTOR BETWEEN BP16 AND BP17
N
Rio Carrenleufu
TO ESQUEL
CORCOVADO
Rio Palena
BP 16
CARRENLEUFU
PALENA (270 m)
Rio Encuentro
CALIFORNIA
Arroyo Lopez
Rio Salto o Tigre
Arroyo Matreras
Rio Azul
CERRO DE LA VIRGEN (1902 m)
Valle Hondo
Rio Valle Norte
Engaño
Lagunas del Engaño
43°50'S.
71°30'W.
Arroyo Siberio
BP 17
Lago Palena
BP 18
Lago General Paz (926 m)
TIMBER FACTORY
SCALE 1:300,000
0 5 10 Kms.
Boundary posts erected before 1966
Boundary posts erected by the Demarcation Mission
The demarcated boundary
Roads passable to vehicles
Mixed Commission triangulation stations used in demarcation
Airstrips
SOUTH AMERICA
SANTIAGO
BUENOS AIRES
CHILE
Area covered by the map
ARGENTINA

between two east-west gaps through the Andes, formed in the north by the Rio (River) Palena and in the south by Lago (Lake) General Paz. The mountains in this area rise to over 2,000 metres, the higher being permanently snow covered, while the forested valleys are unusually low, being generally at 200–500 metres. The area has a very heavy rainfall, with only a short and not very warm summer, but it is protected from the worst of the Pacific storms, so that the valleys in the northern half of the area have been settled, mainly by Chilean migrants. The southern half of the area is uninhabited, except for the occasional summer grazing of sheep. Large areas of valley forest have been burnt, principally to provide grazing, though some of the burning is attributed locally to the "English miners". This possibly refers to the activities of prospectors panning for gold at the end of the nineteenth century, who may have come from the nearby Welsh colony at Trevelin in Argentina. "These gigantic burnt, dead trees, mostly lie where they fell and they are strewn all over the valley floors, making only movement by horse possible. But there are many still standing, grey and stark on the green slopes of the cloud-wreathed mountains. They lend a melancholy air to the countryside".[3]

In summer the temperature in the valleys averages about 10°C, but on the mountains it is often below zero. Rain is frequent and heavy, and the wind in Patagonia is noted for its strength. Skies are generally covered by cloud, which is often well below the tops of the mountains. There are occasional short periods when the clouds disperse, the wind drops and the sun shines to reveal some of the most breathtakingly beautiful, unspoilt scenery imaginable.

HISTORICAL BACKGROUND[4]

The history of boundary negotiations between Argentina and Chile dates back to a Treaty between them in 1855 that the two countries should retain the territories they possessed in 1810, at the time of their separation from Spain. The Treaty also provided for the settlement of disputes by peaceful means and, in the event of disagreement, for their submission to the arbitration of a friendly nation. By a further Treaty of 1881 and later Protocols it was agreed that as far as 52° South the boundary should be the Cordillera of the Andes and it should follow "the line of the highest peaks which may divide the waters". Considerable progress was made in defining the boundary by the two countries, but no agreement could be reached about those parts where the line of the highest peaks did not coincide with the surface water parting. The situation was that "In the classical case of the Southern Andes, the swift west-flowing rivers spread their drainage areas by headward erosion to the eastern flank of the mountains. The problem was insoluble, by a literal interpretation, for the water-parting lay far to the east of the highest crests."[5]

Queen Victoria accepted the office of Arbiter in 1896 and in 1898 both countries submitted the dispute to her. Queen Victoria appointed an Arbitration Tribunal of three members, one of whom was Colonel Sir Thomas H. Holdich (late RE). The Secretary was Major S. C. N. Grant, RE, who was later transferred to South Africa during the Boer War and was replaced by Major E. H. Hills, RE. The Arbitration Tribunal worked with considerable speed and, after an extensive reconnaissance in the field, reported in 1902. Their report formed the basis for an Award by King Edward VII, who had succeeded Queen Victoria as Arbiter. The award contained a delimitation of the boundary, the part relating to the present case reading "Crossing the (River) Palena at this point, opposite the junction of the River Encuentro, (the boundary) shall then follow the Encuentro along the course of its western branch to its source on the western slopes of Cerro Virgen. Ascending to that peak, it shall then follow the local water-parting southwards to the northern shore of Lago General Paz. . . ."

[3] 1966 Award, p. 37.

[4] This paragraph is based upon Parts II, III and IV of the Report by the Court of Arbitration, December 1966.

[5] Jones, op. cit., pp. 99–100. This is an example of a bad delimitation, since it can not be demarcated as it stands.

Before the 1902 Award both countries had asked "the Arbitrator to appoint a Commission to fix on the ground the boundary" to be determined by the Award. Colonel Holdich was appointed as Demarcation Commissioner[6] and four British officers, Captain W. M. Thompson, RE, Captain C. L. Robertson, RE, Captain H. L. Crosthwait, RE, and Captain B. Dickson, RA, were allocated to the Commission. Included in Colonel Holdich's orders was the instruction that "The Duty of the British Officers is to superintend the alignment of the pillars. . . . Only in the case of very grave discrepancy between the mapping and the terms of the Award will it be necessary to appeal to the decision of the Commissioner. . . . Time is an all important consideration." There were discrepancies between the mapping and the topography in the area of the present case, but Captain Dickson, who was responsible for this sector, was not aware of them. In 1903 the area was little known, though both countries had carried out some exploration as part of the preparation of their case. Captain Dickson sited Boundary Post (BP) 17 on the north shore of Lago General Paz without difficulty, but the position of BP 16 at the junction of the Rio Encuentro with the Rio Palena was only settled after some doubt. The boundary between these two BPs was shown as agreeing with the Award on the 1902 Award map which was compiled from the maps submitted by the Parties. Between 1903 and 1907 the area was explored and it became obvious that no branch of the Encuentro reaches the Cerro de la Virgen, so that in this area the 1902 Award map was wrong and part of the 1902 Award was not capable of demarcation. It is not surprising that mistakes were made, for, to quote the Court of Arbitration in 1966, "it scarcely behoves this Court, with all the advantages of aerial survey at its disposal, to attribute any personal blame to these hardy pioneers. Apart from physical hardships, one of the greatest difficulties . . . was that of visibility".[7]

Throughout the following years the area in question was gradually opened up and small communities became established in some of the more fertile valleys. In 1941 the two countries established a Mixed Boundary Commission to demarcate the entire frontier. In 1943 the Commission first considered the area in question. A triangulation system was observed in the area between 1944 and 1947 and between 1951 and 1954 an air survey map was completed. However no agreement could be reached on the line of the boundary, so that in 1964 the British Government was requested to act as Arbitrator for that portion of the boundary between BPs 16 and 17.

THE COURT OF ARBITRATION

In March 1965 the British Government appointed a Court of Arbitration composed of

President: Lord McNair (formerly President of the International Court).
Members: Mr L. P. Kirwan, CMG (Director, Royal Geographical Society).
Brigadier K. M. Papworth, OBE, MC (late RE).

On 1 April 1965 an Agreement between the three countries settled that the Court was to work in accordance with international law, sit in London, and work in English. The Agreement also provided for any surveying required and for the execution, including demarcation, of the eventual Award. Both Parties accepted the Award as legally binding. In August 1965, after consultation with the Parties, the Court decided upon an area to be covered by aerial photography with a view to having a map of some part of that area made. After putting the contract out to tender, the British Government appointed Fairey Surveys Ltd to carry out the aerial photography and any subsequent mapping. In November 1965 I was appointed as Chief Technical Officer to the Court, with Staff-Sergeant M. G. Browning, RE, as my assistant. The Court also decided to establish a Field Mission, with Mr L. P. Kirwan

[6] A short account of the work of the Commission by Colonel Holdich is in the *Professional Papers of the Royal Engineers*, 1903, Vol XXIX.

[7] The conditions for exploring in Patagonia at that time can be discovered from Colonel Holdich's book *Countries of the King's Award.*

in charge, to visit the area. The only suitable time for field operations is the southern summer from December to March, so the advance party of the Field Mission left England on 5 December 1965 for South America.

THE FIELD MISSION

The work of the Field Mission was divided into three phases. The first phase, starting on 12 December 1965, was the provision of ground control for the aerial survey. The ground control available in the area to be photographed was some twenty stations of the Mixed Commission triangulation, which had been observed in 1944–7. If most of these could be found and pre-marked[8] they would be adequate, as Fairey Surveys intended to use APR (Airborne Profile Recorder) to supplement the existing control.[9] The operation was based on Palena, a small market town in Chile, close to the area. The work was carried out by myself and Staff-Sergeant Browning, ably assisted by three liaison officers from each party. Despite some difficulty with snow on the higher points, fourteen stations were marked by 2 January 1966, which was the earliest date that the survey aircraft was expected. All the points appeared clearly on the air photographs.

At a meeting with representatives of the two Parties in London in November 1965 I asked if helicopters could be made available. As a result we were very fortunate to be provided with three helicopters by the Parties. This was the first time they were used on this frontier. Without them the work could never have been completed in the time, as the only other method of movement is by horse. The points were marked in most cases by white crosses, each arm being 10 metres by 2 metres. Either the rock was cleaned, large stones were laid out, or fallen timber was arranged, and then painted white. Two locally engaged labourers were very bewildered when instructed to sweep snow off the top of the hills, so that they could be painted white. The liaison officers and the helicopter pilots from the two countries proved to be most delightful companions and a very good relationship was soon established. Everyone put maximum effort into the work, though it was suggested that rank distinction arose with the provision of a paint spray—only colonels were allowed to use it—majors and captains had to continue with brushes. Splashes of paint on uniforms were considered as honourable battle scars.

The second phase started with the arrival from the UK of the survey aircraft (a DC3) at Esquel, a frontier town in Argentina, with a good airport, on 13 January 1966. Under the direction of Brigadier Papworth, who arrived in South America on 7 January 1966, the Field Mission assisted the aircrew in liaison with the local officials and eventually approved the results of their work. In addition to two very experienced pilots the aircrew consisted of a photographer, electronics technician and flight engineer, so that they were reasonably self-sufficient, but the Field Mission and its liaison officers were happy to help the aircrew establish a record for beer consumption in Esquel's leading hotel. This opportunity arose as we waited impatiently for suitable photographic weather. Then from midday 24 January 1966 to midday 26 January 1966 there was the longest spell of clear skies during the whole of the Mission's visit and the photography was just completed in this time. The survey aircraft left Esquel on 3 February 1966, after the Mission had collected two sets of prints for use in the third phase and had satisfied itself that there was complete cover of a very high quality.

The third phase overlapped the second phase and started with the arrival in Palena of Mr Kirwan on 21 January 1966. The two members of the Court, based on Palena, wished to see the area in dispute in detail. They toured the area, accompanied by the liaison officers and experts, now six from each Party. These tours were mainly

[8] Pre-marking is the technique of marking the ground around a trigonometrical point before photography so that it appears clearly on an air photograph. This is much more accurate and reliable than taking the air photograph and identifying where the point falls by ground inspection. See the *American Manual of Photogrammetry*, Vol I, p. 365.

[9] The method by which the map was made, and the use made of the APR, is to be the subject of a paper to the Photogrammetric Society by Mr W. P. Smith of Fairey Surveys.

by the four helicopters now available, with landings for closer inspection, but trips were also undertaken in the two light aircraft provided by the Parties and by horse. During this period I acted as Secretary to the Mission, while Staff-Sergeant Browning worked with the survey aircraft, which was 150 kilometres away at Esquel at the end of very poor road and radio communications. Collection of topographic names for the map to be made of the area was difficult, as the two Parties frequently had different names for the same feature. Brigadier Papworth decided that for names' collection an outline, monochrome, sketch map should be made of the area, based on enlargements of existing maps, supplemented by detail from the air photographs. As soon as copies of the air photographs were received a team of liaison officers annotated them with major features and form lines. The photographs were then fitted under transparencies of the existing maps enlarged to the scale of the air photographs (supplied by the Military Geographic Institutes of Argentina and Chile) and the annotations were traced off. The result was compiled by myself or Staff-Sergeant Browning and then drawn on six sheets by two draughtsmen provided by the two Parties. The maps were reproduced in Santiago and proved useful as an interim map of the area. The Field Mission left South America between 11 and 14 February 1966.

THE 1966 AWARD

After the return of the Field Mission to England, Fairey Surveys prepared a 1/50,000 map of the area and the two Parties completed their cases for presentation to the Court. The Court sat for five weeks in September and October 1966. The proceedings were concerned with political and geographical arguments about the location of the frontier and are summarized in Part V of the Report by the Court. On 9 December 1966, Her Majesty Queen Elizabeth II made an Award based on the Court's report.[10] This included a delimitation of the disputed boundary, and appointed the Director of Military Survey as the authority responsible for carrying out the demarcation. With very good, complete air photograph cover, the Court were able to make a very accurate and detailed delimitation consisting of a written definition of the boundary and air photographs marked with key points. The Award required BPs to be erected at each of these key points ". . . or, if necessary in order to take account of geographical realities . . . within a distance of not more than 300 metres therefrom". Supplementary instructions by the British Government gave the requirements for additional BPs, ground completion of the 1/50,000 map, trigonometrical fixation of all BPs, and documentation of the boundary.

THE DEMARCATION MISSION

Preparations for demarcating the boundary were started well before the Award so that the whole case could be completed as quickly as possible. Arrangements were made with both Parties at a meeting in London in September 1966 for the required technical and administrative support. Most stores were provided in South America by the two Parties, but consignments from England were sent by sea in November 1966 and by air in December 1966. A thorough office reconnaissance of the area was performed, using the maps and air photographs, and the members of the Mission received training in the aspects of the task that differed from their normal work, such as concrete mixing, ground photography and typewriting. The Demarcation Mission consisted of myself as Officer in Charge, Staff-Sergeant M. G. Browning, RE (who was indispensable after his great success with the Field Mission) and Sergeant W. G. Anderson, RE. We left the UK on 1 January 1967 and flew, first to Santiago and then to Buenos Aires, for discussions with officials of both Parties. The Award aroused intense interest in both countries. The Award and the Demarcation Mission received very full press cover, almost entirely favourable. In both

[10] *Award of Her Majesty Queen Elizabeth II for the Arbitration of a Controversy between the Argentine Republic and the Republic of Chile*, published by HMSO, December 1966. The Report by the Court of Arbitration forms an integral part of the Award. The Award is normally referred to as the "1966 Award".

capitals the Mission was received by the respective Foreign Ministers, both of whom expressed their satisfaction with the Award and their thanks to the British Government for acting as Arbitrator. In both countries there was, very justifiably, a feeling that they were setting an example to the world in the peaceful settlement of an international dispute.

On 8 January 1967 the Demarcation Mission arrived at Palena, which was to be the main base of operations. The flight from Buenos Aires in an Argentine Air Force plane was comfortable and uneventful, but we discovered later that some alarm had been caused by the Buenos Aires papers carrying a story that our plane had made a forced landing well off course. At Palena we met the various personnel that had been agreed at the September 1966 meeting in London and saw the transport and technical and administrative stores that had been provided. The agreed personnel from each Party were a Liaison Officer representing his country (Senor Nestor Martinez from Argentina and Commandante Arturo Ayala from Chile), an Assistant LO, a Chief Technical Officer, a computer, two trigonometrical surveyors and three topographers. In addition there were light aircraft and helicopter pilots and groundcrews, drivers, cooks, orderlies, a draughtsman, a photographer and locally employed labourers. The operation functioned excellently without a single clerk. The transport provided by each Party was two helicopters, one light aircraft, two landrovers or equivalent, sixteen horses and a boat. The stores included all normal camping and surveying equipment and one set of Wild Distomat DL50 and one set of Tellurometer MRA3 Electronic Distance Measuring (EDM) equipment. Dark-room and drawing-office equipment were also provided.

Work started on 9 January 1967 with a reconnaissance of the northern part of the boundary, first by helicopter and then on horseback. The horse is the normal method of transport in the mountain areas. It is used by all ages and both sexes for any journey, whether to call on a neighbour, go to school, or visit the next town two days' ride away. The only roads suitable for motor vehicles are those connecting the main settlements, so that horses, or ox-carts for heavy loads, are the only means of moving around. All South Americans seem to be born horsemen and it was impressive to see how skilled riders negotiated the very steep broken country, and at the same time could study their surroundings and discuss a plan. The British contingent, on the other hand, found that their horses required full attention and for a satisfactory study of the ground it was necessary to dismount. For this reason, and because of the generous allotment of helicopters, the considerable potential of the horses was not fully exploited by the Mission. One Luddite horse had its revenge, by kicking a helicopter and putting it out of action for two weeks.

The helicopters were the mainstay of the Mission. At full strength we had four helicopters, two Hiller SL4 (three-passenger) provided by the Chilean Air Force and one Hiller SL4 and one Hiller 12E (two-passenger) provided by Argentina. Much of Argentina is level pampas, but all of Chile is close to the Andes, so that the Chilean pilots were much more experienced in mountain flying. In fact, the Argentine Hiller 12E could only be used in the valleys, because its carburettor was not heated and it lacked the power to overcome the strong winds at greater altitudes. Because of the strong turbulent winds, sudden mists, snow on the high ground and lack of emergency landing places in the wooded valleys, helicopter flying in Patagonia presents many special problems. We relied heavily on the advice of the senior pilot, Commandante Vicente Rodriguez (Chile), who was a superb helicopter pilot with an excellent topographic memory and who organized all the air effort. Although weather conditions frequently prevented the use of helicopters, when they could be used it made rapid access to all parts of the area possible, whereas any form of ground movement was very slow. The view from the helicopters rendered reconnaissance and perambulation of the boundary easy. Frequent supervisory visits were possible to all working parties and the heavy iron boundary posts, cement, sand and water were lifted to the mountain-tops. All the pilots showed great skill and ingenuity in landing on difficult sites in order to reduce the distance that stores had to be carried.

Generally the helicopters operated to a timed programme which was arranged at the daily evening meeting, but during the spells of good weather the demand for helicopter services exceeded the supply, so that priorities and tight control were necessary. On busy days each helicopter flew over five hours. A total of over 200 hours were flown during the Mission.

Politically, and because of the short and uncertain summer, it was desirable that the task should be completed, and the Mission leave the area, as quickly as possible. In a normal survey operation there would have been a gradual build-up of strength so that various stages of the task could proceed in due order, but this would have been difficult to organize from England and could have led to the task being incomplete at the end of the season. Thus it was essential to start all the tasks as soon as possible in order to deploy the large staffs available and finish quickly. Reconnaissance was always only one, or less, jump ahead of the work and ways had to be devised to enable as many tasks as possible to proceed simultaneously. We were fortunate to have a guide to procedure in the Regulations of the Argentine-Chile Mixed Boundary Commission. While some of these Regulations were not applicable and others were out of date (there was no provision for EDM, for example), in general they formed the basis of our method of working and the records we kept. This has ensured that the demarcation of this sector of the boundary is reasonably consistent with the remainder, which is important, because the Mixed Commission is responsible for the maintenance of the BPs and documentation for the whole frontier. Technical Instructions, which included relevant extracts from the Mixed Commission Regulations, were issued by the Mission before leaving England.

I selected the sites for the twenty-one BPs erected by the Mission, assisted by a senior representative from each Party, at the same time reconnoitring a triangulation and traverse scheme. The erection of each BP was allotted to one or other Party. The BPs are angle-iron pylons about 2 metres high, set in concrete, surmounted by a cast-iron plaque with the names of the two countries on opposite sides. This is the standard Mixed Commission design which is the same as that used by Colonel Holdich. Staff-Sergeant Browning supervised the erection of the first BP by each Party, especially ensuring a high standard of concrete. One local labourer took this to heart when told to get a box of aggregate "like this stone" from a near-by stream. He was seen, some time later, sitting by the stream with the specimen stone in one hand, picking up one stone at a time and only accepting it if it corresponded in size and shape with the specimen. After the first BPs, checks were only made after erection, to ensure that the BPs were properly constructed with all members present, nuts tight, name plates properly oriented and witness marks in position. One BP was not inspected by any Mission member. This was erected on the pinnacle of the Cerro de la Virgen by a lieutenant and a sergeant of an Argentine Mountain Regiment. They carried the BP and cement up the mountain, the last part of which they classed as a fourth-degree climb. They then erected the BP on the only flat space available—barely leaving room for themselves to stand. This was thought to be the first time a BP has been erected on the peak of a mountain in the Andes. After the erection of each BP Staff-Sergeant Browning prepared a detailed description of its surroundings and access routes, marked its location on an air photograph and supervised the taking of ground and helicopter photographs of the BP and panoramic photographs from it. These descriptions were fair drawn by the draughtsman, so that copies, and prints of the photographs, were available to both Parties before the Mission left South America.

The positions of the BPs were determined trigonometrically in relation to the existing Mixed Commission traingulation to third-order accuracy in accordance with the Mission's Technical Instructions. This work was mainly achieved by EDM traverses, but four triangles were measured by classical methods. In order that the trigonometrical work could be completed quickly, stations were sited as far as possible on low ground, so that observations could take place in poor weather, and where helicopters could land. Such sites are more suitable for traverses than triangulation,

so that the use of EDM traverses in place of triangulation speeded the work considerably. Sergeant Anderson was in charge of the start of the field work, but it soon became apparent that he would be required full time for computing. Fortunately one of the LOs, Major Ricardo Cepeda (Chile), was very experienced in this work and took charge of it. The work was done by two observing pairs, each made up of one surveyor from each Party. Eight stations of the Mixed Commission triangulation were occupied, two permanent and nine temporary trigonometrical stations were erected, satellite stations close to twenty BPs were occupied, and one BP was intersected. Temporary satellites were used at BPs so that observing and erection could proceed in either order, or simultaneously. Measurements from the satellite to the BP were made after the BP was erected. All observations were performed by day. Wild T2 theodolites and expendable wooden signals were used for angular measurement. One of the theodolites was graduated centesimally instead of sexagesimally. Both British observers found that, once they had got used to it, this instrument was very easy to read, simple to book and the least unit of 0.0001 centisimal degree was more appropriate to the instrument than 1 or 0.1 sexagesimal second. Centesimal measure is simpler for computing, especially with electronic digital computers. The Distomat was preferred to the Tellurometer for distance measurement, because it was slightly quicker at measuring a line and, being mounted on a trunnion axis, was easier to use on some of the very steep (up to 20°) lines used. The Tellurometer's main advantage of portability was not in great demand, due to the availability of helicopters. The original field observations were immediately triplicated on the return to base on a small office copying machine, run from a portable generator. The original was then filed and not used further. One copy was provided to each computer (British, Argentine and Chilean) and all computations were performed three times, with appropriate cross-checks. The Mixed Commission triangulation was observed before the invention of EDM and internal evidence suggested that a scale error up to 1/20,000 could be expected. Such an error is normal in chains of triangulation of this type and, provided a suitable overall adjustment is made, does not affect the usefulness of results. However, EDM measures distances to better than 1/100,000, so that it is difficult to make EDM traverses sympathize with existing triangulation. Accordingly, the first observing task was to measure three lines of the existing triangulation by Tellurometer and Distomat to give an adjustment factor from EDM triangulation. This factor was used on all measured lengths to ensure that the new EDM traverses fitted the existing triangulation. The computations were completed as far as the rectangular co-ordinates and elevations of the BPs before the Mission left Palena, and these results were issued there as provisional co-ordinates. On the return of the Mission to England the computations were repeated at the Geodetic Office, Survey Production Centre, RE, using its ICT Pegasus computer. This was a more rigorous solution, with no approximations for plane computation, using a variation of co-ordinates, least square, adjustment to control. The results agreed with the field computations within the expected limits and are now the "legal" values of the BPs. All figures closed to well within third-order tolerances, the largest triangular misclosure being 4 in and the worst traverse misclosure 1/44,000.[11]

Simultaneously with the other work, three pairs of topographers ground checked the 1/50,000 map for completeness and accuracy of depiction of the detail, for 2 kilometres on each side of the boundary. There were very few errors of interpretation on the map, but the topographers were able to complete the streams where they could not be seen on the air photographs beneath the tree cover, and to adjust track classifications. Each pair was given a zone, where they camped, and which they covered mainly on horseback, but with occasional helicopter assistance. The topographers were not very familiar with this type of work and close supervision by an experienced surveyor was needed. Unfortunately this proved difficult because of the remoteness of the topographers and also because all the Mission members and the

[11] The technical survey aspects of the work of the Demarcation Mission are to be the subject of a paper to the Photogrammetric Society.

experienced surveyors from the two Parties were busy on other tasks. The presence of helicopters was a disadvantage, as the topographers tended to sit in their camp in the hope that a helicopter would arrive with time to spare to help them. Usually when the weather was good enough for flying the helicopters were busy elsewhere. The work proceeded slowly, but all the areas of importance were completed.

All the administrative arrangements were made by the two Parties, who both made extraordinary efforts to smooth the path of the Mission by providing every possible assistance. Daily evening meetings were held to review progress and plan future operations. The Demarcation Mission had only to allot a task to one or other Party for it to be carried out most efficiently. The Mission was extremely well cared for throughout its time in South America. In Palena, Chile placed a small hotel entirely at our disposal and provided a house as offices for ourselves, the computers, topographers, draughtsman and stores. The liaison officers and surveyors lived in the school and various houses, eating in a central Mess. For one week the Mission moved to the south shore of Lago General Paz, in order to reduce helicopter travelling time in the southern section. Here, at very short notice, Argentina produced good accommodation in a Gendarmaria post and a timber factory. We were very well received by the resident population on both sides of the frontier, from whom we received considerable assistance and hospitality. The liaison officers and their staffs, several of whom were with the Field Mission, proved to be as good companions as in the previous year. They worked extremely hard, often in bad conditions, and I very much appreciate the support they gave me.

The Demarcation Mission completed the field work on 9 February 1967 and left Palena on 11 February 1967. Various documents were prepared in Buenos Aires for copying by the Parties and after liaison visits there, and in Santiago, the Mission returned to England on 25 February 1967. The field work was completed in one month, for although the weather was very bad for much of the time, two fine spells enabled the task to be finished expeditiously.

DEMARCATION MISSION REPORT

The Award required the Director of Military Survey to submit a report on the work of the Demarcation Mission as soon as possible after its return. The first draft was prepared by 15 March 1967, and at this stage the various interested organizations (the Court, the Foreign Office and the Parties) expressed their opinions on the contents and distribution of the Report. Successive drafts were discussed and the supporting documents were prepared and checked. Meanwhile Fairey Surveys made a revised edition of the map, incorporating the BPs, the line of the boundary and the topographer's corrections. Eventually it was decided that the Report (copy of this report is now held in the RE Corps Library) should be produced in two parts, Part I of 94 pages and 3 maps, and Part II of 550 pages and 11 traces. This was a much bigger project than originally visualized. Listed below are the main contents of the Report, as an indication of the large amount of documentation that is necessary in boundary demarcation.

PART I—General distribution (155 copies). Printed by lithography.

Main Report including:

relevant portions of the Award and Instructions;
a description of the area;
the tasks undertaken;
the techniques used;
administration.

Annexes including:

a 1/250,000 diagrammatic map of the area:
the revised 1/50,000 map;

a triangulation diagram;
a list of personnel engaged;
a diary of the progress of the work;
a description of the boundary;
notes on the selection of each BP site;
a minute of erection for each BP;
a description form for each BP (including a half-tone photograph);
a copy of the Technical Instructions;
details of the existing triangulation;
a report on the field computations;
a report on the final computations;
the final list of co-ordinates of the BPs.

PART II—Limited Distribution (ten copies). Mainly xerox copies of originals.

Annexes including:

the original observation sheets;
the abstracts of observations;
the field computations;
the final computations;
the original map-completion field traces;
the compiled addition and deletion traces;
marked air photographs of BPs and new trigonometrical points;
annotated panoramic photographs from BPs and new trigonometrical points;
reports on three detailed surveys in areas of special difficulty.

On 29 June 1967 the report was submitted to the British Government,[12] who passed it to the Court of Arbitration. On 18 July 1967 the Court approved the demarcation and expressed its opinion that the Award had been executed. Copies of the report were passed to the Parties. This, as far as I was concerned, marked the end of a most enjoyable and interesting task.

FURTHER READING

A great deal has been written about the esoteric political and geographical aspects of frontiers, and there are reports in various journals on the activities of individual boundary commissions, but there are very few practical guides to boundary delimitation and demarcation. By far the most useful book is *Boundary Making, a Handbook for Statesmen, Treaty Editors and Boundary Commissioners*, by Stephen B. Jones, published by the Carnegie Endowment, Washington, 1945. This gives practical advice, with abundant examples, on all aspects of boundary work and has a useful bibliography.[13] A useful summary with a very good, though somewhat outdated, bibliography is *The Demarcation of International Frontiers*, by Colonel H. St J. L. Winterbotham, a paper to the Empire Survey Conference, 1928.[14] For more detailed suggestions on demarcation, *Boundary Commissions*, by Major E. H. M. Clifford, RE, in the *RE Journal* of September 1937 is recommended. A good example of an account of the work of a Boundary Commission is *The British Somaliland—Ethiopia Boundary*, by Lieut.-Colonel E. H. M. Clifford, RE, in the *Geographical Journal* of April 1936.

(The photographs were taken by Senor A. Fernandez (Chile) and the map was drawn by Mr J. F. Offley (Survey Production Centre)).

[12] "Report by the Director of Military Survey to the Government of the United Kingdom on the work of the Demarcation Mission appointed to carry out the demarcation of the course of the Argentine-Chile Boundary in the sector between Boundary Posts 16 and 17", Ministry of Defence, June 1967.

[13] On page 175 is the statement: "Improvements in the helicopter may greatly expedite ground work in difficult terrain, permitting the quick movement of men and instruments, and perhaps of material for monuments, to points difficult to reach by surface transportation." This is remarkable foresight for someone writing in 1945.

[14] The section on "Imperial Defence" would be considered tactless today, but it is mild compared with earlier views which regarded frontier settlement as a branch of imperial policy. The most extreme and interesting example of this approach is *Frontiers*, by Lord Curzon, the Romanes Lecture of 1907.

Photo 1. The Field Mission starting a tour of California, the main settled area in the disputed zone. Left to right (on horses): Brigadier Papworth, Mr Kirwan, Major Rushworth, Mr Chapman (interpreter).

Photo 2. The Field Mission studying the northern part of California Valley from the source of the Rio Encuentro as claimed by Argentina. The burnt tree stumps can be seen over the whole valley.

The Argentine Chile Frontier Case, 1965-7 1 & 2

Photo 3. The Demarcation Mission Reconnaissance Party siting BPs where the boundary crosses the Rio Engano/Salto. Left to right: Staff Sergeant Browning, Commandante Ayala (Chile), Lieut-Colonel Marini (Argentina), Major Rushworth.

Photo 4. The author siting BP VII-2J on the straight line between BP VII-2H, in the picture, and BP VII-2K on the far side of the Salto/Engano valley. A "handie-talkie" radio is being used to direct Staff Sergeant Browning to the correct location.

Photo 5. Observations at BP VII-2G, on the northern slopes of the Cerro da la Virgen, with a Wild Distomat by Senor Soria (Argentina) and Major Cepeda (Chile).

Photo 6. BP VII-2H, looking north up California Valley.

Portrait of a Squadron

The Fortress Squadron RE Malta

MAJOR D. R. WHITAKER, RE

"You may talk o' gin and beer
when you're quartened safe out 'ere. . . .
Kipling

MOST of the articles which appear in this *Journal* not surprisingly tell of warlike events and preparations, or of epics of travel and adventure. Few describe the day-to-day conditions in which soldiering is mostly carried on, presumably because these are so dull, or bad, that they do not merit mention. This is a pity, not because contemporary readers would miss much in the way of interesting reading, but because future generations may find it difficult accurately to picture how we spent the greater part of our soldiering lives. This article aims to describe a kind of peacetime soldiering which is rapidly becoming rather rare, a congenial, overseas, permanent station.

There cannot be many unit headquarters which regularly appear as a part of the scene in travel posters, nissen huts and barrack areas generally being hardly conducive to the attraction of tourists. The Squadron Headquarters block of the Fortress Squadron RE Malta is, however, one of these, situated as it is on one of the prettiest bays in Malta, St Georges Bay. The Birdcage, as it is traditionally called, was originally built as a small block of married quarters for St George's Barracks, although it is not known if the name derives from this original use or from its shape. A square "C" in plan, its marble-tiled courtyard looks out across the bay over its own rock lido and provides what must be one of the best uncommercialized pieces of real estate in Malta. On one side is a small but useful bridging hard and on the other is the Robb Lido, the main swimming place of the Army on the Island, whilst on the top floor of the Birdcage is the Sapper Sergeants' Mess. Behind lie the remainder of the barracks and two hundred yards along the bay is the Mess used by the squadron officers. It is difficult to imagine a more delightful place for a unit to live in between exercises and distant works jobs. St George's Barracks, built during the eighteen-sixties, was very badly bombed during the war and could not now house more than a minor unit if many soldiers lived in. The Squadron shares it with the Malta Park Squadron, but can only do so because all the soldiers live out. The buildings are of the local mellow, warm, honey-coloured sandstone, and are architecturally most attractive.

It is not likely that contemporary financiers would allow the decorative stonework which in those days seemed to be normal. The crests of three of the battalions who occupied the barracks still remain, but there have been many more who have left no clue to their identity. A Corps Cipher has sensibly already been carved in stone over the entrance to the Birdcage, but, sad to say, the British Army is being withdrawn from Malta, and our successors are more likely to be *restaurateurs* than servicemen.

There have been Sappers in Malta since 1814, shortly after the Island was taken from the French, and the present HQ RE Malta and Libya is the descendant of the organization which, over the years, has built most of the barracks and service installations on the Island, as well as a great many general public works. These were accomplished by the CRE, or CE as he was at times, with sapper officers and clerks of works and local contractors or civilian workmen and occasionally a RE unit. It was only in 1936 that Maltese were enlisted into the Corps, trained as tradesmen and organized into a Field Company, the forerunner of the Fortress Squadron. Until 1964 the Squadron was organized into one field troop, a tunnelling troop and an

E and M Troop, but in that year a separate Park Squadron was formed and the Fortress Squadron became a normal field squadron with three field troops.

Malta is said to have the best climate in the Mediterranean, although shirt-sleeve order rather than KD has to be worn in the winter, and this is the first of many things which makes peacetime soldiering in Malta so pleasant. Life in the summer revolves around swimming, and for officers and men there is a choice of lidos, which are rocky bits of coast concreted into platforms and with shaded areas, diving boards and canteens added, and several sandy beaches, the latter getting more crowded each year. The officers' main lido is directly below the St George's Mess, which is, of course, very convenient for living-in officers, and provides a splendid setting for barbecues. RE Malta can, of course, use the Birdcage Lido as well, and this comes into its own at the start and end of the season, because it is so sheltered. It is also convenient for anyone wanting to sail the RE RNSA and Bosun dinghies kept on the Birdcage hard, and at the times of the year when the Garrison Water Ski Club is allowed to ski from the hard or during the periods when the Sub Aqua Club operates. This is all rather different to the infrequent, often cold sea swims, complicated by traffic congestion on the journey which is the lot of anyone stationed at Tidworth or Maidstone. Many service families acquire boats of one kind or another and RE Malta have this year acquired a families' boat. The Garrison Yacht Club, the Commodore of which is currently the CRE, has a fleet of dinghies and two Folkboats. A veritable armada sails at week-ends to the twin island of Gozo, which has good beaches, and returns in the early evenings. The local RCT Maritime Squadron have four fast launches which can be hired very reasonably for family outings or boats can be chartered from commercial organizations.

The United Services Sports Club at the Marsa is a real relic of prewar days, but does provide landborne sports for those who want them, as well as dining and dancing. Unfortunately the polo ponies are used by very few nowadays; tennis courts are available in most unit lines and there is better food available commercially, so that it does not receive very enthusiastic support from a great many officers. It has got the only golf course on the Island and does own a lido in Sliema, but these could perhaps be run more easily as separate clubs. It is interesting to hear from people who served in Malta in the days between the wars that this club was the centre of sporting and social life on the Island, but it has now been overtaken by events. The grounds of the Club have become very familiar to the Squadron over the years, since quite a few improvements which the Club has required have given good opportunities for trade training. The most recent of these is a swimming pool for which the construction kit was donated by the Nuffield Trust.

Malta has excellent rifle ranges, but there is not really enough room in the training areas to train more than a platoon in infantry work. Suitable sites for combat engineer training are also hard to come by, the most suitable being so familiar to the soldiers that great ingenuity has to be exercised if any originality is to be introduced into a scheme. Until the Arab-Israeli war the two infantry battalions and the Squadron did most of their serious training in Libya, where the field troops supported the 4th Royal Anglians and the Loyals and the Inniskilling Dragoon Guards; that is to say they supported them whenever the commanding officers could be persuaded to write some sapper warfare into their exercises. Now these training areas are probably lost to us. The year 1967 has been, in fact, particularly bad for exercises, the political trouble of Malta and the Arab-Israel war having caused the cancellation of most of them. In contrast 1966 was a vintage year, the Squadron as a whole exercising in Sardinia in the spring and Libya in the autumn, with individual troops in support of exercises on five occasions, and with two adventure training exercises, one to the Atlas mountains in Morocco and one long-range desert navigation exercise. Finding suitable sapper tasks for the Squadron on exercises in the desert is extremely difficult. Local inhabitants are far too sensitive about the few water sources for water points to be set up, however much they are persuaded that the water will be put back; minelaying is ineffective except on an enormous scale, and anyway there seldom

seems time for exercising units to sit and wait for a night while a minefield is breached. Track denial is pointless and there are no demolition tasks. Airstrips are a possibility and the squadron has built or improved several in the past few years. There is nothing to bridge, though track-improvement tasks can always be found, but with large distances and mostly good going they are a little difficult to sell to the soldiers. One field troop in 1966 helped to deny a beach to a landing party of the US 6th Fleet and for once the operational situation of there not being enough sappers was evident. Sapper units will only be correctly used in the desert when there is a strong body of sappers with vivid imaginations and thick skins amongst the directors and umpires of a large exercise.

The officers and SSM of the Fortress Squadron are all UK-based British Army, but all the other senior NCOs and the rank and file are locally enlisted Maltese. They are all long-term soldiers engaged to serve mainly in Malta, although this is interpreted to mean that they should not spend more than about three months in any one year away from the Island. They all live at home unless required by some special duty or course to live in barracks, and turn up each morning on a variety of scooters, motorcycles, cars and buses. There are relatively few surnames in Malta, so that the Azzorpardis and the Zammits have to be referred to by their last two numbers as well as their names. Possibly for the same reason, but more probably because in the small Island people have always got to know each other very well, most Maltese have well-established nicknames which are often better known than their proper names. The story is told of an officer looking for a soldier whom he did not know, in his village. Stopping the first young man he met, he asked him if he knew where he could find, shall we say, Joseph Spiteri. "No," said the chap, thinking deeply, "do you know his nickname?" "Yes, it is Shirts," the officer replied. "Oh! that's me!" was the surprise reaction. Quite a few of the Squadron are related to each other or to the personnel in RE Malta. Brothers, cousins and in-laws are quite common, and we have one father and son, both sappers, which must be unique. The soldiers are in general older than their UK-based counterparts; discipline comes more easily and serious charges are rare.

The days of this delightful and efficient little unit are, unhappily, numbered. With the rundown of the British services in Malta the Squadron is due to be disbanded in October 1970. All the soldiers will be discharged and will have to find civilian jobs in Malta or by emigration. Unemployment figures on the Island are very high and it is difficult to assess the chances of a skilled tradesman getting a job at a decent wage. The rapidly growing tourist industry will certainly absorb a lot of the men either directly, as for example the cooks, or indirectly on building sites. There is a considerable variety of skills amongst the members of the squadron, such as stone-carvers and boat-builders, tailors and trumpeters, which should stand them in good stead, and the aim of whoever is commanding the Squadron at the time it is disbanded, which should clearly be to leave every man in a job, may not be as difficult to achieve as it appears now.

It seems unlikely that the British Army will enjoy peacetime overseas stations such as Malta for much longer. The fact that for once a station is enjoyable and has got good amentities and that soldiers like it does not appear to be a factor considered by White Papers on Defence. As future generations of soldiers huddle together on Salisbury Plain, waiting for fire-brigade unaccompanied tours abroad, they could not but be envious of the ordered, enjoyable way so many of their predecessors spent their peacetime spells in places like Malta.

Photo 1. The Squadron Headquarters known as "The Birdcage" occupies a delightful site on St Georges Bay with it's own swimming lido, bridging hard and anchorage.

Photo 2. This is one of a pair of crests surmounting two of the few remaining barrack blocks in St George's Barracks, the home of the Squadron. Some unit tradesmen still carve the local stone beautifully but there does not nowadays seem to be the time for such ambitious decoration as these ten foot high monsters, carved in 1863.

Potrait Of A Squadron 1 & 2

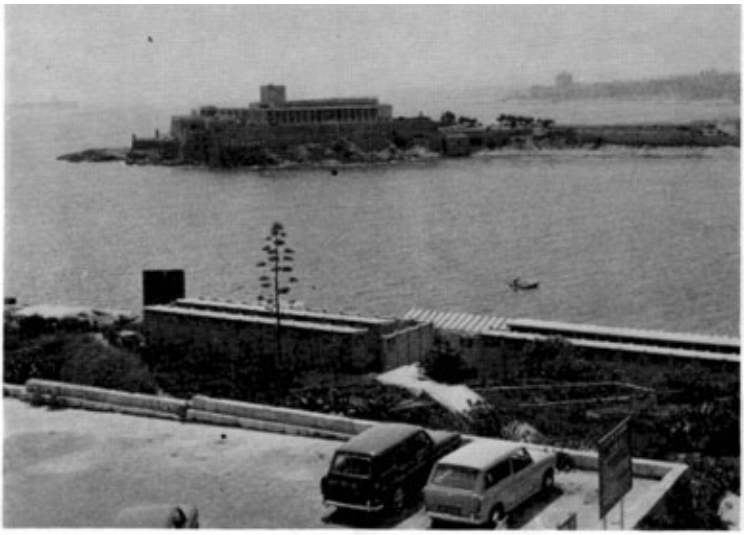


Photo 3. The St George's Officers Mess used to be entirely Sapper but is now combined with the HQ Malta and Libya Mess. The terrace and most of the rooms have magnificent views either out to sea or across the bay to the local Casino.

Photo 4. The RE Sergeant's Mess occupies the top floor of the Birdcage, and the Junior Rank's Club has equally good views, conducive more to quiet contemplation than to thoughts of combat engineering.

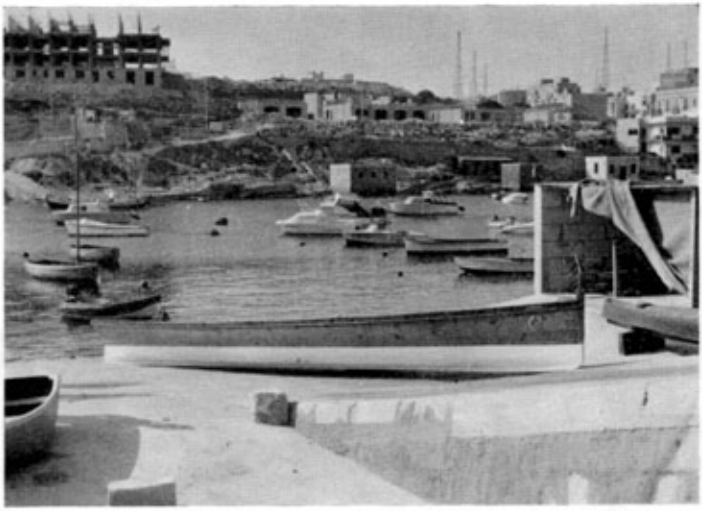
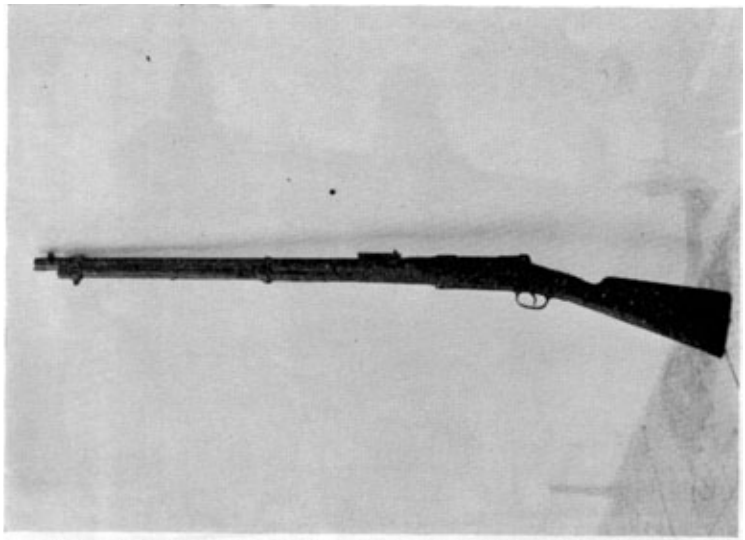


Photo 5. This gig, and another, and two more for the Gibraltar Fortress Squadron have all been built in recent years by Sapper tradesmen in Malta. Squadron oarsmen have for many years raced them with considerable success in local military and civilian regattas.

Photo 6. Football and hockey and athletics are played in Malta on 'shash' a rolled, powdered stone. This is the St George's sports field.

Potrait Of A Squadron 5 & 6



This old Arab rifle was found in a sand dune some thousand miles south of Benghazi by an adventure training exercise, Exercise Far Oasis, in September 1966. There is a bullet hole straight through the forepiece.

'hoto 8. The bridging hard next to the Birdcage sometimes gets rather overcrowded 'atermanship training only just taking precedence over waterskiing, skindiving, sailing, motorboating and swimming.

Photos 9 and 10. The Portes Des Bombes built by Sappers in 1868 and the Marsa Pool built in 1967. Wherever the tourist goes in Malta he is certain to be within easy reach of some sapper built amenity.

The Land of the Five Rivers

MAJOR G. HORNE, MICE RE (retd)

THE word "Punjab" means "five rivers" and for thousands of years these rivers flowed along their ever-changing alluvial beds through a useless desert to waste themselves in the Arabian Sea. Only the well and the Persian wheel made use of a minute proportion of their precious water, and man's existence in this land of healthy brilliant winters and blazing hot summers depended mainly on the fickle monsoon; when this failed, man starved.

Although the early Mohammedan Emperors had created some irrigation works, they were extremely small and generally designed to satisfy the whims of the rulers rather than assist the peasantry, such as the canal built in 1633 to carry water from the Ravi to the Imperial Gardens at Lahore. A river system with an annual flow equal to twice that of the Nile, or three times that of the combined Tigris and Euphrates, was allowed to run mainly to waste.

Then, in 1846, came the British victory at Sobraon and the Sikh Kingdom, which had attained such power under its late ruler Ranjit Singh, began its years as the Province of the Punjab.

Henry Lawrence, its first Governor, had great sympathy with the Sikhs and he immediately embarked on a vigorous programme of development and, most important, initiated a canal system to irrigate and fertilize the barren land and provide the restless disbanded soldiery of the Khalsa Army with a means of livelihood.

British-inspired irrigation works had, however, already been started in many other parts of India and sapper officers were beginning to become involved in this specialized field of engineering, although Proby Cautley, who played the major part in the construction of the Ganges Canal was, in fact, a Captain of Bengal Artillery.

Works had already begun on the Indus itself where it flowed through the Sind. Here Major Baker and Lieutenant Fife were concerned with the construction of inundation canals, although both had realized the weakness of this uncertain system which depended on floods, and were already giving thought to headworks which would contain the floodwaters for use during the months when the river was low and enable a system of perennial canals to be operated. Unfortunately their advanced proposals were so haggled over and delayed by wars that it was not until 1932 that their ideas bore fruit in the shape of the Sukkur Barrage.

Fortunately events moved more quickly in the Punjab, and by 1850 Dyas, a young officer of Bengal Engineers working under Robert Napier, had begun the great work of his life by building the headworks at Madhopur, where the Ravi leaves the hills, together with nearly 250 miles of canal to irrigate the land around Armritsar and Lahore.

This Upper Bari Doab[1] canal system was the first effective irrigation works in the Punjab and heralded the start of a new era for that barren land. Unfortunately the many years spent on his "beloved Ravi" overworking himself in such an exacting climate wrecked the health of its creator, and in 1868 Colonel Dyas died at the early age of 43, being buried at Delhi alongside his illustrious school-fellow, John Nicholson "The hero of Delhi".

The second great irrigation project in the Punjab was the Sirhind Canal, designed to water the Jumna-Sutlej *doab* between Ambala and Ferozepore. Although Baker had explored the region as early as 1840 and Dyas had outlined a scheme in 1856, funds were low, and for nearly twenty years nothing further was done. Then several of the Sikh Princes, realizing the immense benefits which would accrue, pressed for the commencement of the scheme and work started in 1874, being completed in 1882, when the new canal system was opened by the Governor-General, Lord Ripon.

[1] A *doab* is a tract of land between two rivers, the Bari Doab lies between the Sutlej and the Ravi.

In these days of intense organization, with a great deal of design work carried out in head offices and ample data available it is difficult to appreciate the magnitude of the tasks, both mental and physical, undertaken by the early engineers. The control of large silt-bearing rivers was still a new science in the process of being learned both in India and in the United States, and even the hard-won experience of the American engineers was often of little value, as the rivers of the Punjab had very much their own characteristics.

On the ground the few British officers had to survey, design and set out the works, find the raw materials, administer and train the labour and artisans, all this often in barren country. They then had to supervise the opening up of quarries, building of kilns and making bricks, burning lime, arranging transport, building railways and roads—in fact, see to every detail from first to last.

Then there was the fight against the climate and the heat and dust of a Punjab summer. No air-conditioned bungalows and landrovers, but tents and horses and without the present-day knowledge of tropical health. No wonder men like Dyas literally killed themselves.

Once clear of their Himalayan sources the five great rivers meander across the plain, each one flowing in its own *khadir* an area, often over a dozen miles wide, within which the river is generally contained, but in which it may completely change its course from year to year.

Apart from varying their course horizontally, such silt-bearing rivers also vary vertically, as the concentration of silt that they are able to carry depends on their speed. If they slow down silt is deposited, causing the bed-level to rise, and this *accretion* makes the river shallower and the flow faster, thus enabling it to pick up more silt and become deeper and slower again due to *retrogression*—and thus the cycle is repeated.

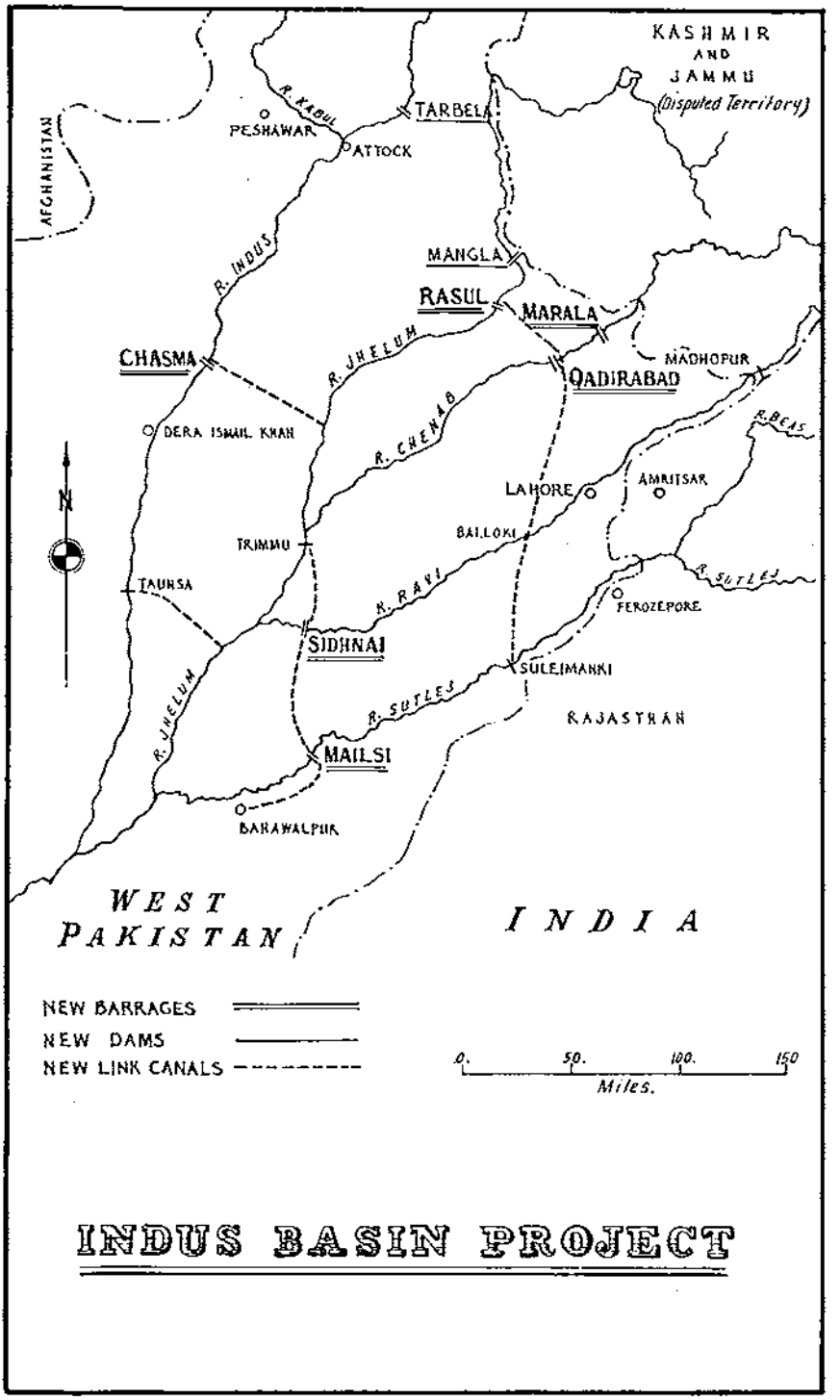
This is of course a very simplified description because river flow also varies seasonally and on occasions daily when small floods, or freshets, occur, added to which obstructions, both natural and man-made, will vary flow and cause *accretion* or *retrogression*. For example, the pond above a barrage or a slow-moving canal will suffer from the depositing of silt, while downstream of a weir, where velocity increases, silt will be swept away; thus any structure built across such a river will alter the régime of that river and cause a change in bed-levels both upstream and down.

Then there is the great scourge of all silt-bearing rivers, that of scour. Build any structure in the river and the obstruction it causes will create the currents and eddies to scour and undermine it.

Probably one of the greatest problems faced, however, is that of keeping the river on a constant course while it passes through structures. Obviously the gap has to be large enough to pass the anticipated flood, but the width of a *khadir* is usually so great that to try to span it completely would be uneconomical and wasteful in resources; equally a structure is useless if the river by-passes it, as nearly happened with the first headworks on the Ravi.

These days, the problem of how great the flood is likely to be is tackled by studying previous records. The first irrigation engineers had no such records and their estimates of flow had to be based on intelligent appreciation, supported to some extent by local knowledge, often inaccurate. The fact that the early canal systems have, on the whole, withstood the tests of time shows just how intelligent the early appreciations must have been.

Siting the gap depends, of course, on local conditions, but the river must be "trained" always to stay on the same course. To reduce a *khadir* several miles wide to a "gap" of about a quarter of a mile by the use of normal embankments, inclined fairly gradually so that a flooding river will not wash them away or punch a hole through them, requires a tremendous length of embankment and quite often a large amount of stone revetment. Even with the modern aids of mechanical equipment this would present a sizeable problem, but when hand-labour, donkeys and head-pans were the methods in use and there was often the need to maintain the labour force in



INDUS BASIN PROJECT

barren country, such long embankments were a great strain on resources, added to which there was always the time element, as such work had invariably to be finished before the next flood if it was to be of service.

There was thus evolved the principle of spurs, whereby the main river flow is kept along the desired line by spur embankments built out into the *khadir* perpendicular to the flow. Such a system does, however, need to be backed up by marginal bunds to contain the water, but these do not experience the scour effect of the main river flow.

Spurs, of course, do experience considerable scour and they tend to cause the swirling which creates the deep spots which will eventually undermine them. Early spurs either had no heads or were T-shaped and there were a number of failures. However, as this new art was learned and hydraulic models used, the siting and shaping of spurs became more of an exact science and there were created the various curved shapes which, heavily armoured with stone, have on the whole held the great rivers on course. Added to these are the small spurs, or guide banks, constructed out from the ends of the actual structures themselves, both upstream and downstream, in order to create the funnel or venturi through which the river will pass.

From time to time there is an excessive flood and most systems have a "safety valve". This is usually a section of the marginal bund which can be breached, on the principle that a few weeks' temporary flooding of the countryside is preferable to wholesale damage of the headworks and canal system.

Add to the above problems those of the design of the actual headworks, together with the need to prevent piping as the hydraulic head builds up behind the gates and the design and operation of the gates themselves, and one will begin to appreciate the enormity of the difficulties which faced, and still do face, the river engineers. These days, however, the science is aided by the experience and empirical formulae which are the legacy of the pioneers.

During the latter part of the nineteenth century more and more desert was reclaimed by successive irrigation schemes, by then carried out by the Public Works Irrigation Department, although sapper officers continued to serve in it alongside their civilian colleagues and also to play an active part in the creation of the new roads, railways and towns, or "canal colonies", which spread out into the erstwhile desert in the wake of the precious water. Many well-known sappers were engaged on these various works, including Colonel Sidney Jacob, who was responsible for the Lower Chenab Canal, and whose young brother, Lionel, earned fame and a knighthood as a civilian engineer in the same sphere.

It is only fair to link the name of Lord Curzon with the establishment of the Punjab irrigation system. As Viceroy he realized the extreme importance of irrigation as the main weapon in the fight against famine, and it is probably the least-known aspect of his administration that through his impetus the then astronomical sum of £20,000,000 was spent on canal works.

The creation of these new irrigated areas not only changed the land physically but also ethnologically, for Sikh domination waned, and the new Punjab became also the home of that sturdy farmer the Punjabi Mussulman, whose sons served the Army of British India so well and who now form such a valuable part of the population of West Pakistan. By the thirties, with the exception of one or two still undeveloped areas, the arid deserts of the Punjab had been turned into the granary of India by man-made irrigation. The Irrigation Department was a well-established and vital part of the community engaged in constant maintenance and the periodic fight against floods, for nature is never beaten, and although some further projects were planned, for such systems can always be improved, no large-scale alterations were envisaged.

Little did the irrigation engineers realize, as they surveyed the well-established scene, that some of the greatest works were yet to come, but this time the cause was not to be the vagaries of nature.

In 1947 the establishment of Pakistan and India as separate states imposed a

border right across this Himalayan-fed Indus river system; a system upon which depended the very existence of 40 million Pakistanis and 10 million Indians, about one-tenth of the population of the whole subcontinent. The sharing of such water was no longer a problem between provinces, capable of being settled by the Central Government, but between countries and required international settlement.

Fortunately through the initiative of the World Bank and the close co-operation of the countries concerned such a settlement was achieved, and in 1960 there was signed the Indus Water Treaty, which allocated to Pakistan the waters of the three western rivers (Indus, Jhelum and Chenab) and to India that of the three eastern (Ravi, Sutlej and Beas—the latter a tributary of the Sutlej). "Replacement Works" would transfer water by link-canal from the western rivers to those areas of Pakistan previously fed by the eastern rivers and during the construction of these works India would limit her withdrawals in proportion to match Pakistan's capacity to replace.

A development fund to finance this work was established and backed by the Governments of Australia, Canada, West Germany, New Zealand, the United Kingdom, the United States and Pakistan with contributions from India, and the stage was set for one of the largest and most vital civil engineering projects of all times—the Indus Basin Project.

In India the Bhakra Reservoir on the upper reaches of the Sutlej and a newly constructed canal system will irrigate large areas of the Rajasthan desert, and this will be helped by the separately financed Beas Project consisting of a dam, reservoir and hydroelectric station.

In West Pakistan, where the bulk of the work lies, two high dams, Mangla and Tarbela, will catch, serve and feed vital additional water to the system and as a by-product produce electric power. Eight major link-canals, varying from ten to eighty miles in length and totalling 400 miles, will transfer the water between rivers, and six new barrages, will enable water to be fed into these link canals.

Many existing structures and canals in West Pakistan are being remodelled and about 2,500 tubewells financed from other sources are being installed and local drainage projects initiated to overcome waterlogging and salinity in irrigated areas, while a new department has been created by the Irrigation Department to promote all the projected work. This is the West Pakistan Water and Power Development Authority, better known as WAPDA.

Pakistani, British and American engineers are involved in the design and supervision of this work, while participating contractors hail from Britain, Denmark, France, Italy, Japan, Pakistan, the United States and West Germany, although the people physically engaged on the actual construction are mainly the sturdy hard-working men and women, with a deep attachment to a land made fertile by the work of their forebears. Now, however, they are showing their skill with mechanical equipment and the other appurtenances of modern engineering, although there is still a need for the traditional shovels, donkeys and head-pans and no one has yet invented a machine to replace man or woman in the laying of the vital stone pitching or the brick and bitumen lining of canals. Reinforced and prestressed concrete have, however, replaced the traditional masonry and metal beams, while steel-sheet piling takes the place of the laboriously constructed cut-off walls.

The cost of such works is astronomical and is constantly rising; originally estimated at 380 million pounds, the figure is now nearly twice as much and likely to go higher.

In November 1967, Field-Marshal Ayub Khan, the President of Pakistan, inaugurated the first part of this project and water from the Chenab and the Jhelum, including some impounded by the completed Mangla Dam, is now fed by the existing headworks at Trimmu into the new link-canal to Sidhnai where the new barrage passes it to the lower reaches of the Ravi, to the local irrigation system and into the new link-canal to Mailsi. Here the newly constructed inverted siphon, thought to be the largest in the world, takes the canal water under the river and feeds it into the new canal to Bahawalpur to water the area previously irrigated by the Sutlej.

By March 1968 a second lateral link-canal will take further water from the Jhelum via the nearly completed barrage at Rasul, pass it into and across the Chenab by the recently completed Qadirabad Barrage, into and across the Ravi by the existing Balloki headworks and feed it into the Sutlej at Suleimanki. Later in the year a new barrage, replacing existing headworks at Marala, will feed further water from the Chenab to the Ravi.

By 1971 the Indus will add further to this new system when the largest of new barrages recently started at Chasma, and near to Dera Ismail Khan, feeds water into the canal to the Jhelum in addition to that being fed from the existing headworks at Taunsa.

By 1974 the recently approved giant dam at Tarbela, not originally part of the project and estimated to cost £300 million, will add greatly to the dry-weather flow of the Indus and thus, through the barrages and link-canals, to the rest of West Pakistan.

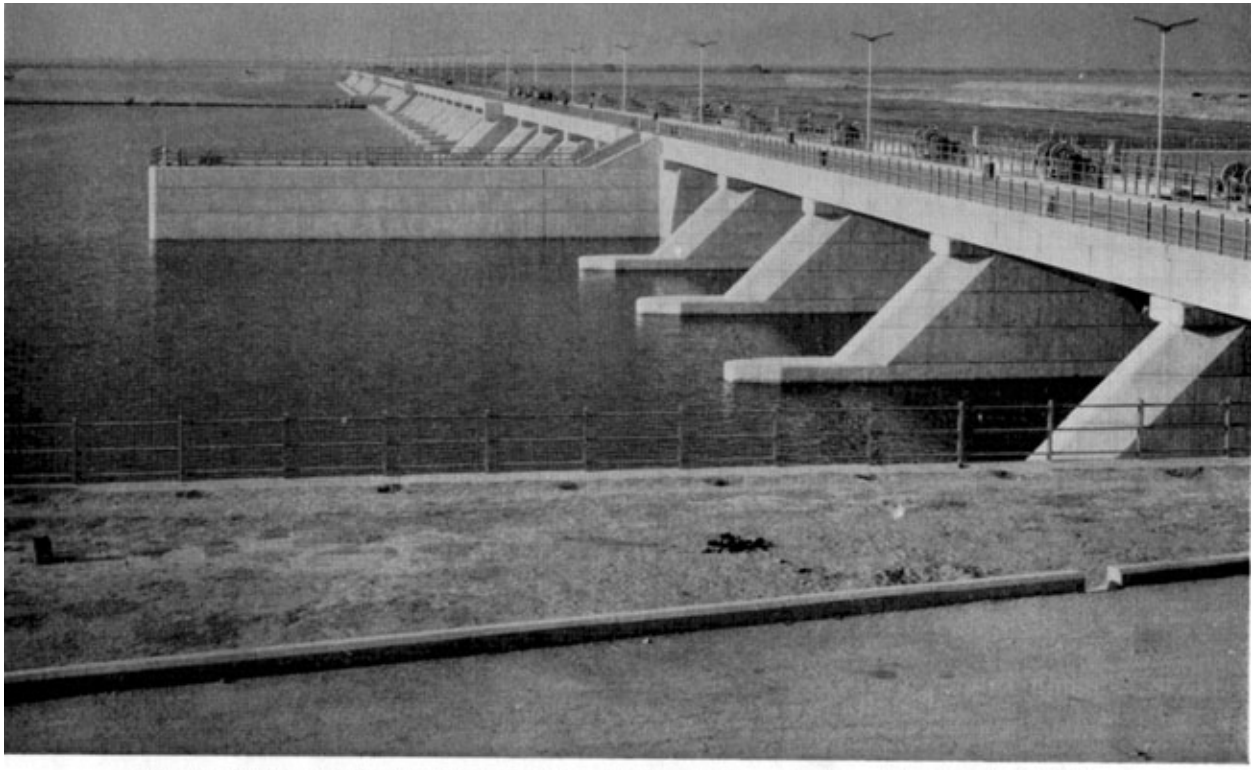
And so once more the Punjab, the land of the five rivers, is the scene of large-scale irrigation works, with Pakistani engineers, now well experienced in the vagaries of their great rivers, playing a major role in ensuring the future prosperity of their country.

Living in air-conditioned bungalows and travelling the sites by landrover and aircraft, and with head office calculations and decisions arriving by air mail and cable (some consider this a double-edged advantage, for the "pioneers" were not "blessed with bumph") the modern engineers now enjoy the hard-won experience of the last hundred years, but even so it is no light task to harness these great silt-bearing rivers.

Men like Robert Napier, Baker, Fife, Dyas and Jacob, to mention but a few, would be thrilled to see the great work which they pioneered thus carried on, much of it by the descendants of the men with whom they toiled. It is also fitting that many of the British engineers at present engaged on this vast undertaking have, in their time, worn a similar badge as the early irrigation engineers, that of the Corps of Royal Engineers.

ACKNOWLEDGEMENT

The Author wishes to thank Messrs Coode and Partners of London, the Consulting Civil Engineers for the six new barrages, for their help with information and their permission to publish the photograph of Qadirabad Barrage.



The recently completed Qadirabad Barrage on the River Chenab. The protruding wall contains the fish-ladder.

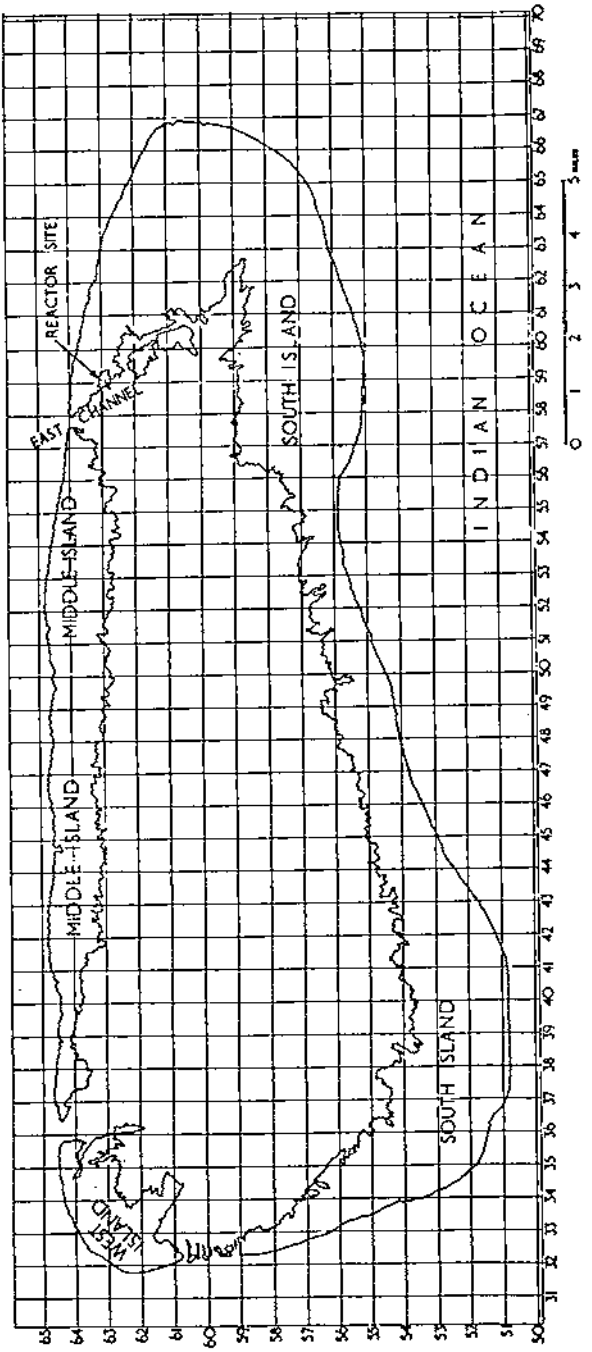


FIGURE I. ALDABRA ISLAND

The Nuclear Island of Aldabra—1975

MAJOR G. J. CHAVE, RE

INTRODUCTION

IT all started in 1966, when Mr Healey, Minister of Defence, suggested that the Island of Aldabra, 265 miles north of Madagascar, would be valuable as a staging post for any future commitments in the Far East. Surprisingly this was repeated in the Defence White Paper of July 1967, which forecast withdrawal from the mainland of Asia; "surprisingly", because of the unpromising character of the islands. The sketch map (Figure 1) shows that Aldabra consisted of four main coral strips surrounding a lagoon which dried out at low tide. There was no safe harbour or anchorage suitable for vessels of any size. The islands, with a maximum height of 80 ft above sea-level, were covered in dense scrub, forest and mangrove swamp, and despite an annual rainfall of 90 in, there was no fresh-water source which could be tapped easily. Despite these disadvantages Aldabra was suggested as a base for nuclear submarines and as a staging post for the RAF, particularly for the F111 force.

ENGINEER TASKS

The Sappers had had experience of a similar situation, though on a smaller scale, on Christmas Island, and a certain amount of preparatory work had been done theoretically in the RSME Exercise P6. It was decided that there was scope in the Aldabra project for the Corps to pioneer yet another technology, not only for the benefit of the three Services, but also as a contribution to civilian programmes.

This article, written in 1975, describes the construction of a harbour to accept vessels up to 30,000 tons, and the provision of fresh water and power for the harbour, the airfield complex and a maximum population of 8,000, including fighting elements in transit.

HARBOUR CONSTRUCTION

An early decision was taken that a harbour should be constructed before work commenced on the main airstrip, to facilitate the importation of heavy airfield plant. Various schemes using high explosive were examined, but they all seemed too time-consuming or too expensive in the prevailing financial climate. Nuclear blasting seemed to be the only attractive solution, fraught though it was with political uncertainties at the planning stage. These were surmounted when the International Agreement for the Controlled Use of Nuclear Explosive for Civil Engineering was signed in 1969, as anticipated in the Nuclear Non-Proliferation Treaty of the previous year.

A 240 kiloton fusion device was detonated early in 1970 in the shelter of South Island, at a point marked X on Figure 1. The device, only 30 in in diameter and 15 ft long cost £170,000. Detonation was at a depth of 750 ft, the optimum depth of burial for cratering efficiency for this device. The harbour which was excavated thus in a fraction of a second measured 1,500 ft in diameter and 400 ft deep at the centre. A lip, or rim, was created around the basin averaging 100 ft in height, which gives additional protection to the anchored shipping. Maximum use was made of the existing East Channel for entry into the harbour, but this had to be improved with the aid of a row of four nuclear charges, each of 2½ kilotons, spaced at intervals of 250 ft and buried to a depth of 200 ft. The result was a clean-cut channel, 400 ft wide and 100 ft deep at the centre, with a 30 ft wall protecting either side, a convenient side product of the explosion. The cost of the four devices was £½ million.

For this operation great emphasis was placed on the safety aspect, particularly as the project became something of a test case to sound out worldwide reaction to nuclear explosions used in this way. The site was well suited for the purpose, with no inhabited land closer than Madagascar. For the firings the entire population of

Aldabra, only 150 fisher folk, was evacuated to a similar environment in the Seychelle Islands, some 600 miles away. They returned to their homes, with suitable compensation, nine months later, by which time the intensity of radiation even in the immediate vicinity of the crater had reduced to safe levels. However, an area of about half a mile wide on either side of the East Channel was found to be more seriously contaminated and access to this part of the island is still restricted. Even with these safety precautions, the main firing was held up for a week until a suitable southerly wind carried the main fallout plume harmlessly away from the South Island. It had been estimated that to ensure radiological safety the ninety-degree sector for fifty-five miles down current would have to be clear of humans for three days, for which reason shipping was not allowed into the area for that length of time. Thereafter the contamination had diffused and decayed sufficiently to permit free entry within the limits set by the International Committee on Radiological Protection.

The concern which had been expressed about possible biological effects in the sea appears to have represented the most pessimistic view. It was feared that the biologically significant nuclides, tritium, strontium 90, and particularly iodine 131, might affect humans through the fish food chain. The worse estimate was that peak concentration could exceed the maximum permissible for about two weeks after the explosion, by which time the contaminated area might be 300 square miles. In the event, after five years of fish sampling, there is no evidence of any significant hazard.

Aldebra harbour, which now accepts nuclear submarines, supply vessels and occasionally a Commando carrier, would not have been a practicable project without the aid of nuclear explosive. With the successful completion of this experiment both civilian and military engineers are now contemplating more grandiose schemes, involving devices in the order of a megaton.

POWER PROVISION AND DESALINATION

One of the factors in deciding which type of power plant should be installed was the degree of impermanence associated with all such bases connected with our ever-decreasing commitments in the Far East. The Treasury favoured plant which could be removed quickly and economically when this became necessary. Hence the dual-purpose nuclear-reactor/desalination plant found on the barge anchored in the harbour, as shown in Figure 2.

The midship section of the barge was widened to accept the reactor, which is a pressurized water system providing 10 mW(e). The fuel is slightly enriched uranium 235 (5 per cent), and demineralized water at 1,500 psi acts both as moderator and coolant. The reactor core has a one-year life, though a standby core, which is at present stored on land, can be installed in ninety-six hours.

The bow section carries a distribution tower, which is connected by overhead power lines to a second distribution centre on land. Alternating current at 60 cps is supplied and a main transformer rated at 15,000 kVA steps up voltage from 13·8 to 66 kV for transmission to the shore. An alternative connexion by underwater cable to the land-based distribution centre is also provided.

The barge has no propulsion capability, so had to be towed to Aldabra early in 1972. It was diverted *en route* to cope with a storm disaster in Ascension, where the reactor and fresh-water plant made a substantial contribution to the British effort to aid the unfortunate civilian population.

It is difficult at this stage to assess accurately the cost of power provided by this equipment. Under normal conditions, without large numbers of troops in transit, use is not made of the full available 10 mW(e), despite the fact that in this equatorial location full air conditioning of equipment stores and living quarters has more than trebled the power requirement. The cost of power is also linked with the cost of water, and in this particular situation there is no other practicable form of water supply with which to compare costs. From all the facts and figures emerge a general feeling that the running costs for the reactor are roughly comparable in this location

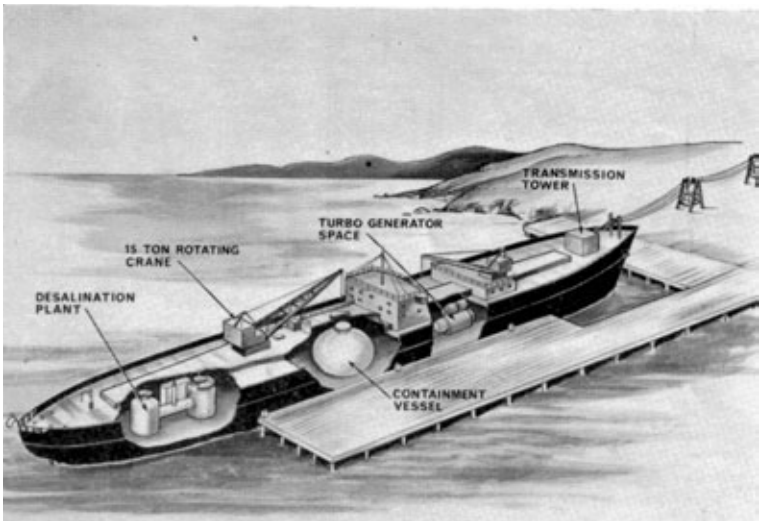


FIGURE 2 BARGE MOUNTED REACTOR AND DESALINATION PLANT

at the 10 mW(e) level with the fuel costs of a similar-sized diesel plant. This is encouraging, considering this is the first prototype British small reactor. In view of its successful operation there are likely to be orders for second-generation equipments, some with purely civilian applications.

The desalination plant is capable of providing 100,000 gallons of fresh water per day, at a cost of about £1 4*s* 6*d*/1,000 gallons. This is about ten times the cost usually regarded as economic for civilian programmes, but represents a saving on the cost of desalinated water using diesel power. The plant is a large version of American Army plant which has been operating in Antarctica for the last twelve years as part of the first dual-purpose reactor/desalination plant ever built either under military or civilian programmes. The process employed is flash distillation, in which use is made of the exhaust steam from the turbine of the reactor power plant to heat the sea water. The heated salt water goes into a low-pressure chamber where the pressure is reduced, causing it to boil immediately, or "flash" into steam. This operation is repeated in further chambers at progressively higher vacuum and lower temperature, and the purified condensate collected.

It is interesting to remember that flash distillation plant, though not reactor-based, was flown to Guantanamo Bay, when the Cuban Government cut off water supplies to the US Naval Base in 1964. Our own forces would have appreciated a second barge carrying desalination plant to relieve the water shortage in Hong Kong in 1969, caused by the Chinese Communists' refusal to continue the supply of water from the Asian mainland.

Mention has already been made of the reserve power supply. It was felt that an alternative land-based reactor should be installed as a safeguard for the continued

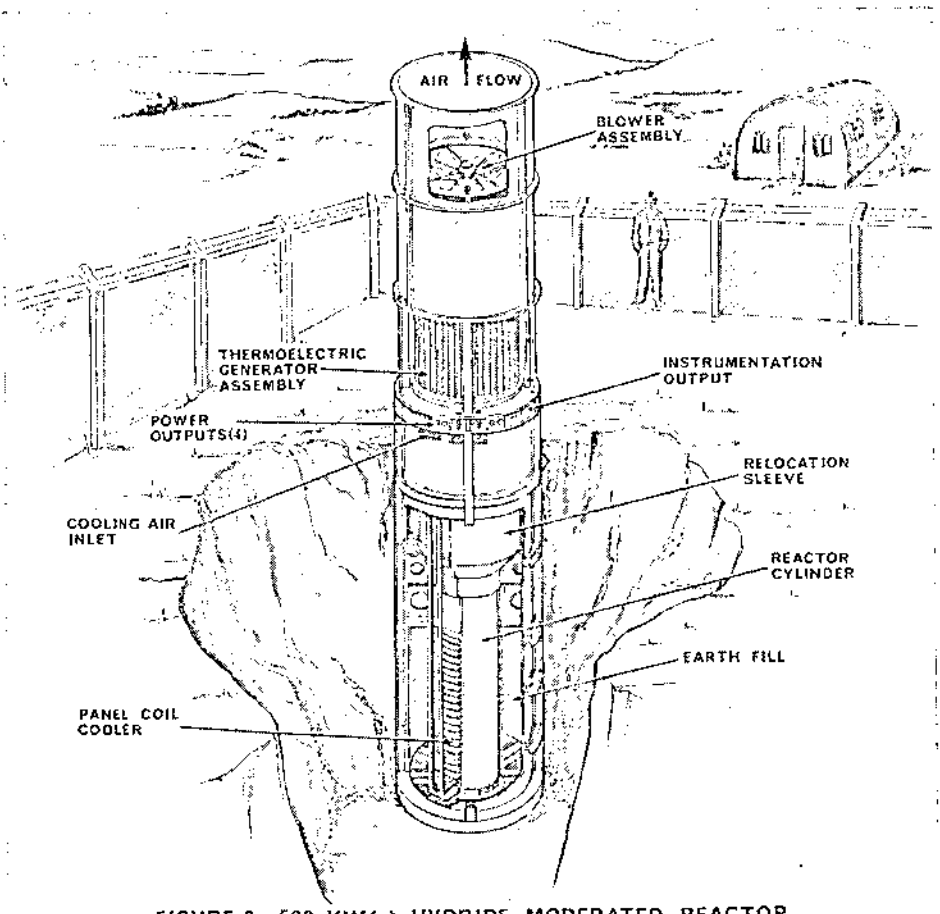


FIGURE 3. 500 KW(e) HYDRIDE MODERATED REACTOR

operation of the airfield itself if the barge plant was put out of action. Again, the Government would only accept equipment which could be removed easily. An experimental 500 kW(e) plant as shown in Figure 3 has been installed, which has the advantage that it does not require the constant attention of operators and it can operate for five years before fuel reloading is necessary.

The whole equipment weighs under 20,000 lb, a large reduction compared with previous systems. This is made possible by digging the reactor into the ground to provide part of the shielding during operations.

The design is based on the migration of hydrogen in zirconium hydride under temperature change. Each fuel element is in two segments, one part containing unfuelled zirconium hydride and the other a uranium zirconium hydride alloy. The reactor automatically adjusts itself to load conditions by making an appropriate increase or decrease of moderator (hydrogen) in the fuel segment, thus raising or lowering the power output. The operation is also fail-safe, so that the reactor can be run without the need for constant supervision.

The second significant advance in this concept is the use of thermoelectric direct conversion at this power level. The rather exotic coolant, tetraphosphorous trisulfide,

is heated by the reactor until it vaporizes and rises into the thermoelectric generator. There it condenses on one side of forty-two wafer-thin thermoelectric plates. The opposite sides of the plates are kept at a lower temperature by a blower assembly: incidentally this is the only noise-producing component in the equipment. The demonstration of the Seebeck effect—joining two wires of dissimilar metals and heating one junction relative to the other to produce an electric current—is an old schoolboy experiment. In modern equipments the efficiency of the process has been improved to nearly 10 per cent by the development of semi-conductor thermoelectric materials, notably lead or tin telluride, germanium telluride or silicide or their alloys.

When operating, the reactor portion of this equipment, encased in a metal container, is underground with the thermoelectric system protruding above ground-level as shown in the figure. Biological shielding is provided by the earth which surrounds the reactor and by two shield plugs located above and below the core assembly. For transportation the reactor has to be completely shielded by the heavy Relocation Shield Sleeve, shown on the diagram.

The whole equipment is only 19 ft long, weighs 18,700 lb and it can be installed and put into operation in approximately seven hours.

The designers of this equipment have managed to solve the problem of previous attempts at a military reactor—cost! The estimated cost in this model is £350/kW, but this has been in the nature of an experiment. It is now recognized that the system is suitable for a military environment, and also it has attracted interest from civilian departments of the underdeveloped countries, and the cost is likely to come down as more equipments are ordered.

Before leaving power production, another small, but important British product deserves mention. This is the isotope generator, with which the reader is already familiar,[1] which is used to power two of the navigation lights on the approaches to Aldabra. The requirement here was for low-level power sources with a long life and no need at all for operator supervision. These 5 watt generators as shown in Figure 4 are capable of operating for ten years without the need for any maintenance. The generator contains the radioisotope strontium 90 which emits relatively penetrating β and γ radiations, necessitating about 500 lb of shielding. Again, conversion is by thermoelectric means. Their operation has been in the nature of a "troop trial", as a forerunner of a 100 watt generator shortly to be introduced to power surveillance devices in the forward area of the battlefield, where the requirement for silence justifies their relatively high price.

FACT OR FICTION

The sceptic may dismiss the foregoing as an unrealistic dream, not achievable by 1975; but he may well be wrong.

First let us examine the possibilities of nuclear explosive. The American Plowshare programme has now assembled a large amount of data on nuclear explosive and its effects. This work has been described in a previous article,[2] since which time there has been little progress in the excavation or cratering programme. This may well have been as a result of political controls resulting from the Partial Test Ban Treaty, and not because of any apparent technical problems which are likely to be insurmountable. Some concern has been expressed in the Joint Committee on Atomic Energy reporting to the American Congress, because of "the overly strict interpretation" of the treaty, which has caused cessation of practical experiments. Nor is the concern felt only in America. Non-nuclear nations make the point almost weekly at the Non-Proliferation Treaty negotiations, that a way must be left for underdeveloped countries to benefit from the non-warlike use of nuclear explosive. Another step forward was taken in autumn 1967, when a 24 kiloton device was detonated in a

[1] "Military Applications of Nuclear Power", by Maj. D. R. Whitaker, RE, *RE Journal*, Mar. 1965.

[2] "The Use of Nuclear Explosive in Defence Planning", by Maj. D. R. Whitaker, RE, *RE Journal*, Sept. 1966.

civilian gas field to facilitate the extraction of gas from a "tight" formation. This was a rather different case, where the explosion was totally contained, so did not vent a radiation hazard. Nevertheless, it was another sign of progress, and a harbour created by nuclear explosive in an isolated spot is certainly not beyond the bounds of possibility by the early 1970s.

The barge-mounted reactor is even closer to reality. A 10 mW(e) plant, manned by the United States Corps of Engineers, is due to come into service in autumn 1967. This particular model does not carry desalination plant, though it would no doubt be incorporated in a Mark 2 version. In concept the barge-mounted reactor is attractive and a lot will depend on the performance achieved by the *Lieut-General Samuel D. Sturgis*, as the prototype is to be named. If it is successful, it may have purely civilian application, possibly as an aid to oceanography, in which case the price might eventually come within the financial capabilities of our own Army.

The figure of £1 4*s* 6*d*/1,000 gallons for desalinated water quoted earlier came from an actual theoretical study of a land-based dual-purpose plant on another island.[3] A 100,000 gallons per day desalination plant when associated with a 7 mW(e) nuclear power system showed a saving of £3,400/year against a similar plant based on diesel. It is only fair to point out that the same study concluded that this small advantage in cost of water would be more than offset by the difference in cost of generation of power. The 7 mW(e) nuclear power system would cost £60,000/year more to operate than the corresponding diesel installation. Price-cutting, therefore, will have to be substantial before we accept such equipment for Aldabra.

The standby power system as described represents one interesting concept being evaluated for American Army use. It is designated TURPS—Terrestrial Unattended Reactor Power System. One significant difference is that TURPS is a conceptual design at present for only 100 kW(e), and not 500 kW(e) as proposed for Aldabra. A second difference is that the Martin Company, who have the contract for the feasibility study, describe £350/kW(e) as a wistful thought. Their estimate would be nearer £1,000/kW, though this might be reduced as orders come in.

It is emphasized that this is only just passing the concept stage. The Martin Company has now been awarded a contract for over $\$\frac{1}{4}$ million for a feasibility study, and estimates for a full development programme have been as high as $35 million spread over three to five years.

Certainly TURPS promises to be more suitable for a military environment than previous nuclear systems, and justifies a continued interest by our own Corps.

It is pleasing to note that desalination plant and isotope generators, the two remaining items, are already obtainable within the United Kingdom. A number of such generators under the generic name RIPPLE have been produced by AERE Harwell, with power output up to 5 watts, all for such civilian applications as weather beacons, marine and air navigation lights and submarine transistorized cable repeaters, all of them being in remote and inaccessible situations where the absence of operators is adequate compensation for the high cost of the generator. (A rough guide to cost is £1,000/watt.) Economic considerations restrict the potential use of such generators to a maximum power output in the order of hundreds of watts. At this level there may well be military application such as providing power for unattended surveillance devices or even for signals stations. Thermoelectric conversion, as employed in the RIPPLE series, would have the additional advantage of silence if used in forward areas.

CONCLUSION

The Island of Aldabra has, of course, only been a thin disguise for an article on matters nuclear.

Previous articles on the subject of nuclear power production described the fortunes of the American Army Nuclear Power Programme, which at this moment

[3] "Ascension Power and Water. Nuclear or Diesel." Report of 5 Feb. 1965.

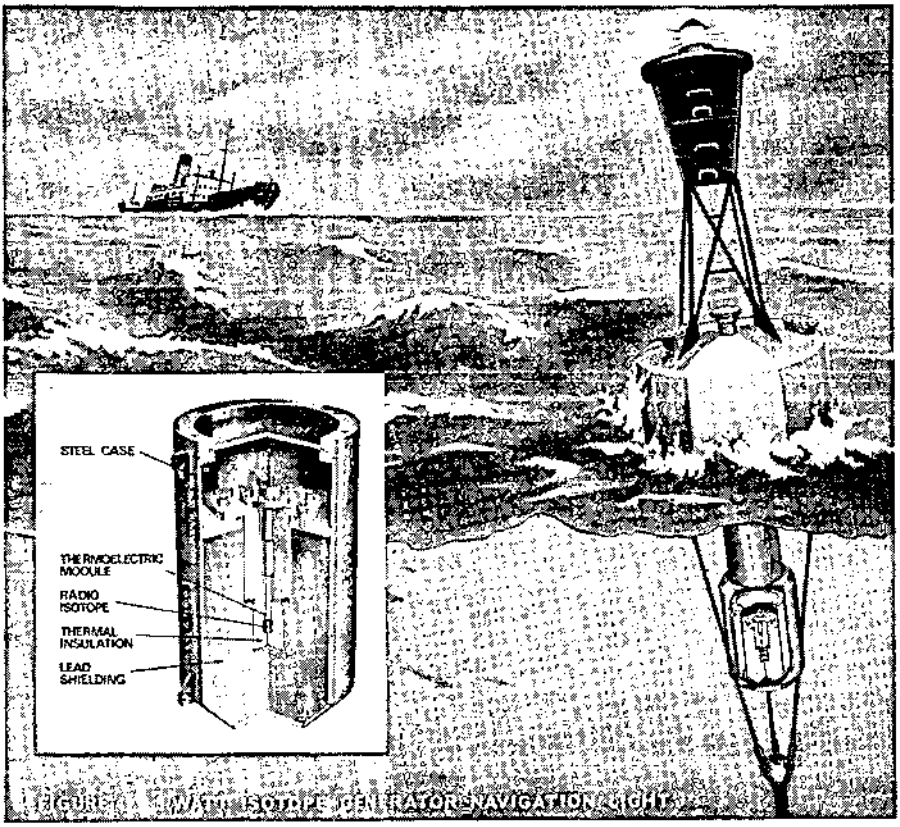


FIGURE 1 WITH ISOTOPE GENERATOR NAVIGATION LIGHT

is in a state of decline. In view of the costly nature of the American work, running into many hundreds of million dollars, the wisdom of the Royal Engineers' decision to restrict their participation to a watching brief on the US programme is apparent. This article has drawn attention to three areas of power production by nuclear means in the order of several thousand kilowatts, hundreds of kilowatts and tens to hundreds of watts where there is still potential military application backed by promising development. The American Corps of Engineers is still enthusiastic, as demonstrated by a three-page advertisement in *Army Digest* of May 1967, entitled "The job of the future wants you today. Its your opportunity as an Army Nuclear Power Man!" A similar advertisement in the *Sapper* in the 1970s is not outside the bounds of possibility.

Brief mention has been made of desalination with an outline description of one of the several methods now available. The Corps being providers of water for the Army, this subject may justify a more detailed technical description in some future edition of the *Journal.*

In the matter of nuclear explosive, we have only studied the American programme. In the not too distant future this could well become a normal civil engineering tool, and a positive decision must then be made by the Corps if our own Army is to benefit from this new technology.

These are matters which justify a periodic review of this *Journal,* and Aldabra could conceivably be a test situation for both nuclear explosive and nuclear power.

It this should ever come about, the author hopes he will be well away from the wrath of zoologists and botanists, who regard the island as an ecological paradise for their studies. But even the New Scientist biological consultant had to admit that it is "a pretty dreadful place", where only tortoises can live happily.[4] The day the Royal Engineers move in it could become a nuclear paradise.

[4] "High Politics on Tortoise Island", *New Scientist*, 8 June 1967.

Sunray Minor

MISCHIEF MAKER

ONE of the penalties of joining a technical corps is the well-known difficulty of finding time to serve with troops. Having spent many years on courses, staff and ERE appointments with only nine months as a troop commander, I relished the prospect of joining a field squadron as second in command for a year. I once propounded a theory in public that the personality and training required of a good chief of staff are quite different from and incompatible with those required for high command. Having been publicly humbled by a general who is clearly a commander, it has long been my intention to write a well-reasoned paper to refute him. However, a natural indolence and a lack of knowledge of my subject forces me to put off that masterpiece and write instead of humbler things. This then, is the saga of how they groomed me for stardom as a field squadron second in command.

The background to the story is of an officer with almost a full house of technical and staff qualifications and a minimum of regimental experience. The squadron (founded in 1862 according to our notice-board) has a long history of complete military paralysis, not having seen active service even in name until 1967. Its reputation, compounded of blarney and honest achievement in BAOR, was high and it had been selected for a six-month emergency tour in Aden.

The plan was—no, on second thoughts it would not be possible to write down all the plans and changes of plan that occurred between January, when I joined, and September, when we returned from Aden. What actually happened bore little relation to any of them:

Phase 1	January to March	Training and preparation in Germany.
Phase 2	April to June	Road construction and repair in the Radfan.
Phase 3	July to August	Odd jobs in Little Aden.

Viewed from Camberley in early January, the future clearly offered plenty of experience to a 2IC. One might almost have said, like Hoffnung speaking of a holiday hotel, "a french widow in every bedroom afforded delightful prospects". However, even the wildest expectations were surpassed by the events contrived by a well-intentioned, though evil-minded fate.

But back to the narrative. As everyone knows, there is no problem in moving a unit by air to a known job in a hot climate. I had done this in paper exercises several times before. A squadron to build roads in South Arabia? Easy, compared with moving a polyglot UN brigade to an IS task in South America. All that is required is a

proper movement plan, some simple documentation, get the unit freight off (What, no G1098? No vehicles? Splendid!)—and now let's get on with the training programme.

Well, we did manage to put some of the soldiers through part of the exhaustive programme which we concocted, and we did get nearly all 213 of them to Aden. Two things linger in my perforated memory. Do you remember that "get fit" order in North Africa and how senior staff officers were slanged for being out of training? For the first time I felt real sympathy for them as I pounded off every morning on those cold, dark, dismal runs round Osnabruck. Why had I said "acclimatization is no problem for fit men"? The other memory is of the passport business. Had I realized that it was so difficult and therefore started earlier perhaps it would not have become a problem. All you need is a photograph, a birth certificate and a signed application form. I suppose every unit has a Jamaican citizen born in Liverpool, a Briton born in India, half a dozen Southern Irishmen of doubtful parentage, and a number of healthy specimens who were never born at all. In desperation I even tried getting Irish passports from the Embassy in Bad Godesburg and was told in an angry brogue that they were not going to help the British Army move round the world; next thing we would be using them to invade the Fatherland. Why, oh why, doesn't the Army get a copy of every man's birth certificate on enlistment?

Our arrival in Aden coincided with the Muslim "Id" festival, which stretched from Tuesday to Thursday; Friday was the Muslim day of worship and in any case was Good Friday; and nobody worked on Saturday, Easter Day or Easter Monday. So we moved straight upcountry without having bought uniform or any of the necessaries which are said to be so cheap and plentiful in Aden. In fact, during the whole of our stay the shops seemed to be more often closed than open on account of strikes, holidays or floods.

Expecting to stay till the end of October, we did achieve one notable success as we stepped off the plane in March. I was asked when we expected to leave again, so I suggested 15 August. We continued to put this date forward and sure enough that was the very day on which our Advance Party left for home.

In other circumstances our camp at Habilayn in the Radfan could have made a magnificent holiday resort. (Incidentally it shouldn't be confused with "Sapper Camp", in which the infantry battalion was living.) Our Advance Party took it and the road works over as a going concern from our predecessors and, having counted all the socks and signed all the bits of paper, we were raring to go by the end of March. Which was a pity, because we couldn't do a stroke of useful work until the main body of the squadron finally arrived on 23 April. So much for our tidy movement plan. One night I spotted the previous 2IC setting off on his rounds of the defences dressed in a pair of shorts, a steel helmet and a furled black umbrella—so that's what six months upcountry can do to a man.

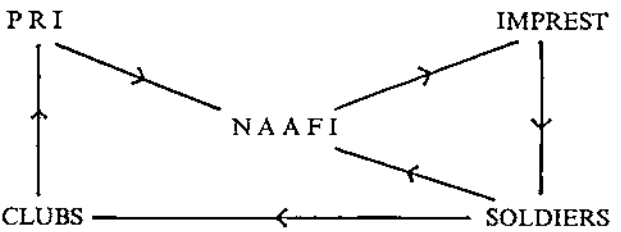
It is not my purpose to describe the road works here; in any case as an administrator they were not my primary interest. Suffice it to say that we had two main jobs. The first was to repair and resurface the main supply road from Aden to Habilayn, a job which was tactically justifiable and "engineeringly" indefensible. The second was to complete a new stretch of road from Habilayn into the Radfan area, which was "engineeringly" interesting and politically and militarily unjustifiable.

Connoisseurs of "Muddle East" will enjoy the command structure under whose lack of decision we suffered. We were under the operational command of Area West (Federal Army HQ) in Habilayn and the administrative command of 24 Infantry Brigade in Little Aden. Straightforward, except that our operational tasks were limited to defence for which we came under command of the resident infantry battalion, and engineer tasks, for which we were controlled by CRE (Ops) MELF. The latter was frequently by-passed by the Chief Engineer in the manner of one-over-one commanders everywhere. Nor did it make much sense for the senior Sapper at Habilayn to have no control over the Specialist Team for whom we provided several tradesmen and whose work overlapped with ours.

My favourite story of the Chain of Command is about the camp civil labours When we arrived there appeared to be no ceiling to the number of Arabs and Somali. we could employ on domestic duties and I was worried that the Command Secretary would one day write and ask me to pay back a few thousand pounds. So I looked around and found a PCLU sergeant in the garrison from whom I demanded an establishment. He asked his company commander, who asked Middle East Command, who asked the Chief Engineer, who asked CRE Ops, who asked his civil labour warrant officer, who rang me up and asked for a copy of my establishment. Astonished, I tried again, with the result that three weeks before we left Habilayn I was asked to write my own establishment. I am sorry to say that I never got round to this, although we did send our quarterly plant return to HQ BAOR as demanded. I often wonder what they made of the D4 tractor that we wrote off *in situ* after a mine explosion.

In the way of 2ICs I took a keen interest in stationery and produced a Pavlovian reaction to my predecessor's letter of advice. "You must bring three things with you," he said, "all sorts of stationery, a ten-ton trolley jack, and as many paperback books as you can." Sea and air freight bulged with these treasures, which we begged, borrowed and stole from all and sundry. We also sent off a stationery indent ahead of us, since these were reputed to take a long time to come through. He was quite right about the paper shortage; before we had been out long I was writing on the last sheet of paper to Ordnance saying, "If you do not respond to this final request, I shall be unable to write again." This produced an emergency supply closely followed by our own freight, our own indent, the indents of the previous two squadrons and eventually by our own sea freight. Perhaps it was as well that the latter arrived so late that we just repainted the boxes and sent it back again. As it was, we clearly aggravated the paper shortage in the Command and finished up making emergency supplies to friendly units. To be honest, we did not miss the other items we had been advised to bring either—there were three jacks in the yard when we arrived and a multitude of books streamed in by every mail from that excellent organization the WRVS. I must not leave out the sad affair of Plant Troop's MFO box which happened to have an old inscription "SILVER" marked on. I am afraid it may still be locked away in the customs shed at Aden.

For a squadron camp we were quite a microcosm of all arms co-operation. When you could persuade people to wear anything beyond a pair of shorts the following cap badges could be seen on residents or frequent visitors—QDG, RE, R SIGS, SAS, RCT, RAMC, RAOC, REME, RAPC, RPC, ACC. Pay was always a problem, since, as well as all these soldiers, I had 400 local labourers to pay. I was always running out of money and would urgently have to set my closed-circuit economy to work. We could almost as well have used beads or cowrie shells instead of dinars and fils. It worked something like this:



As PRI I banked the cash from the clubs and messes and paid their bills. So when I needed cash to pay the soldiers I paid our NAAFI bills and the manager then banked this money with me as Imprest. Simpler than it looks, though I was always getting money in the wrong box and lost a lot of sleep over the quantities involved—I averaged £4,000 a week.

Golly (Arab and Somali) pay parades were quite an experience and I always felt I might be overrun. Once I got a dud coin thrown back in my face and was relieved it wasn't followed by a knife. Screening was essential, since they all have the same name—Ali Mohammed Nasser. However, they receipted their time cards with a thumb print, so we could always prove identity in the last resort. In fact they were vastly overpaid so that threats and sackings usually produced discipline, and exposed one to bribes. The whole system was so open to abuse that I regretted my native scrupulous honesty. Those semi-skilled labourers were drawing more pay than the sappers and were inclined to spend half of it on the protection racket and the other half buying mines and rockets to use against us.

Not that I am anti-Arab; they were not all of the same ilk as the Federal Guard sergeant whose squad used to guard our work sites and plant parks. Wherever he went our equipment was always mysteriously attacked in the night or mines and booby traps were laid. On the whole we got on very well with the locals. For instance, I made a bad mistake by rushing down to the fort in a great hurry after breakfast one morning when the Federal Guards failed to report. Three-quarters of an hour later, after a "fudi" of chapatti and curry dipped in honey, I was allowed to broach the problem in hand. I rather grudged handing over all the stores in camp to the Federal Army at the end of our stay, especially since we had been on peace-time accounting all the while. However, my heart melted towards the little major who came to inspect the stores, who announced that he had been on a QM's course in England and then blandly said: "Is all right, I know all quartermasters have deficiencies and surpluses. I will accept your deficiencies if you give me all your surpluses." Little did he know. Not that we had many surpluses by that time, having dealt with the FAMTO account in a celebrated fire which drew spectators from all over the garrison. All part of the training of course, and I knew much more about fires by the time we had our next one a few weeks later. Thus reputations are made—now I can't even pick up a box of matches in public without someone passing a remark.

Boards of inquiry, abstracts of evidence, statutory declarations (never heard of them), casualty procedure (sadly), promotions, demotions, discharges, re-engagements and transfers—I thought my trainer had covered everything, but I was not prepared for drugs. Soldiers have a great talent for getting up to the unexpected. I was ready for firing weapons accidentally, even for traffic offences, although there was only the one road, but I did not even recognize the pellet of hashish which was produced one day.

Meanwhile work progressed on the road and we approached the time when withdrawal to Aden became topical. It must have been all that staff training which induced me to write a master plan. Nothing very complex, just a four-week programme covering stores handling, convoys, phasing out and the destruction of the camp. I might as well have saved the ink (biros, vegetables and beer were in short supply by this time), since the master plan became a bad joke. Later I realized, having completed two moves and planned another in three weeks, that the most effective way of doing it is to tell everybody where to go and blow a whistle. The result is the same. I gave up rewriting the convoy programme after four changes of the date of Withdrawal Day and took to putting anything on any vehicle that happened to be available. Has anyone seen my cinema screen?

Anyway, the road was completed in record time to our great pride and satisfaction. The road itself was opened in style when a commemorative plaque was unveiled on 15 June 1967 in the Wadi Lossum by the Chief Engineer—twice in colour and once in black and white. The fact that nobody used the extra tons of explosive, the

twenty wheelbarrows, forty bass brooms, six hammer drills and fifty tungsten carbide drill tips which we had obtained with such difficulty was a disappointment to me and a source of indignation to my SQMS, but a small price to pay under the circumstances.

We had to reduce our standard of comfort for the last few days, including switching off the generator which formed a central part of our life. Its background noise became very familiar, not least to the duty operator, who frequently forgot to refill it until the lights went out for lack of diesel. Some noises were less welcome and I remember waking one night to the rattle of machine-gun fire alarmingly close. I raised the alarm and was half-way to the Command Post before I realized that the Sergeants' Mess was seeing the film *The Lost Command.*

I might have suspected something was afoot when my squadron commander left with the first half of the squadron to withdraw to Little Aden. There always seemed to be a crisis whenever he went away. With a cheery good-bye he left me to raze the camp to the ground. There were a lot of earthworks and a number of stone buildings to demolish, so I had originally planned to use our two monster wheeled Michigan 285 Tractors. However, both the "Big Michs" had breathed their last a few weeks before, so I set about the task confidently with a Caterpillar D8H, a Caterpillar D4 and four light-wheeled tractors. All was going well when I was called to the airstrip, where I found a Beverley transport aircraft had blown up on a mine. It looked ridiculous and I laughed, as I promised to send down my D8 to tow it off the runway. But the laugh was on me—the D8 had run a big end before I got back to camp.

Never mind, "keep your plant working" they had told me in training, "work your operators in shifts", and the sandbag walls began to fall. Within four hours the D4 had sheared a whole lot of mysterious bolts, one of the wheeled tractors had burst a blood-vessel, and the other three had all got punctures. At that point I almost lost my sense of humour.

As our last long convoy crawled away from Habilayn the Arab scavengers were in the camp in their hundreds and the area was picked clean by the end of the day. It was a relief to get away intact and even more so to pass through the danger area of the Wadi Matlah unhindered. It grieved me, though, to see the devastation inflicted yet again by floods on the road we had lost two lives in repairing. If only the rains had waited just a fortnight longer to allow the British garrison to withdraw on the mine-proof road.

The story ought to end there with a quiet month or two downcountry passed over without mention. However we were not allowed to languish in a comfortable barracks and found ourselves moved at short notice into the empty secondary school. Some wag repainted the school sign to read "Robin's Reform School" and I occupied an office prominently labelled "Second Mistress". Perhaps the boys were getting their own back on a 2IC who was for ever teasing them. They were a happy squadron and I enjoyed my job with them. There must be a moral in this somewhere.

"Pageos"

MAJOR D. M. R. BATTERHAM, R.E

THIS is not an article about a mythical Greek god, but about a satellite whose unceasing orbit around the world has governed the writer's movements for the past year. Its full and ponderous title is: *Passive Geodetic Earth Orbiting Satellite.* This is not a technical paper, but a record of an interesting twelve months spent on an unusual task. For those interested in this new space-age, geodetic tool the technical details will be written elsewhere.

Early in 1966 I heard that I was to be in charge of the first British Army BC4 Camera team to take part in the USA Worldwide Geodetic Satellite Programme. A short attachment to an American team, then working near Edinburgh, gave me a preview of the equipment and the programme, and an insight into the problems faced by American tourists trying to get iced tea in Scottish country hotels in the off season.

In October 1966 the team formed up at Barton Stacey, comprising a warrant officer and two corporals, all Field Survey Technicians RE, and a Staff Sergeant Instrument Artificer, REME. On a crisp, sunny October morning we flew from London Airport on the first leg of a journey which was to take us during the year following some 27,000 miles.

First impressions of the United States followed and still remain vivid: the air of easy opulence, the freeways, parkways and beltways, the drug stores, endless cups of coffee, the White House and Capitol, centre of the greatest political power on earth, disposable cups, plates, knives, forks, and perhaps above all the warm-hearted people.

We spent five weeks training on the BC4 camera equipment at Beltsville, Maryland, near Washington DC. The team lived at Fort Meade, where we became acquainted with life on a US Army Base: the Post Exchange, Commissary, the cinemas, theatres, bowling alleys, golf courses; you name it, they had it—including a trip to New York's concrete jungle by Greyhound bus.

Rumour and counter-rumour preceded our first 'assignment' which consisted of a 2,500-mile flight across the North American continent to Moses Lake, a small Western town named after an Indian Chief Moses, situated near the centre of the great Columbia River basin in Washington State. Here we spent six months photographing Pageos on its three-hourly, 2,500-mile polar orbit and sightseeing in Washington State: the breath-taking Cascade mountains, Mount Rainier, and many excellent ski resorts: the amazing Coulee Dam project, whereby millions of acres of arid desert are being turned into some of the most fertile farm land in the USA: visits to British Columbia, over the border into Canada, where British Sappers once blazed a trail to the goldfields: the friendly Westerners, who were convinced we must be Canadians, since no one could possibly come all the way from England to the Pacific North-West.

More rumours and counter-rumours spread as our next move became imminent. Pitcairn Island, home of the famous 'Bounty' mutineers? Villa Dolores, Argentina? More hurried references to the library travel sections. Punto Arenas, Chile? Our geography improving daily. Then finally, could it be true? Hawaii!

Handing over our equipment to an American team, we flew over the Cascades to Seattle, and thence to Honolulu and finally Maui, the second largest, and possibly the most beautiful, of the eight principal islands of Hawaii. Here we were greeted by the British Secor team, who were already well established on the island and nearing the end of their stay. We found our BC4 station to be 10,000 feet up near the crater of a dormant volcano known as Haleakala, or "House of the Sun", where the god Maui was said to have trapped the sun in its course and persuaded it to move more slowly across the island. From the county town of Wailuku, where the team lived, a one-and-a-quarter-hour drive took us past a beautiful coastline with blue seas, paled by coral reefs, white beaches and palms fanned by the gentle (and often not so

gentle) trade winds, through sugar and pineapple fields, then cattle ranches and scenery reminiscent of the Cotswolds, through forests of eucalyptus trees to a twenty-two-mile winding but excellent mountain road with scenery changing from fields and flower-filled gardens to Dartmoor's heathland, and finally—could it be the moon? So similar is the surface of Haleakala's vast crater, twenty-two miles in diameter, to man's idea of the moon that US spacemen go there to train. As we puffed and panted in the rarefied atmosphere we could see other Hawaiian islands peeping through the clouds and set in the deep blue of the surrounding ocean.

Any job of a repetitive nature, as many survey jobs are, can be tedious, and this was no exception. Diversion and outside interests were of prime importance, and these were not lacking on Maui. Golf handicaps improved, coral reefs were scanned for their treasure of attractive shells by bronzed skin-divers. Visits to Honolulu on Oahu Island, some one hundred miles away, were possible, thanks to the kindness of the US Air Force detachment on Maui. These and many other diversions kept us fit and happy between long nights of observing on the mountain and the hundred-mile round trip up and down to the station on alternate nights. Our equipment was set up in Science City, a maze of radio and radar antennae, solar telescopes, observatories and other mysterious objects, wherein much scientific and technological knowhow remained entombed, emerging only to race up and down the mountain to the terror of timid tourists.

But even a posting to the Paradise Islands cannot last for ever. The work progressed well enough to enable the team with all the equipment to move to a new station, part of the next phase of the programme.

And so, with our equipment safely swallowed up by the cavernous jaws of a US Air Force C124 aircraft, we said good-bye to Maui after three months and began a five-day journey to Surinam in South America, a country about which the combined knowledge of the BC4 team would not have answered an elementary school exam question. The journey of some 9,000 miles was uneventful except for the interference of hurricane Beulah, which made us double back to Panama from Charleston, South Carolina, instead of to Puerto Rico.

We landed at Zanderij, the international airport of Surinam, at 1 am on 12 September to find, as we emerged from the belly of the huge aircraft, many smiling faces and helping hands waiting. These belonged to an advance party of the US Coast and Geodetic Survey, members of a US Secor team and a USAF PC1000 camera team who were already established on the site. The equipment off-loaded, we were driven at a dangerous speed along a pot-holed road, thirty miles to our hotel in Paramaribo, the capital and seat of government of Surinam.

This tropical country, only a few degrees north of the equator, is very different from one's idea of a typical South American country. Part of the Kingdom of the Netherlands and populated largely by the descendants of slaves and indentured labourers of past Colonial rule, here are found Creoles, Hindustanis, Chinese, Bush negroes, Amerindians and Europeans all living together in apparent harmony. The national language is Dutch, but English is widely understood. Here the writer was able, through the kindness of the West Indies Mission and the Missionary Aviation Fellowship to fly into the interior and visit a small Wayana Indian village. Here American missionaries have not only brought medical care, education and the ability to read and write a hitherto unknown language, but have given these very fine people, who until recently were doomed to extinction by infanticide, murder and superstition, the true meaning and purpose of life.

This article would be incomplete without a word of tribute and thanks to the American people as a whole and in particular to the US Coast and Geodetic Survey (equivalent to our Ordnance Survey), with whom we worked and whose acceptance of, and patience with, our British ways ('What did that British guy mean by his Sunray on the radio today?') helped to make our stay so enjoyable and worth while.

In November the writer returned to England at the end of an unique and interesting year.

Critical Path Planning for All!

(Reprinted by kind permission from the 29 June 1967 issue of the *Contract Journal*)

SITE personnel may regard the production of Critical Path programmes as the province of remote experts. In fact, this handy method of decorating the walls of site huts is readily available to all having the minimum of basic instruction.

Such a minimum is hereby provided, in the form of notes on Do-It-Yourself Critical Path Planning. As with all DIY activities, the aim is to produce a job with a professional appearance, and if the instructions below are followed a reasonably convincing network should result:

1. Obtain a piece of paper about 30 in high and as long as the site hut will permit. The longer the diagram, the safer from close scrutiny. Few agents are capable of following a 15 ft long network from start to finish without a tea break, and something is bound to crop up before the chase is resumed.

2. Starting at the left-hand edge of the paper, draw a continuous chain of short arrows from left to right. (Oriental staff, of course, begin at the right.) At intervals start new chains branching off from the original line, but ensure that these, too, proceed inexorably towards the right-hand edge of the paper. Chains of arrows wandering off the sheet and down the wall towards the foreman's size elevens spoil the professional effect you are striving to achieve. Dotted lines wandering between the chains are an indispensable part of the network.

3. On reaching the right-hand border of your sheet of paper, draw all the chains of arrows together to indicate contract completion. Write "CONTRACT COMPLETION" in large letters. This will foster the illusion that your network is likely to contribute in some way to finishing the works.

4. Above each arrow, write a description. (Oriental staff write below the arrows.) This should preferably be connected in some way with typical contracting operations, but should not permit identification with the durations which you will shortly be adding to the diagram. Thus "Excavate from lines A to E" would be excellent, providing the building contained no lines so lettered. The recommendation to confine the descriptions to those connected with contracting work might be challenged by some Do-It-Yourself Critical Path planners, notably by those who prefer to play safe by departing from sense altogether with descriptions such as "Fix grummets to Conveyor Canopy" or "second coat weaselproofing to lobbies". Personally I feel this to be too risky. I know agents who would spot it long before the end of the maintenance period.

5. All that remains now is to attach durations to the network and analyse it. The process is very simple, consisting merely of writing two figures at each arrow-head and a third in a box beneath the centre of each arrow. (Oriental staff take the day off.) Any figures will do. If the agent should happen to check an arrow and find he is twenty-six weeks behind programme on that operation, point out to him that he would never had known this had not Critical Path planning been used to control the job. Since he will be a busy man and unwilling to admit he is unaware of the location of the Conveyor Canopy, this will almost certainly silence him.

Those are the rules. Now—go to it!

The Officers' Association

THE Officers' Association was formed by the late Field-Marshal Earl Haig in 1919 for the purpose of promoting the welfare of all those who have at any time held a commission in our Naval, Military and Air Forces and of the wives, widows, children and dependants of such persons. On the formation of the British Legion in 1921 the Officers' Association adopted the additional title of "The Officers' Benevolent Department of the British Legion", but continued to operate under its own Royal Charter, with the Monarch as Patron and with its own Presidents, Vice-Presidents, Council and Committees.

The Association's activities are fourfold:

(*a*) *Relief of distress.* The Association gives financial help to needy ex-officers and their dependants including the provision of clothing. In the financial year 1965–6 it made 7,947 awards at a cost of £129,060, of which £26,184 was provided by other charities.

(*b*) *Homes.* The Association maintains a Country Home in South Devon for thirty-five elderly ex-officers of limited means and, near Watford in Hertfordshire, it has a Garden Homes Estate of twelve bungalows for needy disabled ex-officers and their families.

The Association holds the right of nomination in some other homes for the elderly and will assist generally in finding suitable permanent and convalescent homes for elderly applicants. In the financial year 1965–6 it placed 154 individuals in homes and also gave financial assistance to a further sixty-one who found places in homes for themselves.

(*c*) *Pensions.* The Association advises on all matters concerning Service Retired Pay and Pensions, assists in the preparation of disability and war widows pension appeals and arranges representation at the hearing of the Pensions Appeal Tribunals. In its general work on pension questions the Association co-ordinates its activities with all the other ex-Service organizations interested in dependants. In the financial year 1965–6, 912 cases were handled.

(*d*) *Resettlement and Employment.* The Association assists ex-officers to resettle in civilian life and to find employment. It is available for advice to serving officers at any time, but will not register them for employment until they are within three months of leaving the Service. It works in close co-operation with the Ministry of Labour and with other Service Employment agencies and is linked with the Regular Forces Resettlement Service administered by the Ministry of Labour.

Many thousands of ex-officers have been placed in employment by this Department. In the financial year 1965/66 it directly placed 563 ex-officers in employment and helped a further 697 to place themselves.

The Association is greatly assisted by Honorary Representatives throughout the United Kingdom, in Commonwealth countries and in many foreign countries where there are sizeable British communities, and these Representatives investigate cases and recommend appropriate action to the Association's Headquarters. Members of the Relief Committee visit the Association's Headquarters every working day to decide what assistance should be given. Under this system help is swift and effective. Over £100,000 a year is distributed in this way on the relief of distress.

Funds to carry on the Association's work come mainly from the Annual Poppy Day Collection, the British Legion, the King George's Fund for Sailors, the Army Benevolent Fund, the Royal Air Force Benevolent Fund and from legacies and private donations which are greatly welcomed. It works in close co-operation with all the Service charities and with Corps and Regimental benevolent funds. The Association has special working arrangements with the Officers' Families Fund, the Housing Association for Officers' Families and the ex-Services War Disabled Help Department of the Joint Committee of the Order of St John and the British Red Cross Society.

The Association also works very closely with other national charities and benevolent funds, from whom it obtains assistance in cases of ex-officers who have had a professional or other civilian career.

Calls on the Association for financial help have been so heavy that expenditure has exceeded income for many years, resulting in considerable depletion of the Associations' funds.

Anyone hearing of cases of distress among ex-officers or their widows or dependants, or any ex-officer requiring help, is invited to contact the General Secretary, The Officers' Association, 28 Belgrave Square, London, S.W.1 (Tel: 01-235 8112). The Association also has branches in Scotland at 223 Drumsheugh Gardens, Edinburgh 3 (Tel: 031 6684), and at 1 Fitzroy Place, Glasgow, C.3 (Tel: 041 CND 8141), and the Scottish Branch runs a Nursing Home for male ex-officers in Edinburgh. It also has branches in Northern Ireland at the War Memorial Building, 5 Waring Street, Belfast 1 (Tel: 0232 24025), and in Eire at 2 Martello Terrace, Sandycove, Co. Dublin (Tel: Dublin 801673).

Correspondence

DOWSING

THE following letters have been received commenting upon Major D. P. Cadoux-Hudson's article "Detection of Underground Objects in Divining", published in the June 1967 issue of the *RE Journal*, and Colonel A. H. Bell's article "Dowsing" and the letters to the Editor on those subjects, published in the September *Journal*.

Major-General W. G. Fryer, CB, CBE,
c/o Warminster Press Ltd,
Warminster, Wilts.
15 September 1967

Sir,—Since I wrote my letter of 5 July, giving some reasons for using geologists and geophysicists and not diviners, correspondents have reminded me that:

(*a*) In general diviners flourish only where the chances of striking water are 100 per cent or close to it.

(*b*) In some States in USA it is a criminal offence to take, or ask for, money for divining—its worthlessness being agreed as proven.

(*c*) Experienced well-drillers have very severe things to say against diviners, particularly those who have worked in areas of low chance of striking water.—Yours faithfully, W. G. Fryer.

Major-General Sir G. Brian O. Taylor, KBE, CB,
Tresillian, Durley Road,
Seaton, Devon.
17 September 1967

Sir,—I have read with much interest Major Cadoux-Hudson's article in the June *Journal* and the subsequent correspondence in that of September.

I am afraid that my experience in bomb disposal did not confirm the claims made in Major Cadoux-Hudson's article. While it was normally possible to identify the hole of entry of an unexploded bomb, its subsequent path through the earth was often impossible to trace or predict. Any change of texture in the soil, stone, etc, was sufficient to divert it. In one extreme case, for instance, a 1,800 kilo bomb, not only penetrated over 50 ft into the ground, but travelled some 60 ft laterally as well. As can be realized, anything which would enable us engaged on bomb disposal to determine accurately the exact location of a bomb underground would have been of inestimable value to us.

Early in September 1940 Colonel A. H. Bell suggested to me that the services of water diviners might be useful in locating UXBs and, after a hasty study of the available literature on the subject, I decided that it was worth a thorough investigation. At that time, in common with other RAF Fighter Stations, Biggin Hill was being intensively bombed by the enemy and I was told that there was a considerable number of UXBs lying about at various points on the aerodrome. I, thereupon, asked my opposite number in the RAF if he would be agreeable to my bringing down a water diviner to Biggin Hill with a view to accurately locating these UXBs and whether he could then undertake their excavation with his own organization, and this he agreed to.

I had at that time on my staff Colonel K. W. Merrylees, a RE officer with an international reputation as a water diviner, and on the following morning we proceeded to Biggin Hill. In between air raids Colonel Merrylees located some dozen UXBs and pegged out their actual location on the surface of the ground with a note of their depth down. I must admit that it was a most impressive performance, and there was no doubt that his divining rods indicated something underground. However, in no case was the object indicated more than a dozen feet or so from the hole of entry, or more than 15 ft or so in depth. Unfortunately, however, Biggin Hill was again very heavily bombed that afternoon and evening and again the next morning. Most of Colonel Merrylees' marks had been obliterated, some of the UXBs had gone off, and altogether Biggin Hill was in such a state that the RAF Bomb Disposal organization was quite unable to carry out the investigation we wanted.

I was naturally not satisfied with this and I got in touch with the National Physical Laboratory whose Director very kindly agreed to carry out a proper scientific test at their

laboratory at Teddington. Half a dozen metal objects of various kinds were buried at different depths about the grounds, the water diviner was led to a few feet distance from each object in turn and asked to locate it. The test was admittedly a severe one, as the grounds were interesected with water piping, buried cables, etc, and no doubt had an underground stream or two leading to the River Thames. The test proved to be an absolute failure, and in not a single case did the diviner locate the metal object.

I was still reluctant to give up hope and arranged for a further test to be carried out near Bristol with two well-known West Country diviners. Unfortunately I was unable to be present at the test, as my car crashed on the way to Bristol, but I received a subsequent report from my officers there that the result had been entirely negative. I, therefore, reluctantly came to the conclusion that divining was a totally unreliable means to depend on for the accurate location of buried bombs.—Yours faithfully, G. B. O. Taylor.

Brigadier H. E. Hopthrow, CBE, CEng, MIMechE,
Surrey House, Cowes, I.W.
14 September 1967

Sir,—I was very disturbed to read in the *RE Journal* of June 1967 that an interest in divining as a serious method of finding water is being revived. Fostered by articles on divining in the *Journal* between the two world wars, and a sentence in the *Water Supply Manual*, a large amount of working time and equipment were wasted by well-sinking units from 1939 to 1945. As General Fryer writes in his letter, published in the September *Journal*, diviners are sincere in their belief in their art or, to use Colonel Bell's words, their innate perception. In my experience most of them have vivid recollections of their successes coupled with a complete blank in their memory of failures.

When I was Director of Fortifications and Works during the Second World War, I had the good fortune to have as my adviser on water supply that great geologist the late Professor W. B. R. King, OBE, MC, FRS, with whom I often discussed divining. He likened the successful water diviner to the man who, using a hazel twig, slowly passed it over a billiards table and, following some movement from it, made a mark on the cloth and prophesied that if a hole were drilled at the mark slate would be found. A good friend, a retired officer of the Corps and an ardent diviner, is also a very good hydrologist, and I am sure he would be at least as successful in locating water without his ivory rods as with them.

As General Fryer says, divining makes a good story in the non-technical Press. We were plagued with this sort of publicity during the Second World War. After receiving a very cynically critical comment from a scientist in America about a Press report of a diviner's success in North Africa I signalled to the E-in-C Middle East for information. His reply ran something like this, "Diviners have more failures than success, conclude their skill is in locating aridity not water."

The *New Scientist* (31 August 1967) made critical comment on Major Cadoux-Hudson's article in the *Journal* and concluded that "it would be worth while for the technique to be investigated, possibly by the Army".

Owing to its early beginning and subsequent history, the water-supply industry of this country is not scientifically based. The Water Research Association is doing a lot to remedy this and, should the Corps undertake the investigation suggested by the *New Scientist*, I hope the co-operation of the WRA will be sought.—Yours faithfully, H. E. Hopthrow.

The comment made in the *New Scientist* of 31 August 1967, quoted by Brigadier Hopthrow, is published below by kind permission of the Editor of that journal.

THE MAJOR WANTS TO KNOW ABOUT DOWSING

The detectives who were eagerly searching for buried gold on a Bedfordshire farm recently need not, according to one view, have called in scientists equipped with sophisticated sensing gear. They could just as easily have done the job themselves, using bent pieces of wire. This, it may be presumed, would be the view of Major D. P. Cadoux-Hudson, of the Royal Engineers, who claims in the latest issue of the *RE Journal* (Vol 81, p 164) that practically anyone can successfully dowse, and that buried objects can be accurately located and their size and depth readily determined.

All that is necessary, he says, are two pieces of wire bent in an L shape. Wire from the coathangers used by cleaners serves admirably. With each hand shaped as for holding a beer mug (familiar to detectives) the shorter ends of the wire are held vertically and lightly in the hands while the longer ends are made to point out horizontally in front and parallel to each other. Dowsing, or divining, can now commence. This is done by moving forward at a slow walking pace with the forearms parallel to the ground and the whole body perfectly relaxed. When over an object the wires will swing inwards and cross, ending up right across the body. With a few people the wires swing outwards; and with even fewer, as Major Hudson rather naively points out, nothing happens at all. Once the wires have crossed right over, the object will lie directly under the feet. This can be upsetting if the object happens to be an anti-personnel mine!

To find the depth of an object the movement of the wires must be watched. As soon as they start to move together a mark is placed on the ground; another mark is put down when they are fully crossed. The distance between the two marks is the depth of the object below the surface. The nature of the substance can be found from the very convenient fact that if a sample of the same substance is held in the hand next to the wire, no movement of the wires takes place as the object is passed. A polythene tube of water can be made to confirm water (and presumably also polythene) and similarly a gold coin or ring can be used to confirm gold. The size of the object can be ascertained by approaching it from different directions and noting where the wires cross.

The point about all this is that Major Cadoux-Hudson is wholly serious and is convinced that the technique works, though he admits that he does not know how or why. His view, moreover, is shared by many both inside and outside the Forces. For this reason it would be worth while for the technique to be investigated, possibly the by Army. Indeed, it may not be an exaggeration to say that the modern image of the Army lies at stake.

If it is shown to be bunk, then this fact should be loudly proclaimed. But if it is even partially valid, as Major Cadoux-Hudson claims, then the limits of its validity should be clearly defined and some explanation put forward for its mechanism.

Major (IREM) S. Osborne, RE, Rtd,
Edgehill, 14 Lower Port View,
Saltash, Cornwall.
4 October 1967

Sir,—I was most interested to read the correspondence in the September *Journal* on water divining and, having strong views on the subject, I would like to join in the discussion.

I have always been a complete sceptic in this matter, and nothing in my experience has caused me to change my opinion. I have tried experiments myself with both twig and wires (when no doctor was looking), and have even held hands with a self-said dowser so that the twig was in circuit with us; but all with no result.

Also, I have heard stories of dowsers coming back after a field day with their chests bruised from the impact of the twig, so violent was the reaction. Other tales described the effect as so strong that the twig could not be raised to the horizontal position. From this it would appear that the twig acts differently with different individuals. What utter nonsense! There are always some people who like to imagine that they are different from the rest of us. This, of course, is simply vanity which shows itself in religious fanatics, self-styled spirit mediums and dowsers. To me, while the human element is involved in dowsing, it savours too much of the occult.

As to the power of innate perception resembling the instinct common to all animal life, as mentioned by Colonel Bell in his article on dowsing, I have always understood that what is termed instinct is really racial memory which, in the case of a domestic dog, makes him turn round several times before lying down to sleep as his ancestors in the wild state trampled down the grass to make a bed. Since there seems to be no record of our ancestors having had the power to discover water by any form of divining, there is no instinct of this nature for us to inherit.

At the risk of making this a long letter I would like to record some trials by self-styled dowsers.

In 1936 one of these was given a test at the Alexandra Palace, and a description of the proceedings was broadcast over the radio. The dowser claimed that he could detect the presence of metals as well as water, so some pieces of six different metals were buried at

shallow depth and a water pipe was laid just under the surface in the field used. The dowser failed to find the water and "discovered" only one metal, and the commentator said that, in his opinion, the dowser was really lucky to have found that.

In India in 1934 we required an additional supply of water for Fort Sandeman on the Baluchistan/Afghan border. The existing supply was by gravity from a natural spring some eleven miles out, but we were hoping to find a second source nearer the Fort. A suitable area was selected on the map and shown to the dowser who was sent from Simla. He eventually chose a spot for a borehole and, as an official of the Geological Survey of India agreed that this was the best spot, a borehole was driven, but with no result. I have forgotten to what depth the bore was carried before being abandoned.

Here I would like to introduce a humorous note. There was much argument in the Chief Engineer's office in Quetta on the failure of the Sandeman borehole. We were equally divided in opinion; the Chief himself and one other being believers, and we in the E and M office were hardened sceptics. Just at this time I happened to spot a copy of *The Humorist* which had on its cover a most amusing cartoon by H. M. Bateman entitled "Testing Water Diviners at the National Physical Laboratory". It showed a dozen or more candidates sitting blindfolded either side of a board-room table, each holding a twig at the ready. By a contraption of pulleys and strings and a hand windlass an assistant was solemnly drawing a large water melon along under the table. The twigs of the pair of candidates in line with the melon were vibrating like mad, while the remainder were deathly still. I made haste to take this to the office and, when we had got over our laughter, the cartoon was taken in to the Chief. He certainly laughed, but not nearly so long as we had.

Finally, in 1939, when the Didcot Depot was rapidly expanding, it was realized that we would require a much larger quantity of water than the 90,000 gallons per day then being obtained from a borehole in the Didcot valley. We were pumping from the green-sand level at 80 ft, I think, as were also the Didcot Water Co, who had a borehole some little distance from the WD site. The area was surveyed by a diviner from the War Office, who advised us to go deeper—to 120 ft—when we would obtain a much greater supply. So a second bore was driven. We struck water at the Green-sand level, but the remainder of the bore proved barren, even through we went down a further 50 ft on War Office advice and another 50 ft on our own. When we presented our problem to the Geological Survey we were told that the whole water-bearing area of the Didcot valley was good for only 120,000 gallons per day at maximum yield. Faced with this information, the War Office agreed that the only solution was a river intake scheme, and this was finally adopted. The demand at Didcot actually reached a quarter of a million gallons a day.—Yours faithfully, S. Osborne.

Captain H. Bradshaw, Royal Anglican Regiment
Post Crown Force, BFPO 656
16 October 1967

Sir,—As an Infanteer amongst Sappers, may I report that on the whole I am treated with kindness. I would, however, like to say, since Major Cadoux-Hudson's excellent article on Divining was published in the June 67 edition of the *Royal Engineers Journal*, my stock of wire coat hangers has dwindled alarmingly.—Yours faithfully, H. Bradshaw.

Major-General R. L. Bond, CB, CBE, DSO, MC,
The Dykeries, Compton,
Guildford.
23 September 1967

Sir,—I am amazed to see in the September number of the *RE Journal* a letter from Major-General Fryer casting grave doubts on the authenticity of water divining. Surely the value of this gift has been well proven and cannot be denied. I myself have used the skill of water diviners in Indian both as a Garrison Engineer and CRE, with valuable results.

When I was GE Ambala in 1932 I had occasion to suspect the performance of the surface wells which supplied the cantonment, graphs of the maximum and minimum water-levels showed me that the water supply would fail in less than five years. After reporting this grave state of affairs to Headquarters, I arranged for a well-known diviner, a RAMC officer in Rawalpindi, to visit me. Neither he nor I had any idea at all where water might be found if

at all. We toured the cantonment in my car and at one point his twig gave strong indications of water. After a series of tests he reported that there was an underground flow at, I think, 200 or 250 ft. He thought this was a fair flow, but in case it was inadequate there was an important flow at 700 ft. I immediately placed a contract for test boring with a well-known firm of well-borers. The test bore at the point indicated did, in fact, produce a fully adequate supply of water for the cantonment at the first depth. This officer and I traced the course of the flow to outside of the bazaar, a town of 50,000 inhabitants, where there was only a pitiful supply of water. As a result we were able to put down another well at the same depth giving a good supply.

As CRE in Waziristan, when building the Wana Cantonment, it became essential to find water within the cantonment boundary, as our existing Kareze supply was open to stoppage in the event of tribal trouble. I enlisted the services of a very expert RE officer water diviner (Colonel K. W. Merrylees). This officer was operating in the area successfully for the political authorities. We went to Wana and again, neither of us having any idea of where to look, we toured the cantonment. Merrylees eventually indicated a place where he said we should find a flow at 50 ft with a secondary and stronger flow at right-angles to the first at 60–65 ft. Test boring proved him to be correct and ample water for the cantonment was duly obtained.

Finally I remember some years ago reading an article (in *Blackwood's Magazine*?) by a lady employed as official water and oil diviner by one of the Western Provinces of Canada. Her finds were of the greatest importance. I cannot believe that a Government would employ at a large salary someone whom General Fryer would look on as a charlatan.

I have no doubt whatever from personal experience that water divining is an important and valuable characteristic of certain individuals.—Yours faithfully, R. L. Bond.

Lieut-Colonel A. A. C. Walker, AMIMechE, MIEE,
Bryntirion, St Mary's Road,
Leatherhead, Surrey.
12 September 1967

Sir,—Major Woollatt's method of detecting underground electric cables with two L-shaped wires may be compared with doing the same with cable tracers. These detect the magnetic field surrounding an electric cable when current is flowing through it. This reaction may be also felt when water is flowing through soil underground. A field is formed which reacts with a person standing above the flowing water. This field is caused by the flow of electric current associated with the flow of water in soil under the name electro-osmosis, see Bainbridge and Roscoe "Instantaneous Soil Stabilization by Electro Osmosis—Fact or Fantasy" in the *RE Journal* of June 1963.

When a potential of 30 volts is applied to a clay sample there is a flow of water from the negative terminal leaving the positive terminal dry. The same rate of flow occurs if the clay sample is placed under a potential of nearly one mile head of water. Thus in both cases there is a flow, which induces a field round it, which can be picked up by someone walking within this field. Hence the "Field" concept is a useful starting-point to solving the problem of how detection works.

Major Cadoux-Hudson detected unknown objects in the Black Bog of Co Tyrone, and confirmed it by prodding and digging.

Magnetic metal objects can be demagnetized, as were ships in the Second World War to protect them from magnetic mines. This may explain how there are conditions when the field surrounding an object to be detected can be neutralized, or weakened, and produces no reaction to the person trying to detect it. General Fryer's letter in this correspondence relates how the water diviners in the Libyan Desert were unable to discover water, but the geologists geophysicists "carried away the honours in locating desert water". Under the "Field" concept, the diviners would fail if the field was too weak to give a reaction to their rods, and one would then ask "Was the water still? Or too deep? Or what was the cause?" More evidence is required to enable the diviner's case to be properly judged.

At the SME in 1937 Captain (now Brigadier, Rtd) A. J. Edney, lecturing on Dowsing, said he firstly had a good look at the ground, having studied the geological maps and history of the area, to see if there was any vegetation on the site. His first detecting operation would be near a clump of trees or other tell-tale object. Water diviners and others use all the information available including, recently, photographs from low-flying aircraft which add

considerably to what is already known of buried objects, for example, "Roman remains". I have used the term "detection" in this letter because the word "divining" barely covers the operation used, and because this is a real thing and not just a phenomenon.—Yours faithfully, A. A. C. Walker.

From a Member of the British Society of Dowsers.
2 October 1967

Sir,—General Fryer's letter attacking dowsing contains some delightfully vague and unproved statements.

(*a*) He gives no names of the textbooks to which he refers.

(*b*) The search for UXBs by dowsing was abandoned because in most cases it was impossible for the dowser to walk all over the area under which the UXB was lying. In open country it was shown that exact location was possible. Laboratory-type experiments were unsatisfactory and still are.

(*c*) I know of no serious official search by a competent dowser in the Western Desert. *Military Engineering*, Volume VI, *Water Supply*, *Supplement No* 1, gives several examples of perched water tables found by geologists, but these were stagnant aquifers and soon exhausted. Fuqa was one, and here the "geological and hydrological conditions had already been determined by an extensive drilling programme involving more than 50 boreholes". I doubt if any dowser was ever given such a good start. The writer of this *Supplement No* 1 wisely makes no claim whatever that water moving in fissures can be exactly indicated on the surface above by any of the instrumental methods described. There are, in fact, very few fissure flows in the North African coastal area except for the drainage from the Nile Sudd swamp—too deep for wartime development—and some in the Cyrenaica limestone.

A military water-supply problem arose in Cyprus, where the water sources used were many miles from the two Bases and, apart from initial pipeline cost, required continual protection. No attempts by geologists or geophysicists appear to have been made to find water inside the perimeters—or perhaps they were unsuccessful? It would have been possible by dowsing to site wells inside the camps to draw from the same subsoil flows which fed the sources actually used.

One further comment. General Fryer insists that no one who knows the answers should be present when dowsing tests are being carried out. He evidently believes in telepathy, which is one part of Extra-Sensory Perception. Dowsing is another.

Can General Fryer possibly be wrong also about flying saucers?—Yours faithfully, "Dowser".

The following letters to the Editor of *Electronics and Power*, published in the August and October 1967 issues of that journal, are reprinted by kind permission of the Institution of Electrical Engineers.

K. H. Allen,
3 The Hundred,
Waterlooville, Hants.
6 June 1967

UNDERGROUND-SERVICES DETECTION

Sir,—I have always been sceptical towards the claims that some people are able to detect underground services, such as water mains or electric cables, with the aid of divining rods. Recently, however, I have been experimenting with an instrument which is now on the market based on this principle, and I confess to being somewhat surprised to find that I have been able to achieve the results claimed.

Although the practice appears to have more in common with black magic than with engineering, there must obviously be some physical explanation for the phenomena. If anyone can offer such an explanation, I am sure that a great number of us would be very interested to hear it.—Yours faithfully, K. H. Allen.

G. A. Langley,
4 Madeley Court,
London W5.
9 August 1967

THE ART AND SCIENCE OF DOWSING

Sir,—K. H. Allen (Aug 1967 *E & P*, p 311) mentions the use of divining rods to detect underground cables and pipes.

I was introduced to the art and science of water divining when I was a cadet at a Royal Signals OCTU early in the Second World War. Dowsing was, of course, not part of the formal practical training of telecommunication engineers in the British Army; it was a spare-time activity under the guidance of a brother cadet.

I well remember a group of us tracing the course of an underground stream while we walked across a Catterick moor. Half-way down a slope, the stream appeared to us to turn sharply through 90 degrees; we were engrossed in our dowsing and followed the new direction until, to our surprise, we walked right into an electricity-supply pylon. Turning round and looking back, we saw that our plotted trace lay directly under the overhead power wires from the point where we had made our right-angle turn.

Water divining certainly deserves a research effort; how the human brain is able to detect something that is presumably related to electromagnetic radiation must be one of the few sensory hurdles still uncrossed. And why are some people unable to "feel" the presence of water while others are excited by it?—Yours faithfully, G. A. Langley.

J. H. Leverton,
27 Drayton Park Avenue,
West Drayton, Middx.
9 August 1967

Sir,—With reference to K. H. Allen's letter, I was introduced to this method of services detection early this year using home-made divining rods, and it was only subsequently that I discovered the set Mr Allen refers to, which is now on the market. There is no doubt in my mind that the rods work, and both types work equally well, although the manufactured sets are more convenient to handle than home-made sets. It is quite clear, however, that not everybody is able to use them, but they appear to work for about 80 per cent of people I have tested. This causes a sharp division of opinion, those for whom they work being completely convinced of their effectiveness, and those for whom they don't equally being convinced that they cannot work.

I have not been able to determine the vital difference between the two, but am inclined to suggest that it is more likely to be physical than mental, as no one was more sceptical than I was at first, and yet I can now use them with confidence. I have had them used for surveying routes for new cable runs and ducts with complete success in practice, and for detecting cables (both energized and de-energized), water mains, gas mains and drains.

In spite of my conviction, I have been unable to formulate any theory as to the explanation of their operation, especially when the fact that it is possible to determine the material from which the buried object is made is taken into account. If, for instance, the object is an iron pipe, and if, after detection in the normal way, a small piece of iron is held in the hand in contact with the handle, the rods will no longer detect the iron pipe. The material of other objects can be determined by a process of elimination. As Mr Allen says, this savours of pure black magic, and I also should be very interested to obtain a physical explanation of the operation.—Yours faithfully, J. H. Leverton.

J. R. W. Murland,
25 Bedford Street,
Belfast 2.
7 August 1967

Sir,—May I refer K. H. Allen to *Biological Effects of Magnetic Fields* (Ed. M. F. Barnothy, Plenum Press, New York, 1964), which is in the IEE Library. In this work (p 279) there is a chapter, "Actions of a very weak magnetic gradient—the reflex of the dowser", which I think he will find relevant.

The footnote on the first page of this chapter is perhaps worth quoting: "The controversy of the dowsers versus the scientific world is such that accounts of such experiences are practically excluded from scientific literature. To find them, one must have the courage to explore the so-called literature of the dowsers and attempt to read it with a critical mind. We cite in this regard: Sir William Barrett and Th. Besterman, *The Divining Rod*, 1926; J. Cecil Maby and T. Bedford Franklin, *The Physics of the Divining Rod*, 1939; Dr Jules Regnault, *Bagnettes et pendules*, 1948; *Biologisches Neuland*, 1964; Prof S. W. Troup, *Psychical Physics*, 1949.

From a very extensive literature on the subject, three more references might be added:

Beasse, P.: *A New and Rational Treatise of Dowsing* (Progres Scientifique, Nice, 1941).

Mermet, A.: *Principles and Practice of Radiesthesia* (Vincent Stuart, London, 1959).

Maby, J. C.: *Physical Principles of Radiesthesia* (1966, published by the author, reproduced by Rank Xerox Ltd, Birmingham).

In conclusion, I would advance the iconoclastic view that the appearance of papers on this subject in learned-society journals will mark the beginning of another era in our technology.—Yours faithfully, J. R. W. Murland.

Major A. M. Pyne, RE,
The Royal Military Academy Sandhurst,
Camberley, Surrey.
20 September 1967

AHMED's PARABLE

Sir,—Ahmed remembers Brigadier R. A. Barron with respect, and he was delighted to read the Brigadier's interesting and witty letter in the September *Journal*. His only criticism is directed to the Brigadier's remark: "Wherever, at least, Tancore is to be found, Ahmed must be there as well"; for Ahmed has found in recent years that his good friend Futsoljah needs Ahmed's toys every bit as much. Futsoljah hardly uses his boots at all in Germany and it seems that he needs rechristening, too.

However that may be, Ahmed is a disappointed man. He has asked me to put his case provocatively, and he had been waiting with ill-concealed glee for the torrent of abuse which he was sure would fall about my head from outraged field squadron commanders and others. Ahmed would willingly have tolerated castigation or counter-argument, but silence (apart from the Brigadier)—that was a blow indeed! Did this mean disbelief or merely disinterest? I couldn't tell him. "You must be yet more provocative", said Ahmed; and so, with your permission, sir, I shall.

A vehicle-mounted army—and that, after all, is what we have in BAOR—is at the mercy of physical obstacles. Even quite small streams, if they are boggy or have steep banks, will stop tanks, APCs and SP artillery, let alone the enormous number of wheels in the echelons of any British formation in Germany.

Field squadrons are incapable of providing rapid crossings over obstacles of this sort. On major exercises one has so often seen engineer umpires imposing time delays at an obstacle—during which a field troop establishes a purely imaginary crossing—and then routing tanks and APCs over a civil bridge near by, even though that bridge had been 'blown' earlier. Why? Because if the troop had attempted a real crossing of the obstacle with the equipment available to them, the exercise would have had to be brought to a halt for several hours; and this would be unacceptable to the Exercise Director.

Yes, sir, I know all about the real bridging and ferrying operations over the Weser; and very impressive they are. But the Weser, for all its size, is not nearly so severe an obstacle—except in spate—as a much narrower, but steeper-sided river. There are not many Wesers around, yet field squadrons tend to be trained and equipped to cross them at the expense of the less impressive-looking obstacles they will meet so much more often.

Ahmed, perhaps, has an axe to grind. I have none. I ask only that our ordinary field squadrons in BAOR should be given the best equipment for the job they are called upon so frequently to perform. Will nobody deny that in terms of rapid obstacle crossing they do not have it?—Yours faithfully, A. E. Pyne.

Brigadier K. B. S. Crawford,
Redesdale, Broomleaf Corner,
Farnham, Surrey.
13 September 1967

COLONEL G. DE C. E. FINDLAY, VC, MC*, DL

Sir,—Thank you for the splendid Memoir about George Findlay.

At Bisley in 1908 he won the Spencer Cup as the best schoolboy shot of the year. After his initial course at Chatham he was Assistant Adjutant for Musketry for a time.—Yours faithfully, K. B. S. Crawford.

Brigadier R. Chenevix Trench, CB, OBE, MC,
Little Westport,
Westport Road,
Wareham, Dorset.
21 September 1967

Sir,—I was greatly impressed by the Memoir of Colonel Findlay in the September *Journal*.

His VC exploit recalls a story by my Company Commander before the First World War, Major Richard Lee. In the Boxer campaign in China at the turn of the century his column, without artillery, had to take a walled city, and the Kashmir Gate drill was followed. He led the party, with little expectation of surviving. Strangely, they were not fired on. The gate was blown, the bugle sounded and the assault went in, to find an undefended city, newly abandoned by its garrison through the opposite gate. He lost his VC, but preserved his life to command a division on the Western Front in the Great War.

He told me that the task fell to him automatically as the Senior Subaltern of his Field Company, and that this was the tradition of the Corps—a simple matter of routine duty. I wonder whether this reference to tradition justifies a place for my letter in your Correspondence Columns.—Yours faithfully, R. Chenevix Trench.

Brigadier Sir Mark Henniker, Bt, CBE, DSO, MC, DL,
Pistyll, Began Road,
St Mellons, Nr Cardiff.
14 September 1967

COLONEL J. M. LAMBERT

Sir,—May I add a few lines to the excellent Memoir to Jeff Lambert, published in the September 1967 *Journal*?

He took his place easily amongst the giants in wisdom of men and affairs. There were extraordinarily few subjects on which he was not well informed; and his views and judgements were illuminated by shrewdness and wit.

It was he, I believe, who first perceived that mines might be lifted by stealth from under the noses of the enemy in the Western Desert. He had weighed the chances and judged the risks rightly, and his plan worked so simply that no one ever suspected that it had been difficult or dangerous. Being so modest, he got little credit for the achievement.

He was wonderful in his dealings with persons. He could chat genially with corporals or learnedly with bishops; and was equally at home in a pot-house or a palace. He could tame the most unruly. He was never out for himself. His wisdom and judgement were at the disposal of anyone who cared to seek them. No one sought in vain. His contemporaries and juniors, particularly, have lost a man they trusted.—Yours faithfully, R. C. A. Henniker.

Lieut-Colonel J. D. Gemmill, MC*,
2110 Abbott Street,
Kelowna,
British Columbia,
Canada.
16 July 1967

POLO AT GIBRALTAR

Sir,—In 1914, just prior to the First World War, a team consisting of Neame, Oxley, Cracroft-Amcotts and myself won the Subalterns' Cup at the Gibraltar polo tournament.

It will probably interest old Sappers to hear that on a recent brief visit to England I was entertained by the three other members of that team, now Lieut-General Sir Philip Neame, VC, KBE, CB, DSO, DL, Major-General W. H. Oxley, CB, CBE, MC, and Sir Weston Cracroft-Amcotts, MC, JP, DL. With the exception of Neame, who was then recovering from a bad car smash, we are all extremely fit and enjoying life despite an average age of nearly eighty. Yours faithfully, J. D. Gemmill.

2nd Lieutenant R. P. Griffin, RE

2nd Lieutenant L. D. Palfrey, RE

2nd Lieutenant C. W. Prockter, RE

2nd Lieutnant, Roger Paul Griffin,Lancelot David Palfrey, Colin Winfred Prockter

Memoirs

2ND LIEUTENANT ROGER PAUL GRIFFIN

2ND LIEUTENANT LANCELOT DAVID PALFREY

2ND LIEUTENANT COLIN WINFRED PROCKTER

SHORTLY after midday on Saturday, 23 September 1967, three young Sapper 2nd Lieutenants, Roger Griffin, Lance Palfrey and Colin Prockter, were most unfortunately killed when in thick mist the Royal Engineers Flying Club Piper Tripacer crashed into the top of a ridge at Croft Ambrey, five miles from Shobdon Airfield in Herefordshire. They had taken off from Rochester earlier in the day and were flying to Shobdon. All three officers were cremated with military honours; 2nd Lieutenants Griffin and Prockter at Chatham on 28 September, and 2nd Lieutenant Palfrey at Hereford the next day after a service in Hereford Cathedral.

Roger Paul Griffin, was born on 21 June 1946, the only son of Mr and Mrs F. J. Griffin of 4 Marian Drive, Rainhill, near Liverpool. He was educated at Liverpool College and entered the Royal Military Academy, Sandhurst, with Intake 38 on 5 January 1965. He was commissioned into the Corps on 16 December 1966 and joined the Royal School of Military Engineering with 38 YO Course on 4 January 1967. He was due to finish his YO Course on 29 September and had been posted to 51 Field Squadron (Airfields) in Singapore. One of his main interests was flying and he held a private pilot's licence.

Lancelot David Palfrey, was born on 1 February 1947, the second son of Mr and Mrs W. Palfrey of 9 Orchard Gardens, Putson, Hereford. He was educated at Hereford Cathedral School and entered the Royal Military Academy, Sandhurst, with Intake 39 on 14 September 1965. He was commissioned into the Corps on 28 July 1967 and joined the Royal School of Military Engineering with 39 YO Course on 2 August 1967. He went on the Sandhurst Ethiopian Expedition in the summer of 1966. He, too, held a private pilot's licence and was a very keen pilot.

Colin Winfred Prockter was born on 15 December 1945, the only son of Mr and Mrs L. Prockter of 32 Chippenham Avenue, Wembley. He was educated at Kilburn Grammar School and in autumn 1964 went to Bristol University to read civil engineering. He found there that his interests were more aligned to soldiering, and on 3 November 1966 he joined Course 26 at Mons Officer Cadet School. On 15 April 1967 he was commissioned into the Parachute Regiment. Shortly afterwards he transferred to the Corps. He joined the Royal School of Military Engineering with 39 YO Course on 2 August 1967. He was well known for his enthusiasm for free-fall parachuting.

This tragic accident has deprived the Corps of three young officers with a remarkable amount in common. Each had the initiative, energy and interest to organize his own activities and to take full advantage of all that life offered, and of the opportunities for adventure which the Corps and the RSME provide. They had developed independence and self-reliance, yet all three were drawn together by a spirit of comradeship and a feeling of mutual trust. Thus it was that they shared in the enterprise that ended so tragically in their deaths.

All three had a love of adventure which was given practical expression in enterprises which match ability against a worthwhile challenge. Such enterprises demand high endeavour and are rewarded by that sense of achievement which is the goal of endeavour. This spirit of adventure was one of the most important influences in the character development of these three young officers.

Colonel S H Fisher CB MC TD DL FRIBA

COLONEL S. H. FISHER, CB, MC, TD, DL, FRIBA

STANLEY HOWE FISHER, who died in a nursing home at Eastbourne on 6 July 1967, joined the Inns of Court Regiment early in the First War and was commissioned into the 2nd London Division RE (TF) in February 1915. He joined the Reserve Regiment (2/2 London Division RE), and on 27 June 1915 he was posted to the British Expeditionary Force in France to join the First Line. He remained in that theatre to the end of the war, serving as Section Officer, as OC 4th London Field Company, from September 1916 to March 1917, and as Adjutant. He was awarded a Military Cross and was mentioned in despatches five times.

After the war he took part in the preparation of *47 (London) Division* (1914–18) *War History* and personally prepared all the maps.

He rejoined the Regiment at Chelsea, on re-formation of the Territorial Army, as major in command of No 2 Company, and succeeded Lieut-Colonel A. G. Birch, DSO, as CRE in 1923. At the end of a six-year command he was appointed Brevet Colonel and became Honorary Colonel of the Regiment in succession to Major-General Sir S. D'A. Crookshank, KCMG, CB, CIE, DSO, MVO, retaining that post until 31 March 1958. On 20 March of that year he was dined out by a gathering of all ranks of the Regiment and members of the Regimental Association, when he was presented with a silver statuette of a sapper officer in full dress—a combined gift from serving and retired members.

On the outbreak of the Second War he commanded 4 Training Centre RE and formed the Bomb Disposal School. He subsequently held appointments in Works Services and was promoted Colonel in 1945.

He was a member of the County of London Territorial Army Association from 1923, awarded TD 1934, appointed a Deputy Lieutenant of the County of London 1950, Chairman of Works and Building Committee TAA 1951, Vice-Chairman and Chairman TAA 1954/7, and created CB 1956.

Colonel Fisher was an architect by profession, qualifying as ARIBA in March 1914, and joined his father's practice immediately after the First War. He became the senior partner in 1928 and was elected FRIBA in December of that year. He retired from active participation in 1962, when he went to live at Eastbourne.

His sons did not follow their father into the Corps. Major B. S. Fisher was commissioned into the Gunners from Sandhurst in 1947 and, after fourteen years' regular service, he served a further six years in RA (TA). Captain M. H. Fisher, TD, followed his brother into the Gunners and, after National Service, served in RA (TA) to 1966.

Colonel Fisher had an unrivalled record of service in the 101 (London) Engineer Regiment (TA). He was a great London Sapper, a fine officer and friend, and he is mourned by all his old comrades.

D.K.E.

Brigadier CEA Browning CBE MC CStJ BA

BRIGADIER C. E. A. BROWNING, CBE, MC, KStJ, BA

COLIN EDWARD ARROTT BROWNING, a former Deputy Engineer-in-Chief and Commandant of the School of Military Engineering, Chatham, from 1951 to 1954, died on 30 May 1967, aged 67 years.

He was the eldest son of George Eliott Browning of the Indian Civil Service and was born in India. He spent, however, most of his childhood days in Budleigh Salterton and was educated at Cheltenham College and the Royal Military Academy, Woolwich. He was commissioned into the Royal Engineers, at the age of 19, in September 1918.

After a short course at Chatham he was posted to Longmoor, where he completed a Railways Course and then remained on the staff of the Railway Training Centre. In 1924 he returned to Chatham for a Supplementary Course and went up to Cambridge University as an Undergraduate at Trinity Hall, where he sat the Mechanical Sciences Tripos. On coming down from Cambridge he returned once more to Longmoor to become Adjutant of the recently reformed Transportation Branch of the Royal Engineers Supplementary Reserve—a plumb appointment for a Sapper subaltern. He was a keen games player and, as a young officer, represented the Corps at rugger, hockey, boxing and fencing.

Promoted captain in September 1930, he left in January the following year for Ceylon to take up command of the 31st (Fortress) Company, RE. After three years there he became a staff captain in QMG 8 at the War Office and, on promotion to major in May 1938, he was given command of the 15th (Field Park) Company, stationed at Bulford. He did not, however, stay long with the unit and in October of that year he moved to Aldershot to command the 23rd (Field) Company which formed part of the 1st Divisional Engineers.

His company went with the division as part of the British Expeditionary Force sent to France on the outbreak of war in September 1939. He was mentioned in despatches and awarded the Military Cross in recognition of gallant and distinguished services in operations during the retreat to Dunkirk. He next saw active service with the Eighth Army in the Middle East. He was CRE 8th Armoured Division at the Battle of El Alamein and CRE of the 50th (Northumbrian) Division at Mareth, where his Sappers advanced under a hail of fire, as though at the storm of Badjoz, carrying quantities of fascines and scaling ladders to force a crossing of the Wadi Zig Zaou—a formidable obstacle, about 200 ft wide with steep, unclimbable banks 20 ft high and a bed of deep, glutinous mud. Despite heavy casualties, the wadi crossing was an inferno of fire, a small infantry bridgehead was established and one fascine causeway was built over which a few tracked vehicles were able to cross. Heavy rain, however, brought the wadi down in spate, making the causeway unusable. To assist the depleted RE of the 50th Division two field companies of the 4th Indian Division were placed under command and, in the face of enemy counter-attack and heavy artillery fire brought down on the struggling British and Indian Sappers working under appalling weather conditions, the causeways over the wadi were completed. During the final stages of the North African Campaign, just before the capture of Tunis, he took over as CRE 6th Armoured Division of the First Army from Lieut-Colonel Basil Davey, promoted to become Chief Engineer XXX Corps. He returned to his old division as its CRE for the invasion of Sicily in July 1943.

Then followed a tour of duty as a colonel in the United States, first at the US Army Engineer School, Fort Belvoir, and then on the British Army Staff in Washington, DC. His unbounded enthusiasm and warm-heartedness endeared him to his American colleagues, and all with whom he had dealings were impressed by his experience and personal knowledge of combat engineering, gained on the battlefield, and his professional competence as a military engineer.

His final wartime appointment was as Brigadier, Engineer Staff, at GHQ India, which he held from March 1945 until October 1947.

On returning home he became Assistant Commandant, the School of Military Engineering, then located at Ripon. When the Headquarters and most of the School returned to Chatham in October in 1948 after a sojourn of over eight years in Yorkshire, he remained as Commandant of the Ripon Wing. In this capacity he was present on the parade, held on 27 July 1949 in the historic Ripon Market Place, when the Freedom of the City of Ripon was bestowed upon the Corps of Royal Engineers and accepted on our behalf by the Chief Royal Engineer of the day, General Sir Guy Williams, KCB, CMG, DSO.

In 1950 he was appointed Deputy Engineer-in-Chief at the War Office and he was created CBE in that year's Birthday Honours List.

In November 1951 he became the fortieth Commandant of the School of Military Engineering, Chatham, succeeding Brigadier Basil Davey, where he was to be connected once again with the presentation of a Freedom to the Corps. This time it was the presentation of the Freedom of the City of Rochester on 22 May 1954, which was accepted by the Chief Royal Engineer, General Sir Edwin Morris, KCB, OBE, MC, at a parade held in the Castle Gardens, overlooked by the Cathedral and the ancient keep of Rochester Castle, both so closely connected with Gundulf—our Founding Father and the first link in the long chain which so closely binds the City to the Corps of Royal Engineers.

He retired in September 1954, but returned to Chatham on 20 July 1962, together with seven other previous Commandants, on the occasion of the presentation of the Freedom of the Borough of Gillingham to the Corps and the visit of HRH The Duke of Edinburgh, who, after the Loyal Toast, informed those present at luncheon in the Headquarters Mess that Her Majesty the Queen, our Colonel-in-Chief, had graciously bestowed, as a hundred and fiftieth birthday present, the Royal title on the School of Military Engineering. It was a great occasion for the Corps of Royal Engineers and a personal recognition of the services of the long line of Commandants who had maintained the high traditions and achievements of the School since its foundation in 1812, at the insistence of the Duke of Wellington, and preserved that standard of individual and collective performance which its exigent founder Pasley demanded should never be less than excellent. Colin Browning, during his tour as Commandant, and throughout his entire service, never accepted anything less. His drive, enthusiasm, and good humour were infectious and his understanding and kindness to the young officer will never be forgotten by those who had the good fortune to serve under him in that capacity. On retirement he went to live in Ottery St Mary in the Devonshire countryside where he had spent so much of his boyhood. He was an accomplished and enthusiastic fisherman, a keen shot and an unusually knowledgeable naturalist. To walk with him along the River Otter, which he knew so well, meant a fascinating lesson on the wild life to be seen there. For him retirement did not mean a complete withdrawal from service to the community and, in recognition of his work as Secretary of the Devon St John's Ambulance Association, he was elevated from a Commander to a Knight of St John of Jerusalem in 1964. The British Legion and his own parish church also received in full measure the support which he so freely gave to any worthy cause which needed his help.

In late 1959 he decided to live again in Budleigh Salterton and there he remained until he died, at home with his family, in May 1967.

On 11 October 1927 he married Louise, daughter of Mr and Mrs A. S. Norrish of Budleigh Salterton, at Holy Trinity, Brompton, who survives him. They had a son and two daughters, one of whom married into the Corps. Our deepest sympathy is extended to them in their sad loss.

Book Reviews

MECHANICAL ENGINEERING DIRECTORY AND BUYERS GUIDE 1967–68

(Published by British Mechanical Engineering Federation, 25 Victoria Street, London, SW1. Price 40*s*)

This *Directory* replaces the British Engineers' Association *Classified Handbook of Members*, which was published annually for thirty-four years and was recognized as a reliable reference book on British supply sources of mechanical engineering equipment. The present *Directory*, now published every two years, is of particular interest to buyers, as it embraces a much larger number of British manufacturers whose products range from ball bearings to steelworks and power station equipment.

The first section of the *Directory* is the Buyers Guide and Foreign Language Glossary (French, German and Spanish), which lists manufacturers' products under more than 3,000 headings. Reference numbers facilitate easy cross-reference. Included also is a list of the British Mechanical Engineering Federation Members (including the Council) as at 1 March 1967 and short, descriptive summaries of the activities of the Federation.

F.T.S.

AN INTRODUCTION TO PRESTRESSED CONCRETE: VOLUME 2

PAUL W. ABELES, DSc, MIStructE, FAmSocCE

(Published by the Concrete Publications Ltd, 60 Buckingham Gate, London, SW1. Price 72*s*)

The author is a consultant on prestressed concrete and is recognized as one of the leading authorities in this relatively new subject. This volume is the second of a series of three which the author intends to write on this subject, which will cover all aspects of the use of prestressed concrete. Volume 2 is in continuation of his first volume and is divided into two principal parts. The first deals with the basic considerations for analysis and design and the second part is devoted to details of the applications, economics, faults and examples of the present-day use of prestressed concrete in the civil engineering industry. It is understood that the author intends to devote his third volume to the theory of prestressed concrete.

Far from being an "introduction", the two volumes so far published are very comprehensive indeed and are more advanced than the average civil engineer is likely to need unless he is actually involved in the design of a complete prestressed concrete structure. The two volumes are very useful reference books, but as the third is intended to cover the theory, they are of more use to the practising engineer than the student. Dr Abeles has a refreshingly unusual style of writing, so that both volumes make pleasurable reading. His approach is basically a very practical one and includes an excellent chapter on the Engineer, Architect and Contractor. This book is well illustrated with clear diagrams and an up-to-date series of photographs to illustrate the text.

R.C.G.

CEMENT AND CONCRETE ASSOCIATION RESEARCH REPORT NO 18: AN INVESTIGATION OF THE CRACK CONTROL CHARACTERISTICS OF VARIED TYPES OF BAR IN REINFORCED CONCRETE BEAMS

G. D. BASE, BSc (Eng), AMICE, J. B. READ, ESQ, A. W. BEEBY, BSc (Eng), AMICE, and H. P. J. TAYLAR, BSc (Tech)

(Published by Concrete Publications Ltd, 60 Buckingham Gate, London, SW1. Price 20*s*)

This report, which has been recently published by the Cement and Concrete Association Research and Development Wing, is of an investigation into the factors influencing the width and distribution of cracks in zones of uniform bending moment in reinforced concrete flexural members incorporating various types of reinforcement bar. The investigation, which was sponsored by the Civil Engineering Research Association, involved the authors in tests on 133 beams and measuring and analysing nearly a quarter of a million cracks. Rather surprisingly, the research reveals that the type of bar (whether plain round, square, twisted or bibbed) and the size of bar had little influence on cracking.

This report is unlikely to be of interest to the average RE officer, as it is a very specialized subject, but will certainly be of great use to consultants, contractors and, in particular, companies specializing in the design and casting of precast concrete units.

R.C.G.

STRUCTURAL ANALYSIS. 2ND EDITION

JACK C. MCCORMAC

(Published by International Textbook Cy., Scranton, Pennsylvania. Price $10.50)

The author is Associate Professor of Civil Engineering at Clemson University, North Carolina. This is the Second Edition of his book, the First Edition of which was published in 1960. This book illustrates the general trend in textbooks; in contrast with those of perhaps twenty years ago, it is readable and concerned with real problems.

Professor McCormac deals only briefly with design. In this field his references are to US practice. Starting from the Newtonian statements of equilibrium

$$\Sigma H = 0$$
$$\Sigma V = 0$$
$$\Sigma M = 0$$

he develops the methods available for the analysis, first of determinate structures and secondly of indeterminate structures. The reasons for the study of each new concept and its applications are fully discussed so that the approach is a strictly practical one and the reader's interest is held. The text is profusely provided with photographs which illustrate the type of structure being discussed. Diagrams are clear and adequate.

Each concept is illustrated with worked examples and chapters conclude with a series of problems. Only primary stresses are considered, but the examples are complicated enough to be real rather than the simplified problems frequently to be found in the usual textbook.

The first fourteen chapters deal with determinate structures and include the calculation of reactions, sheer and bending moments, the construction of bending-moment diagrams from sheer diagrams, the computation of stresses in trusses by the method of joints and the method of sections, graphical statics, influence lines for beams and trusses, reactions and stresses due to moving loads and, finally, an introduction to the analysis of space frames.

Chapters 15 to 24 deal with indeterminate structures. Chapter 16 is perhaps of particular interest and explains methods for approximate analysis. Later chapters deal with the calculation of deflections and deflection methods for the analysis of beams and trusses, Castigliano's theorems and the Three Moment Theorem, Slope Deflection, Moment Distribution, and the application of the Column Analogy to the calculation of fixed-end moments, carry-over and stiffness factors.

An excellent introduction to plastic analysis in structural steel explains all the essential concepts of the method.

The final chapter is a welcome addition to a book on structural analysis; it deals with the solution of simultaneous equations by matrix algebra with particular reference to structural analysis. The author foresees methods such as slope deflection regaining popularity as a result of computer solution of the large number of simultaneous equations which result. He stresses the mechanical nature of the matrix algebra involved and recommends its use in the analysis of complicated structures or in situations having many loading patterns.

Professor McCormac has produced a first-class book suitable either for initial study or as a reference book which would occupy a worthy space on any engineer's shelf.

J.D.W.

LOOSE BOUNDARY HYDRAULICS

A. J. RAUDKIVI, PhD, DipIng, MNZIE, AMICE, VDI

(Published by Pergamon Press Ltd, Headington Hall, Oxford. Price 50*s*)

Dr Raudkivi is Associate Professor of Civil Engineering at the University of Auckland, New Zealand. In preparing his book he set himself the task of summarizing and correlating all the relevant publications throughout the technical literature. In view of the very large list of references (some 240, appended to a text covering three hundred-odd pages), his emphasis has, of necessity, been on the production of a concise text. Nevertheless, adequate and frequent reference is made in the text to all the papers from which he has drawn his material.

The author has correlated the available material into fourteen chapters and an introduction. These cover the properties of sediments, the movement of sand by air and the formation of ridges and dunes. Later chapters are devoted to the movement of sediments in water, channel design and flow in channels. The book concludes with a discussion of coast formation, watercourse geometry, and scour.

This is no handbook; it is intended as a textbook for final-year undergraduates and requires an appropriate appreciation of the mathematics involved. It will serve as a valuable reference to the basic concept for the practising engineer. For the new-comer to the subject, by providing a discussion of the reasoning which led to present-day knowledge, the book forms a guide to the literature so that the student can add to his knowledge by a study of the source references.

J.D.W.

Technical Notes

CIVIL ENGINEERING

Notes from *Civil Engineering and Public Works Review*, July 1967

WESTERN AVENUE EXTENSION. The July edition shows a photograph of the first precast concrete unit of this 2½-mile elevated motorway which will run from White City to Paddington Green. The unit shown is 63 ft wide and weighs 45 tons. About 700 similar segment units will be cast by St Alban's Concrete Ltd, who are subcontractors to John Laing Construction Ltd. The consulting engineers for the whole £15.5 million project are G. Maunsell and Partners.

EXPLOSIVES USED IN US EARTHMOVING DEVICE. A short report and artist's impression is given of an earth-moving device using explosion cells and mounted on a Universal Engineer tractor. The device is being developed for the US Army Mobility Command Engineer Research and Development laboratories by the Southwest Research Institute, San Antonis. It is expected that the machine will be capable of digging a trench 10 ft wide, 5 ft deep and 14 miles long in 8 hours.

LATERAL STABILITY OF NON-UNIFORM ELASTIC BEAMS, by Campbell Massey, PhD, BA, BE, MIEAust, MNZIE. From the theorum of stationary potential energy and assumptions regarding the variation in twist along the span in the deformed state, the author derives equations for the critical loading conditions on single-span beams reinforced over the central part of the span to increase resistance to buckling. Three different types of loading and two different end conditions are considered. Examples are included in the article to illustrate the use of the derived equations. This article is only likely to be of interest to graduates in civil engineering, as the mathematics is complex.

The remainder of this edition is devoted to details and photographs of the engineering models and apparatus exhibited during the annual conversazione held at the Institution of Civil Engineers on 21 June 1967. The following articles are of particular interest to officers of the Corps:

THE NEW LONDON BRIDGE, shown by M. K. King, OBE, MICE. A brief description and photographs of the model of the proposed new London Bridge is included. The new bridge, which will replace the present one built between 1824 and 1831, will be a three-span prestressed concrete structure of 260 ft side spans with a 340 ft central span. The centre span is designed as a cantilever with a slung span measuring 107 ft. The project is scheduled to commence in November 1967 at an estimated cost of £3.3 million. The consulting civil engineers are Messrs Mott, Hay and Anderson.

NEW ENTRANCE TO LEITH HARBOUR. Messrs Rendel, Palmer and Tritton showed details of the new entrance lock to Leith Harbour. Major R. Jukes-Hughes, RE, worked as a section engineer with Edmund Nuttall, Sons and Co (London) Ltd, the main contractors, as part of his Long Civil Engineering Course last year. Currently Captain B. R. Rawlings, RE, who is on No 14 Long Civil Engineering Course, is working for the same contractor on the same contract.

MILITARY ENGINEERING EXPERIMENTAL ESTABLISHMENT EXHIBITS. Great interest was shown at the conversazione in the MEXE exhibits, which included prefabricated assault trackway, Mexiflote pontoon equipment, medium girder bridge and airportable bridge, high-speed road-surfacing unit, the rough terrain crane, light mobile digger and equipment for airfield reconnaissance. Particular interest was shown in the rough terrain crane which has already been used in prototype form on assault landing exercises.

BEA/BOAC CARGO TERMINAL AT HEATHROW. Sir Frederick Snow and Partners, consulting engineers, showed a model and photographs of the proposed BEA/BOAC Cargo Terminal at Heathrow. Work on this £10 million project is due to start shortly. BEA will occupy 18 acres of the 33.5 acre site and BOAC the remainder.

R.C.G.

Notes from *Civil Engineering and Public Works Review*, August 1967

TRENDS IN THE PRODUCTION AND USE OF REINFORCING STEEL. This article by N. P. Roberts, BSc(Eng), AMICE, who is the Senior Lecturer in the Department of Civil Engineering at the City University anticipates the revision of two codes of practice due to be issued in the near future. The codes involved are BS.785 (Rolled Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement) and BS.1144 (Cold Twisted Steel Bars for Concrete Reinforcement). The delay in producing these revisions has not stopped manufacturers from marketing a bewildering variety of deformed bars and for this reason alone the anticipation of the revised codes by this article is to be welcomed. In addition the factors affecting the choice of the various reinforcing steels are discussed and the article concludes by looking forward to the major revision of CP 114 due in two years' time.

ENGINEERING IN ANCIENT GREECE. A short but very interesting article by V. J. Wilmoth, MA, AIStructE, the editorial director of the *Civil Engineering and Public Works Review*, describes with illustrations the construction of water and sewage systems some 2,500 years ago. Such items as manholes, covered reservoirs, sand filters and earthquake-resistant construction are often considered as inventions of the recent past; the evidence of this article shows that this is not the case.

VARIATIONS IN STRENGTH, MOISTURE CONTENT AND UNIT WEIGHT FOR LIME-SOIL MIXTURES. C. A. O'Flaherty, BE, MS, PhD, Professor of Transport Engineering at Leeds University, and D. C. Andrews, BSc, Lecturer in Soil Mechanics at the same University, have produced in an article the results of a laboratory investigation into this subject. The object of the investigation was to rationalize some of the confusion which at present exists in different printed papers concerning the manner in which the addition of lime to a soil affects the moisture–unit weight–strength characteristics. Nine types of hydrated lime and a Portland cement were added to four soil types. It was found that there were considerable variations in the dry unit weight of a particular mix depending on the type and quantity of lime that was added, particularly noticeable when the clay content of the soil was increased. Other relationships were also investigated. This month's review covers Part I of the study.

Other articles in the August edition cover the Design of Circular Raft Foundations for Chimneys and the Fluid Motion associated with Flow-Induced Structural Vibrations.

B.O.B.

Notes from *Civil Engineering and Public Works Review*, September 1967

News items include the collapse of two sections of the prize-winning Calder Bridge. This occurred in late August and is thought to be due to a failure of temporary works. No explanation of the causes is as yet available. Notice is taken of the award of contracts for the extension of the new Victoria Line south to Brixton. This will ensure continuity of specialized production and retention of experienced personnel. Attention is drawn to the use of card-board tubes as form-work for concrete; in this instance the application is to the casting of cylindrical piers for an industralized housing development.

I. C. Hilton, BSc, PhD, Lecturer in Civil Engineering at the University of Manchester, proposes a system for the classification of grouts. This may well prove to be a valuable contribution to a field in which little quantitative data is available. The suitability of a grout depends largely upon its ability to flow through soil interstices and upon the final alteration which it imparts to the soil. Logically Dr Hilton bases his classification upon the

flow characteristics and upon the properties of the set grout. He provides for the selection of a grout by consideration of the permeability of the soil to be treated and upon the desired final strength and reduction in permeability. The article is accompanied by a list of eight references and an appendix giving very brief details of a wide range of commonly used grouts.

O. J. Ozomaka, BScEng, DipCE, of the University of Newcastle upon Tyne, writes an extremely well-referenced article in which he reviews four theories which have been developed for the estimation of foundation settlement on cohesionless soils. He concludes that the classical Terzaghi one-dimensional analysis still provides the most suitable design system. If for no other reason, the paper is of value in that it provides a list of no less than 102 references to the literature.

A short article describes the construction and operation of the world's largest solar distillation plant. This provides 11,000 gallons of potable water per day during the summer months, to the island of Patmos in the Aegean.

The second part of a report on the effects of the addition of lime to soils appear. (The first part was included in the August issue.) The authors, Professor C. A. O'Flaherty and Dr D. C. Andrews, provide a series of illustrative graphs and reach twelve conclusions, among which the most important are:

(*a*) That there are clear differences between the soil-stabilizing properties of different types of lime.
(*b*) Addition of lime decreases maximum unit weight of clayey soils and increases maximum unit weight of sands.
(*c*) Greatest improvements in unconfined compressive strength resulted from soils having highest clay contents.

The Feature of this issue is devoted to Maintenance. R. C. S. Stewart, Esq, CEng, AMICE, AMIMunE, contributes Part I of an article dealing with major maintenance to the main runway at a RAF Airfield. The runway is 9,000 feet long and tested to LCN 65. It had been used for the operation of B29 and Valiant aircraft, to the extent that total coverages exceeded the original design criteria. The article discusses the performance and condition of the existing pavement and the design and construction of remedial treatment. Some of the construction detail included is of particular interest.

J.D.W.

Notes from *Civil Engineering and Public Works Review*, October 1967

Three articles in the October edition of this periodical are likely to be of interest to RE officers.

DEFLECTION OF PERFORATED CYLINDRICAL SHELLS, by A. Chronoqicz, DipIng, PhD, AMIStructE, and M. A. Smith, BSc, PhD. The first-named author of this article is well known for his research and professional papers on the evaluation of the behaviour of shell forms. Architectural trends are towards the use of shell roofs of various shapes for buildings when large spaces without intermediate supports and required. Most shell forms result in economy of materials and minimum dead loads, so they are becoming increasingly popular. Analysis of simple cylindrical shells is usually based on the use of the membrane theory. Analysis becomes a major problem, however, when shells are perforated—normally in shell roofs to enable windows to be incorporated. This article is of interest, as it details the results of experimental work done by the authors in stressing aluminium sheets, bent to a cylindrical shape, with holes cut in them of various diameters and spacings. In addition, the experiments included tests on 6-ft-long, edge-stiffened shells made of cement mortar, some of which were perforated with holes of various diameters. The article is of some military value as the behaviour under load of cylindrical shells is of interest to those involved in the development of field shelters.

DESIGN AND CONSTRUCTION OF TYNE TUNNEL. The Tyne tunnel is the latest crossing of this river to be constructed and is the nearest to the mouth of the river. It is the first tunnel under the Tyne for use by vehicles. It will form an important link between Newcastle and Jarrow and between South and North Shields and will tend to relieve traffic congestion at bridges farther upstream. Construction of this new tunnel started in 1961 and was completed in October 1967, when it was opened by the Queen. The tunnel is 5,500 ft long and 15 ft 6 in radius; at the lowest point it is at a depth of 100 ft below the Tyne. The

consulting engineers for this project were Messrs Mott, Hay & Anderson and the main contractor for driving and the primary lining of the tunnel was Edmund Nuttall Sons & Co. The total cost of the project, including the pedestrian tunnel and approach roads, is expected to be about £12·5 million.

MAINTENANCE WORK AT A MAJOR RAF RUNWAY, by R. S. C. Stewart, CEng, AMICE, AMIMinE. Part 2 of this article, the first part of which was described in the *RE Journal* review of the September edition, is included in the October edition. It describes in commendable detail how quality control and supervision of the Marshall Asphalt surfacing was achieved. For this reason this article is of particular interest to those serving in airfield units of the Corps. The author has included a number of very useful design mix graphs for Marshall Asphalt and a number of photographs of the paving machine, the asphalt mixing plant and the Mettexture four-gun machine which is used for cutting chases in existing concrete slabs.

R.C.G.

THE MILITARY ENGINEER

JULY-AUGUST 1967

AUTEC, by Saul Fine. AUTEC stands for Atlantic Undersea Test and Evaluation Centre, which is being used by US Navy to evaluate weapons and defences for underwater warfare. This navy test range is sited in the Bahamas. This well-illustrated article describes the installations which provide for the testing of existing and experimental in-water weapons and weapon systems, the calibration of sonar systems, and the measurement of the noise radiation characteristics of surface ships and submarines. There are three ranges—Acoustic, Sonar-Calibration, and Weapons Tracking.

THE AERIAL CONE PENETROMETER, by Major S. J. Knight, US Army Reserve. A description in considerable detail of an instrument for assessing the trafficability of an area to which access is denied. The Penetrometer can be released from an aircraft or fired from a gun. It is actuated to signal the strength or consistency of the medium it penetrates either by the force of its impact or by the depth of its penetration.

CIRCULAR BARRACKS FOR THE COAST GUARD by Lieut-Commander Fred F. Herzburg. The Coast Guard corresponds to the Air Sea Rescue Service provided by the RAF. In order to save time in taking action on alert, the barracks for the personnel were ideally sited at the junction of two runways at the Naval Air Station, Barbers Point, Hawaii. In order to reduce the noise to a tolerable level for resting crews, a circular-planned building has been built. This article gives a detailed description of the building and of the special features in the design.

AIRBORNE CONTROL SURVEY SYSTEM by Hugh B. Loving. The Airborne Control (ABC) survey system is used for extending ground control by ground-to-air measurements. It will provide standard quadrangle maps at the scale of 1/24,000. The system and equipment is described in this article.

SUPPORT FOR THE VIETNAMESE HOME GUARD, by Major Herbert C. Puscheck, Corps of Engineers. The Vietnamese Regional and Popular Forces (RF/PF) comprise a unique and vitally important military structure. This article briefly describes the organization of the RF/PF and the help given by the US particularly in providing materials such as prefabricated buildings and cement, roofing materials, etc.

SUBMARINE PIPELINE IN AUSTRALIA, by Louis C. Wellman. This is a well-illustrated account of the construction and laying of a seven mile pipeline across the upper reaches of Spencer Gulf in South Australia. The pipe was made in Adelaide and delivered to the site, where it was welded into lengths for launching. The method of pulling the pipe across the gulf is described with photographs; to quote the article, "7 miles of pipe (internal diameter 33 inches, external diameter 39¾ inches) now rests in a back filled trench 9 feet below sea bottom in up to 70 feet of water".

THE NEW SHAPE OF SHAPE, by Fremont Felix and Colonel J. B. Newman, Corps of Engineers. A short well-illustrated account of the new SHAPE headquarters at Casteau in Belgium. The organization of the project is described and there are brief notes on the various construction techniques employed.

THE BRAIN TRAIN, by Major D. Bakeman, Corps of Engineers. On account of the move of NATO new accommodation to house the automatic data processing equipment had to be provided. The equipment, which handles the functions of stock control, financial management, and supply maintenance, includes computers of various kinds which have to be housed in accommodation which can be maintained at constant temperature. The solution was a train of railroad cars. This article describes the equipments and their housing, and is well illustrated.

HOT ASPHALT MIX—A JETTY CONSTRUCTION MATERIAL, by Walter C. Carey. The basic concept for the use of asphalt to repair and improve rubble mound jetties was originated in the Gulf Engineer Division, where engineers had been disappointed by some recent failures of concrete caps on several jetties along the Gulf of Mexico a short time after completion. This article describes the methods employed for capping and for an experimental all-asphalt jetty. It is profusely illustrated.

AIRCRAFT ARRESTING BARRIERS, by H. E. Burchell. A description in some detail of four resisting devices by means of which aircraft can be stopped on landing. The article shows the development of the design as faster and heavier aircraft came into use.

MILITARY ENGINEER FIELD NOTES

KA-DU MOUNTAIN ROAD, by Sergeant M. Edward J. Malen, 62nd Engineer Battalion. Describes the provision of a road crossing over an irrigation canal by laying corrugated iron culverts. A solution which was less expensive than bridging, as a bridge would have had to be above flood-level.

HYDROJETTING WATER WELLS IN VIETNAM. Lack of pure water seriously affects the living conditions in the rural areas in Vietnam. This article describes methods adopted by the engineers to overcome this shortage.

TRICKY TRAINING, by Private Larry Edwards, US Army. A description of a village resembling those built and fortified by the Vietcong in the rural areas of Vietnam which has been constructed at Fort Hood with the object of training. The fortification, consisting of "Mouse Holes", escape wells, tunnels and punji stakes and other hazards contrived by Vietcong, are illustrated with good photographs.

ENGINEERING LESSONS LEARNED IN VIETNAM, by the Army Engineer School. The subjects covered by this article are mainly connected with water supply and roads, including methods of overcoming erosion.

J.S.W.S.

G. PERCY

TRENTHAM

LIMITED

BUILDING

AND

CIVIL ENGINEERING

CONTRACTORS

READING BIRMINGHAM
LONDON STOKE-ON-TRENT
CARDIFF GLOUCESTER

PANGBOURNE READING BERKS — MAIN OFFICE —
WOOD LANE BROMFORD BIRMINGHAM
NEW ROAD RAINHAM ESSEX
PARK HALL LONGTON STOKE-ON-TRENT
ROATH BASIN BUTE DOCK CARDIFF
LAWRENCE DRIVE STOVER TRADING ESTATE
YATE Nr. BRISTOL
BRADMAN ROAD KIRKBY LIVERPOOL
64/66 HOPETOUN ST. BATHGATE (SCOTLAND)

Pangbourne	2201
Erdington	2491
Rainham	52902
Stoke-on-Trent	39147
Cardiff	30256
Chipping Sodbury	2024 AND 2636
Simonswood	3264
Bathgate	2494