INSTITUTION OF ROYAL ENGINEERS
CENTENARY MEETING
27th NOVEMBER 1975

FOREWORD

I would like to welcome you to the display of some of the activities of the Corps of Royal Engineers. This event and the meeting commemorate the centenary of the Institution of Royal Engineers.

J. C. Woollett

President
Institution of Royal Engineers

SOME HISTORICAL NOTES

The approval, given in 1871, for the foundation of the Institution of Royal Engineers, and the construction of the Institute building, was symptomatic of a wind of change which was to transform the whole of the British Army, to jolt it out of its traditional grooves and to propel it into the world of science and technology, from which it had, until then, largely stood aside. In 1868 Edward Cardwell became Secretary of State for War in Gladstone's new administration, which was to carry out some of the most important reforms of the Nineteenth Century. The famous Cardwell reforms themselves, introduced between 1870 and 1872, abolished the purchase of commissions and re-organized the Army on more modern lines, although they by no means did all that was needed to bring it up to date.

There are other good reasons too for regarding the years 1870 to 1875 as the start of a new era. Almost any year can be said to have been a landmark in the changing pattern of history, but this period seems particularly to have marked the end of one phase and the beginning of another. The age of steam and iron, of which the railways were the most impressive product, had almost passed its peak, whilst that of the new technology, based on steel, electric power and the internal combustion engine, which was to produce the motorcar, the aeroplane and the tank, had scarcely begun. At the same time the Franco-Prussian War of 1870 had aroused fears of further conflict and stimulated expenditure on defence by all the major powers. It was also a manifestation of the growing conflict of interest between the European nations, engendered by the rising tide of nationalism and colonial expansion, which was to culminate in the catastrophe of the First World War. Previous to 1870 there had been a long period of peace, whith no major war which involved Britain, apart from the Crimean War, since Waterloo. As a result, even the technology of the steam age had not had a great impact on the Services.

Life in 1875 would seem to us to have exhibited a curious mixture of the old and the new, of sophisticated technology and of old fashioned, traditional methods. Although a journey of any distance almost anywhere in Europe could be made by rail, road transport was still horse drawn, and the internal combustion engine was not to be invented for another ten years. Balloons were regarded as an amusing novelty, whilst the idea of a heavier than air flying machine was hardly taken seriously. Telegraphy was well developed and in widespread use, but the telephone had only just been invented and the first radio was not to be produced for another twenty years. Much was known about the uses of electricity, particularly in the communications field, and the potential of electric light was beginning to be appreciated, but the generator had only recently been invented and the generation of electric power on a large scale lay in the future. Although steel was employed in large quantities for machinery and on the railways, it was not yet available on a commercial scale for structural purposes, and concrete bridges were not yet in use. As far as armaments are concerned, smokeless powder, the magazine rifle, and a fully automatic and reliable machine-gun were not to be in service for many years, whilst the development of accurate, long range, heavy artillery, and of quick firing field artillery, was only in its infancy. Indeed the technology of the industrial revolution had scarcely touched the Army, outside the Sappers, and, to a lesser extent, the Gunners.

It was fortunate, therefore, that during the long period of relative stagnation in the Services as a whole before 1870, the Royal Engineers had established a system of training and of interchange with the civilian world of science and engineering, which kept them abreast of developments. As a result, when war made it urgently necessary to profit from the latest technology, they were in a position to provide the connecting link between the civilian engineer and the Services. It was in this role that they were of the most importance, rather than as innovators themselves, though some were that also.

It was an indication of the changes that were to come that in 1867 Sir Robert Napier, a Royal Engineer, was appointed to command the expedition to Abyssinia. It was at last beginning to be appreciated that engineering and technology had become a key factor in warfare, and in all the subsequent campaigns of the Nineteenth Century it was realised that success was dependent on the capacity of engineers to provide the means of supply and of communication in the field, in the form of railways and telegraphy. This was still true even in 1914, except that the telephone had replaced the telegraph for many purposes, but at the same time a whole host of new technological problems presented themselves, which the Army urgently needed to solve. Hence Royal Engineers were to be found not only at the heart of the development of military aircraft and of the tank but also helping to meet less spectacular but equally important needs, such as those for rifle grenades, trench mortars, and projectors for smoke and gas.

By the beginning of the Second World War the absolute necessity to make use of the products of science and engineering had been almost universally accepted throughout the Army, and such doubts as remained were quickly driven out by the combined pressure of military reverses and the influx of civilians. However, the scale of operations, the distances over which forces had to be moved, and the range of requirements which had to be met placed tremendous new burdens on the Royal Engineers, even though the Corps had previously shed two of its largest commitments, the provision of communications and of anti-aircraft searchlights. As always the main task was to provide the means of movement and of supply. But, whereas in the First World War this was dependent on a transportation system which was already in existence and to which the enemy could do relatively little damage, in the Second it was necessary to create, or re-create, the infrastructure needed to support an army over huge areas of territory and often at the end of long sea lines of communication. Moreover mechanization and airpower had made roads, airfields, electric power, bulk fuel and water supply of far greater importance.

The more that one examines the history of the Corps of Royal Engineers, the more difficult it is to disentangle the achievements of its members from those, on the one hand, of their civilian counterparts, and, on the other, of their brother officers in the Army. In the Nineteenth Century they moved freely between posts in public works or civil administration, military engineering, and command or staff. It was quite normal for them to proceed directly from survey work, or the supervision of the construction of canals, to take part in a campaign in Africa or on the North West Frontier of India. Numerous important posts in railways, telegraphs, irrigation, water supply, survey and other public works departments, particularly overseas, were filled by Royal Engineers and they pioneered a number of achievements in these fields of engineering. On the other hand, they did not do so on their own, but in conjunction with civil engineers and administrators, from whom they learnt and to whom they in their turn gave the benefit of their own ideas and experience. Equally the two World Wars brought great numbers of civil engineers and technologists of every kind into the Corps and it would be wrong to appropriate their achievements as solely those of the Royal Engineers. Nonetheless it was through the medium of the Corps, and the military experience of its officers, that these reservoirs of expertise were organized and put to useful military purposes.

Thus the Royal Engineers contributed substantially to the needs both of the nation and of the service. The variety of their employment is reflected in the careers of individual officers who were serving in 1875, on which there are some notes below, whilst the extent to which this system enabled the Corps to meet the needs of the Services is amply demonstrated by the displays covering different fields of military engineering throughout the past hundred years. These also serve to emphasize that whilst the task of the military engineer remains essentially unchanged, the means available to him have changed almost beyond recognition since 1875, as also have the weapons and equipment of the Services which he serves.

Apart from the survey companies, the Royal Engineers was a general purpose organization until 1870 and consisted of a number of identical companies and the Royal Engineer Train, which held equipment for use on operations. In 1870 the 22nd Company became a Telegraph Company and commenced a trend towards specialization which was to become more and more pronounced. By 1886 there were only six field companies left, and these were vastly outnumbered by specialist companies in fortress work, telegraphy, submarine mining and railways. This trend reached its peak in November 1918 when there were specialist units covering some twelve major specializations: works, electrical and mechanical engineering, water supply, fortress work, searchlights, mining and tunnelling, gas warfare, forestry, signals, transportation (including railways, port operation and construction, and inland water transport), and survey. At the same time there has been a counter-balancing trend to divest the Corps of specializations which threatened to disintegrate or swamp it, and, as far as possible, to revert to the all purpose organization, which provided greater unity and flexibility. Thus it no longer has responsibility for searchlights, signals or transportation, and has a greatly diminished role in works, and electrical and mechanical engineering. The 1975 organization is once more a general purpose one, with some exceptions, and the problem of integrating specializations has been at least partially overcome by grouping specialists into teams which can be employed separately or attached to units as required.

Meanwhile there has been a profound change in the orientation of the work of the Royal Engineers, due both to changes in the Services and to the radically transformed international and political scene. The deployment of the Corps in 1875, and indeed of the Army as a whole, was conditioned primarily by the needs of the Royal Navy. The major part of its work was concerned with the defence of ports, at home and overseas, whilst the possibility of involvement in a major European war on land seemed scarcely conceivable and operations were confined to minor colonial wars. The Corps also played an important part in colonial development, for which they had an ideal combination of qualities, those of engineer, administrator and keeper of the peace. By 1900 the defence of ports had become of less significance, because it was increasingly evident that they could be better defended from the sea than from the land, whilst involvement in a European war was beginning to seem a real possibility. By the middle of the First World War the Corps had been almost wholly transformed, from an organization primarily concerned with fortification and colonial expansion and development, to one which provided all the engineering and communication support for a huge field army in Europe. This change in orientation, which lost some of its force between the wars, was given further impetus by the Second World War and by the events which followed it. The decline of British colonial responsibilities and the civilianization of Works Services, which was completed in 1960, even threatened to prevent the Corps from maintaining its wide experience altogether and to confine it almost exclusively to combat engineering. But in practice this did not occur, because of the many unexpected military commitments which arose, mainly overseas but recently also in Northern Ireland, as well as calls for assistance in natural disasters and in providing aid to developing countries; examples of work of this kind can be seen in the display of civil engineering since 1945. This has been one exception to the general turning of attention in Britain towards Europe and away from the old Empire and Commonwealth. The operations in Northern Ireland have also made new demands of the Royal Engineers in developing counters to terrorist methods, and these may perhaps presage the start of a new period of re-orientation. In any event both past history and the unpredictability of the future more than justify the tenacious hold which the Corps has kept on its general engineering capability.

THE ROYAL ENGINEERS IN 1875

In 1875 the Army, and the Royal Engineers, still wore scarlet uniforms in the field. This is perhaps one of the most striking indications of the gulf in outlook which exists between then and now.

The Royal Engineers had 43 companies, of which 15 were overseas. Their locations are shown on the map display. However, the companies of the Bengal, Bombay and Madras Sappers and Miners must not be forgotten; they were all officered by Royal Engineers, the Indian Engineers having been absorbed into the home Army in 1869. Indeed by 1875 the Indian establishment had become larger than the home establishment, being 9 battalions, as compared with 8 for the home establishment, with a complement of 432 officers, compared with 385 at home. Some 285 of the officers on the Indian establishment were employed in public works and administration in India, including railways, telegraphs and irrigation.

The locations of the companies overseas indicates the close links with the Royal Navy, Halifax, Bermuda, Gibraltar, Malta and St Helena all being heavily fortified naval bases.

In addition to the companies there was the Royal Engineer Train, comprising three troops and a depot. 'A' Troop (Pontoon) carried and could build 100 yards of infantry bridging or 80 yards of bridge for field guns. Its complement was 4 officers, 122 NCOs and sappers, 95 drivers and 140 horses, 12 pontoon wagons (each carrying two pontoons), one GS wagon (tentage and tools), one forge wagon, one wagon carrying an iron boat (for casting anchors and laying out moorings), one wagon carrying landing bay and spares, and a cart fitted up as a travelling office. 'B' Troop was about the same size and was a complete mobile store of engineer tools and equipment, the forerunner of the modern field support squadron. 'C' Troop carried all the equipment needed for field telegraphy, including special wire laying wagons, and wagons fitted up as mobile telegraph offices.

The North American Boundary Commission was set up under the Treaty of Washington in 1842, which defined the boundary between Canada and the United States. The task was a large one and took a long time. No less than three successive Commissions were set up over the years. By 1875 the third Commission was at work, its task being, in conjunction with an American Commission, to fix the boundary across the whole extent of the prairies, a distance of approaching 1,000 miles, from the Lake of the Woods, 200 miles West of Lake Superior, to the summit of the Rocky Mountains on the boundary between Alberta and British Columbia. However in those days the province of Alberta was not yet in existence, and the whole vast area of the prairies was almost unknown and inhabited only by nomadic bands of Indians. The Engineer portion of the Commission consisted of three officers, two of whom were astronomical surveyors, and 44 rank and file. The method of work was to fix positions by astronomical observation at intervals of about twenty miles and then chain and mark the line connecting them. Swamps, blizzards and temperatures below -20^{o}F had to be contended with. Work began in 1872 and was completed by the end of 1875.

Some of the more prominent officers serving in the Corps in 1875 are shown on the map display. Of these, the lives of Kitchener and Gordon are too well known to justify more than the briefest comment here. Gordon at this time was eradicating the slave trade in the Sudan. Lieutenant Kitchener was on the Palestine Survey. He became seriously ill during the year and had to be invalided home, but he later returned to Palestine and completed the work upon which he had been engaged, in 1878.

It is unnecessary also to dwell on the lives of the two most distinguished members of the Corps at the time, Lord Napier of Magdala and Sir John Lintorn Simmons. The former was Commander-in-Chief in India and the latter Governor of the Royal Military Academy, Woolwich. Both were to become Field Marshals and were nearing the end of their careers.

H. Taylor Siborne succeeded Gordon as HM Commissioner on the Danube in 1873. The International Commission was set up after the Crimean War to control the works to be undertaken to improve navigation at the mouth of the Danube, which involved great engineering and diplomatic difficulties. As a young man Siborne had been charged with forming the first troop of the RE Train towards the end of the Crimean War. He managed to keep this going after the war, despite official neglect, and introduced the "lasso draught", a method by which several horsemen used lassos to draw wagons across difficult terrain, in which sappers were trained up until the time when mechanized transport replaced the horse. Subsequently he was responsible for designing the new fortifications of the Thames and Medway, built between 1860 and 1863.

R. Murdoch Smith, Director of Persian Telegraphs, was largely responsible for the successful establishment of the Indo-European telegraph line through Persia, which linked India with the government at home. This was an almost single handed epic against extraordinary difficulties. The Persian government insisted that they would build the line themselves with only one British officer to advise them. In the event this meant that he had to direct the work with one or two NCOs to help him, inefficient and ill-paid labour, and shortages of tools, equipment and transport. In addition he had to contend with disease, an inhospitable climate and arid and mountainous terrain in which there were few roads or even tracks. Furthermore the whole project was extremely unpopular with the Persians and Smith showed extraordinary tact and diplomacy in winning over the Shah and his officials. He arrived in Persia in 1863 and worked on the line, which was 1,250 miles in length, for more than twenty years, before accepting the post, in 1885, of Director of the Science and Art Museum of Edinburgh. In 1888 he became the Director-in-Chief, in London, of the Indo-European Telegraph Department. He retired as a major-general and died in 1900. During his career he had also made a name for himself as an archaeologist. He was an expert on Persian art and wrote a handbook on the subject, published by the Committee of the Council of Education in 1876.

Edward Stanton, British Agent and Consul-General in Egypt, had served with gallantry in the Crimea. He had subsequently been appointed British representative on the International Commission for the delimitation of the new boundary between Russia and Turkey in Bessarabia, on which Gordon was one of his two assistants. He left Egypt in 1876 to become British Minister in Bavaria until his retirement in 1882.

Edmund du Cane, Chairman of Directors of Convict Prisons, Surveyor-General of Prisons and Inspector-General of Military Prisons, took over all three of these posts from another Royal Engineer, Colonel Henderson, who left the Corps in 1869 to become Chief Commissioner of the Metropolitan Police. Henderson had been sent out to Western Australia in 1850 with a small party of sappers and seventy-five picked convicts, to start a new penal settlement. He subsequently asked for the assistance of three engineer officers, of whom du Cane was one, all of whom had come to his notice because of their work in connection with the Great Exhibition of 1851. Du Cane arrived in Australia in 1852 and remained there until 1856. Henderson returned in 1863 and was called on to give evidence before a Royal Commission on prisons, where he evidently created such an impression that, on the accidental death of the Chairman of Directors of Convict Prisons shortly afterwards, he was appointed to the post. He in turn nominated du Cane for the appointment for which he had originally been destined, that of Director of Convict Prisons. During his time as Chairman du Cane initiated a major reform, which transferred County and Borough Prisons from local to central government control. This became law in 1877 and he himself became Chairman of the Commission responsible for the management of the prisons of this kind in England.

John Donnelly, Director for Science, South Kensington served with distinction in the Crimean War as a subaltern. In 1856 he was given command of a detachment of sappers at the South Kensington Museum, which had only recently been founded. He quickly drew the attention of the authorities in the new Department of Science and Art and in 1859 he was appointed Science Inspector, responsible for organizing the Science Section and for supervising science schools and classes throughout the country. In the following years he was promoted within the Department, eventually becoming, in 1884, Secretary and Permanent Head of the Science and Art Department. He was instrumental in fostering the expansion of science teaching. In 1859 there were only four schools receiving grants from the department; by 1869 the number had increased to over 500 and by 1899 to over 2,000. He retired in 1892.

<u>Andrew Clarke, Governor of the Straits Settlements</u>, had as a subaltern been sent out to Tasmania with a small working party of Sappers and Miners. There he attracted the notice of the Governor, another sapper, Sir William Denison, who employed him as his private secretary. On Denison's recommendation he was appointed in 1853, Surveyor-General of the colony of Victoria at the early age of 29. The following year he stood for election, won a seat in the Victoria parliament and became a member of the cabinet, again as Surveyor-General. In the winter of 1857 he was asked by the Governor if he was prepared to form an administration and so could have become the Prime Minister of the colony. However, he declined, and returned home to England. He subsequently became Director of Works at the Admiralty, a post which he held for seven years. He left the Straits Settlements at the end of 1875 to become Member of the Council of the Viceroy of India with responsibility for public works. He returned to England again in 1880 and became Commandant of the School of Military Engineering for a year and then Inspector General of Fortifications.

John Ballard, Mint Master of Bombay, had a unique and extraordinary career. Whilst on leave from India in 1854, he joined the Turkish Army, then engaged in the Crimean War. The Turks made him a lieutenant-colonel and employed him as an adviser, and were so impressed with his abilities that in September 1855, at the age of 25, he commanded a Turkish infantry brigade in the successful battle of the Imgour River. For his services on behalf of the Allies he was made a Companion of the Bath whilst still a lieutenant, which is believed to be the only instance on record of such a distinction. Afterwards he accompanied the expedition to Persia in 1856. He became Mint Master in 1862 and held the post until 1879, by which time he had become an important adviser to the Indian government on currency matters. He became General at an unusually early age, but died unexpectedly in 1879, shortly after his retirement, when only 48.

Both the Bombay and the Calcutta Mint were built by Sappers, the former by John Hawkins, of the Bombay Engineers, between 1824 and 1829, and the latter by William Forbes, of the Bengal Engineers, at almost the same time. Forbes is famous also as the architect of St Paul's Cathedral, Calcutta. From about the middle of the century onwards both Mints were in the charge of the Indian and Royal Engineers.

Daniel Robinson, Director-General of Indian Telegraphs, a Bengal Engineer, was for twenty years a prominent member of the Survey of India, in which he became an expert in topographical survey. He spent some eight years carrying out a topographical survey of more than 10,000 miles of territory between the Jhelum and the Indus and was in charge of the Topographical Survey of Central India from 1859 to 63. He was appointed Director-General of Indian Telegraphs in 1865 and remained in the post until his unexpected death in 1877. He proved to be an administrator of rare ability; during his tenure of the office the telegraph system was extended over the whole of India and was connected by overhead and submarine cables with England.

Frederick Chapman, Inspector-General of Fortifications had had many years of peaceful service in the West Indies and the Mediterranean until distinguishing himself as a captain in the Crimean War. In 1867, after a year as CRE Dover, he was appointed Governor and C-in-C of Bermuda, where he remained until 1870, when he returned to England to take up his appointment as Inspector-General.

Lionel Gallwey, Commandant of the School of Military Engineering, had seen much service in North America and was an expert on fortification, having built forts at Portsmouth. He came to Chatham from Quebec in 1868, as Director of the Royal Engineer Establishment, and became the first Commandant the following year, when the title of the Establishment was altered to that of the School of Military Engineering. He later became CRE Gibraltar, Inspector-General of Fortifications and finally Governor of Bermuda, retiring eventually in 1888 as a lieutenant-general.

SOME NOTES ON OTHER OFFICERS SERVING IN 1875

There were many other officers serving in 1875 whose careers would be of interest and who are not singled out in the map display. There is not the space to do justice to them here, but brief notes on four selected from amongst them are as follows, first of all two who were fairly senior and then two younger ones:

After distinguishing himself in the storming of Delhi in the Mutiny George Chesney had done important work in the Public Works Department in Calcutta. In 1869 he persuaded the Indian Office of the need to establish a college in England for training civil engineers for service on government works in India. He started this College himself, at Cooper's Hill, engaged the staff and became its first Principal, a post which he was still holding in 1875, by now a lieutenant-colonel, aged 45. He returned to India in 1880, as Secretary to the Military Department. In 1887 he became Military Member of the Council of India and held this appointment until he retired as a General in 1892. Chesney was an outstanding example of the many fine administrators produced by the Indian and the Royal Engineers.

Like Chesney, Colin Scott-Moncrieff was a Bengal Engineer, who served with distinction in the Mutiny. In 1875 he was a major, employed on public works in Calcutta. He worked almost exclusively on improving and maintaining various systems of irrigation, and became one of the leading authorities on the subject. After retiring as a colonel in 1883 he was asked to report on the irrigation of the Nile Delta. He spent nine years in Egypt and started a full investigation of the whole system for the control of the waters of the Nile, which led to the construction of the Assuan Dam. He retired from Egypt in 1892, joined the public service in England and became Under-Secretary for Scotland, a post which he held for ten years.

As a subaltern George Sydenham Clarke spent nine years at the Royal Indian Engineering College at Cooper's Hill teaching practical geometry and engineering drawing, from 1871 to 1880. He then served in Egypt and the Sudan, returning to England in 1885 to become secretary of the new Colonial

Defence Committee at the War Office. He was subsequently sent on a number of special missions abroad, to examine defences and fortifications and the effects of gunfire. He became a leading expert on imperial defence, particularly on coast defence and naval warfare in relation to it. From 1894 to 1901 he was Superintendent of the Royal Carriage Factory at Woolwich, much of this during the critical time of the South African War. He did much to improve the mountings of the naval and coast defence guns of the period. After serving as Governor of Victoria, he returned to England as a member of the famous Esher Committee which reorganized the War Office, subsequently becoming the first Secretary of the Imperial Defence Committee which it created. He retired in 1905 as a colonel, and two years later was appointed Governor of Bombay, at the age of 59. He left this post in 1913, as Lord Sydenham of Combe. Throughout his life he wrote many influential articles and books, including many articles for the Times. His work on fortification, published in 1890, became a classic, and forecast, amongst other things, the imminent collapse of the Belgian fortresses covering Liege and Namur, if they were attacked; these were widely regarded at the time as masterpieces of modern fortification, but as Clarke forecast, were overrun by the Germans in a few days in 1914.

Another junior officer in 1875 who was to reach high rank was Lieutenant William Nicholson. He was commissioned in the Royal Engineers in 1865, three years before Sydenham Clarke. He spent thirteen years on irrigation and railway works in India before going on active service in Afghanistan in 1878 and then in Egypt in 1882, in both cases as a Field Engineer. In 1890 he became Military Secretary to Lord Roberts and five years later Chief Staff Officer, Punjab Army. He then rose through various staff posts to become CIGS in 1908, a post which he held until 1912, when he retired as Field

Marshal Lord Nicholson of Roundhay. Although none have achieved quite such eminence, his career was the prototype of the careers of many Sapper officers in the Twentieth Century, who reached high rank on the staff, particularly during the two World Wars.

ACTIVITIES IN THE LATE NINETEENTH CENTURY

This display is intended to show equipment, and activities of the Royal Engineers of the period, which do not appear in other displays.

The cylindrical Blanshard Pontoon seen in some of the photographs, designed by a Major Blanshard, had been in use since 1836. A new pontoon, the Blood Pontoon, designed by Lieutenant Bindon Blood (late General Sir Bindon Blood, Chief Royal Engineer) was introduced in 1870. This was boat shaped with covered ends and can be seen in the photograph captioned "Landing bay of trestle equipment and pontoon rafts 1875".

The Royal Engineers purchased their first steam traction engine, or Steam Sapper, in 1868. By 1875 the Corps had a total of ten, one of which was equipped with a crane. Initially they were used for the transport of heavy guns, but many other tasks were subsequently found for them, including the carriage of the heavy hydrogen gas cylinders used by the Balloon Service RE. Royal Engineers steam transport was used on a substantial scale in the South African War from 1899 onwards and by 1902 its complement of vehicles was 46 tractors and 2 lorries. A Mobile Electric Light Company RE, formed for the South African War and originally horse drawn, was converted to steam traction, and the tractors were subsequently adapted for many purposes to assist the work of the company. One of the officers of this company, Captain R S Walker, was a keen advocate of the internal combustion engine and was one of the first to advise its use in the Army for both vehicles and aircraft. The war drew attention to the potential of mechanical transport, in which the Sappers, the

Gunners and the Army Service Corps all had an interest. In 1902 it was decided that it should be made the responsibility of the Army Service Corps, but due to their experience of it the Royal Engineers continued to play an important part in its development for some years.

SUBMARINE MINING

The origin of the Submarine Mining Service RE lay in a memorandum written by the Inspector-General of Fortifications, Sir John Burgoyne, in 1863, which recommended the use of mines and floating obstructions for the defence of ports. The first Submarine Mining Company was established in 1871, but the service expanded rapidly, so that by 1901 there were no less than 13 companies and an equally large Volunteer establishment. The work of the companies included not only mining but also the operation of electric lights, used to enable quick-firing guns to engage targets at night. When responsibility for submarine mining was taken over by the Admiralty in 1904, the electrical side remained with the Royal Engineers and continued to be a major commitment.

The Brennan Torpedo was the invention of a Mr Louis Brennan, an Irishman resident in Australia. It was a wire-guided missile weighing $3\frac{1}{2}$ tons and with a range of over a mile. The torpedoes were manufactured in a special factory set up at Chatham by the Royal Engineers and installations for their employment were constructed at eight ports in the United Kingdom. It came into service in 1887.

Submarine mining involved what was, for the time, very sophisticated technology. The main weapon was a spherical, floating mine, known as the EC (electro-contact) Mine, which held a standard charge of 100 lbs of gun cotton. This could be fired electrically from on shore or by a circuit closer fitted to the mine, which completed an electric circuit when the mine was 'bumped' by a ship. The circuit closer eventually adopted was an electro-magnetic device which could be switched on and off from on shore, enabling a minefield to be made safe when our own ships were in the vicinity. This was much simpler than command detonation from on shore, which required a separate cable to each mine and entailed the danger of the operator firing the wrong mine. Even so this method was used in some cases, particularly for larger mines, with charges of up to 500 lbs, placed on the seabed. For this purpose an ingenious device, known as the Watkin position finder, was introduced in about 1885. An attacking vessel was followed with a telescope, which moved a pointer on a chart in the observing station. As the vessel approached a mine the pointer touched a contact which detonated it.

Many difficult technical problems were overcome. Making the mines waterproof after they had been filled with a charge was an initial problem, eventually solved by employing greased and paraffined leather washers. The circuit closing devices had to be developed empirically such that they would be activated by even a small ship and yet remain unaffected by wave action. Mooring the mines at the correct depth and taking account of the tide was another problem, which was never completely solved. Lieutenant R M Ruck invented an ingenious system in 1881, which allowed the mine to rise and fall with the tide, but it was considered too complicated to be adopted. Ordinary shackles which connected the mine to its sinker were found to work loose even if done up tightly with a marline spike. The same officer devised a shackle which automatically locked when any strain was placed on it.

The Mining Service did much to further the knowledge and experience of the Corps in several areas, including the use of explosives, electrical and marine work.

AERONAUTICS

The official connection of the Royal Engineers with ballooning and aeronautics began in 1878 when authority was given for experiments to be made at Woolwich, but for a long time it was hardly taken seriously and was given little support. Even as late as April 1909 the War Office prohibited further experiments with aeroplanes, as it was considered that the £2,500 already expended was too great!

The first successful use of balloons for observation during operations was in the Sudan in 1885, but it was in the South African War that they really proved their worth, when there were four Balloon Sections in the field.

The main weakness of captive balloons as observation platforms was that they could not function in winds of more than about 20 mph. To supplement them the man-lifting kite system of Mr S F Cody was purchased and Mr Cody himself was engaged as Chief Instructor in Kiting, in 1906. These kites could lift an observer to about 1,500 ft and could be operated in winds between 20 and 50 mph. There is an interesting account of the operation of this unique system in Brigadier Broke-Smith's 'The Early History of British Aeronautics', part of which reads as follows:

> "A light pilot kite was first sent up on a 1,000 foot length of cord or piano wire. Lifted by this, a steel cable able to withstand a pull of 2 tons was let out. Along this was despatched a series of winged box kites, in number seven to two according to the strength of the wind. These gripped

the cable, at short intervals from the upper end, by means of steel bulbs ..... When the necessary pull of one ton was exerted on the cable (which was indicated by a dynamometer on the winch), the large man-lifting kite or carrier, 19 feet in span between its principal wing tips, was hooked on to the cable and sent up. This drew a balloon basket or car which was slung from a steel trolley on the cable, to which the bridle of the kite was attached.

Reports could be made by telephone or message bag, as from captive balloons, and the same cable, observer's car or basket, and limbered winch wagon, could be used for both kiting and ballooning. A drill for the erection and flying of the kites, and for hauling down and repacking, corresponding to the balloon drill, was evolved, and the kites could be set up and flown, and an observer sent up, in the twenty minutes taken to fill and put up a balloon."

In October 1907 the first British Army airship was flown to London from Farnborough and encircled St Paul's Cathedral. It was piloted by Colonel J E Capper (later Major-General Sir John Capper, who became Director-General of the Tank Corps in May 1917), Commandant of the Balloon School RE. HM Airship Beta was its successor, 84 feet long and 24 feet 8 inches in diameter, and capable of a speed of 20 mph when equipped with a 20-25 hp radial air-cooled engine and two propellers.

Experiments with radios in balloons were carried on from 1903, and in 1908 the practicability of both receiving and transmitting from them was demonstrated, up to distances of 20 and 8 miles respectively.

The Farman Biplane was a French machine, purchased by the War Office in 1910. It was piloted by Captain C J Burke, Royal Irish Regiment, who had learnt to fly machines of this type in France and was attached to the Balloon School in advance of the formation of the Air Battalion RE in April 1911. It was powered by a 50 hp Gnome engine.

Lieutenant R A Cammell RE purchased the Bleriot XXI himself in May 1911, when the Army Bleriot which he had been flying was written off. It had a 70 hp Gnome engine and was capable of a speed of 60 mph. The pilot and passenger sat side by side in this aircraft. Cammell covered a distance of 110 miles in it in March 1912, which was a notable achievement for those days, but he was unfortunately killed in an accident in a new type of aircraft, which was later found to be unstable, in September the same year.

On 13th May 1912 the Royal Flying Corps (Military Wing) was officially inaugurated and took over from the Air Battalion RE, which by now had six aircraft and two airships in service. Up to this time the War Office had provided the minimum of money and resources, but with the formation of the Royal Flying Corps an initial requirement for 131 aeroplanes was specified, 26 of which had been ordered by February 1912.

FIELD TELEGRAPHY AND SIGNALS

The first Telegraph Troop RE, 'C' Troop of the RE Train, was formed in 1870, but there had been a Field Telegraph Train at Chatham since the Crimean War, when 21 miles of cable had been laid by a Royal Engineer officer and 25 sappers. A retrograde step was taken in 1875 when visual signalling was taken over by a new infantry school at Aldershot, and the electric and visual methods of communication were not brought together again under a single corps until the formation of the RE Signal Service in 1908. From 1870 onwards the field telegraph was regarded as essential in every campaign; it always followed, and even sometimes preceded the leading troops in an advance.

The heliograph was first used in the Zulu war of 1879, by the Telegraph Troop. Its peculiarity was that morse was sent by tilting the mirror, whereas its predecessor, the heliostat, functioned by means of a shutter which interrupted the beam reflected by a fixed mirror. It was found to give a much clearer and steadier signal than the heliostat.

Sir Garnet Wolseley's signal to the Queen, announcing the successful conclusion of the Egyptian Campaign of 1882, epitomizes the revolution in communications which the electric telegraph had brought about. It was handed in to the field telegraph office, established that morning at Tel-el-Kebir railway station, at 8.30 am on 13th September, and Her Majesty's reply from Balmoral was received an hour and a quarter later.

When the government decided to nationalize the telegraph system in 1870, two Telegraph Companies RE were raised for service with the Post Office, to assist in the rapid expansion of the system and at the same time to gain valuable training. In 1884 the Postal Telegraph Companies and the Telegraph Troop were amalgamated to form the Telegraph Battalion, which was to play an important part in the South African War. The latter established the value of the telephone, but not of the radio, which was not yet sufficiently advanced to prove a success. Previously, resistance to the proper use of the telephone had been considerable. It had been employed for some years by the submarine miners, but its value to the Army as a whole had been stultified by the insistence of the staff that all messages must be written down and sent by operators.

With the creation of the RE Signal Service, an era of rapid expansion began. By 1914 the Service had 75 officers and 2,346 men. However at the outbreak of the war a hundred messages a day was considered exceptional at a Corps Headquarters, whereas four years later the average daily number was 4,500. By that time the Service had expanded to some 70,000 all ranks. For the Somme offensive alone, in 1916, over 50,000 miles of cable were laid.

The RE Signal Service became the Royal Corps of Signals in 1920.

THE TANK AND ARMOURED ENGINEERS

The invention of the tank is closely assoicated with the name of Lieutenant-Colonel (later Major-General Sir Ernest) Swinton RE, who was largely responsible for its conception and for persuading the War Office to accept it. It was he also who coined the name "tank", as security cover. In 1915 he arranged for experiments to be carried out by the Ministry of Munitions, Trench Warfare Department, which was headed by another Royal Engineer, Colonel (later Major-General Sir Louis) Jackson. At the same time his idea had been taken up by Winston Churchill at the Admiralty, which accordingly had a head start in the work and produced the first model, adopted in 1916.

Several Royal Engineers played a prominent part in the employment of tanks in battle for the first time, notably Lieutenant-Colonel (later General Sir Hugh) Elles, the commander of the first tank unit and later GOC of the new Tank Corps, formed in 1917.

By the time that the Tank Corps was formed, it was already apparent that it would need a substantial scale of Royal Engineer assistance in crossing obstacles. Major C E Inglis RE (later Professor of Engineering at Cambridge) was put to work designing bridges and special equipment, including the 21 ft bridge carried by a tank shown in the display. It was planned to form three special RE battalions, each equipped with 12 of Inglis' tubular bridges and 48 of the special bridging tanks, but, due to the signing of the Armistice, only one battalion was formed, under Lieutenant-Colonel (later Lieutenant-General Sir Giffard) Martel RE, who had initiated this work when GSO2 of the Tank Corps.

After the war Martel commanded the Experimental Bridging Company RE, which, whilst under his command, was converted to become the civilian Experimental Bridging Establishment at Christchurch, the predecessor of the famous Military Engineering Experimental Establishment. He produced the design for the Large Box Girder Bridge and himself designed and built tracked vehicles, including a light one man tank. Two of these vehicles are shown in the display. Martel subsequently commanded the first mechanized field company RE and, as Assistant and then Deputy Director of Mechanization, played a major part in the mechanization of the Army before the Second World War.

In the Second World War the need for armoured equipment to assist tanks in crossing new forms of obstacle became of paramount importance. The first flail tank for clearing mines was developed secretly in the desert by a field park company of the South African Engineer Corps and was used at the Battle of El Alamein. In April 1943 a Royal Engineer officer, Major-General P C S Hobart, was appointed to command the 79th Armoured Division, formed to develop techniques for the armoured assault of defended and fortified beaches. A whole range of devices were produced, employing the Churchill tank as base vehicle. The principal equipment was the Armoured Vehicle RE (AVRE), which normally had as standard fittings a petard, a spigot mortar capable of throwing a 40 lb charge accurately a distance of some 80 yards, and a dozer blade, and could carry an 8 feet diameter fascine. Other versions included bridgelayers, "Arks" (tanks with the turret removed and tank tracks laid over the top and with hinged tracks at either end, used to form bridges and causeways), flails, and snakes (which used explosive filled hose to blow lanes through minefields).

The Chieftain bridgelayer is the latest version of these equipments, whose history dates back to 1917, whilst the Combat Engineer Tractor will take over many of the tasks of the AVRE.

RAILWAYS

Royal Engineers were building railways even before the rail boom had really begun. As early as 1840 a Royal Engineer was appointed as the first Inspector-General of Railways under the Board of Trade, to try to bring some order into the rapid expansion of the civil railway system, establishing a link which has existed ever since. A railway $10\frac{1}{2}$ miles long was built by the 10th Company (which became a Railway Company in 1885) in the Abyssinian Expedition of 1868. The bridge over the Kumayli torrent was one of the works on this line, which linked the base on the water's edge with the camp inland. However the first Company to become a Railway Company was the 8th, in 1882. Both the 8th and the 10th Company were engaged on railway construction in the Sudan Campaign of 1885-6, and the 8th formed part of General Wolseley's column which attempted to save General Gordon.

The Harnai railway is an example of the many strategic railways built in India under Royal Engineer supervision, with the assistance of civil engineers, and, in this case, both military and civil labour. The former included five companies of the Bengal Sappers and Miners and three Indian Pioneer battalions. The building of this particular railway was an epic achievement. It formed part of a system which linked the Indus valley with Quetta and the pass into Afghanistan leading to the important town of Kandahar. The first part of the line, across the desert, was laid during the Afghan War of 1878-80, at the rate of a mile a day. The Harnai section involved exceptional difficulties, of which the most formidable was the Chappar Gorge, in which the line had to run through nine tunnels totalling 6,400 feet in length and across the Louise Margaret Bridge, with a central span of 150 ft, at an elevation of 250 ft above the river. Working conditions were appalling. Cholera was rife and the temperature ranged from 124°F in the summer to -18°F in the winter. The country is described as "a region of arid rock without a tree or a bush, and with scarcely a blade of grass". In the monsoon season there were devastating flash floods, which scoured out culverts and wrecked bridges which were under construction. The line was opened in 1887, a monument to its creator, Brigadier-General James Browne, who had spent his life in the Indian Public Works Department and had designed the Jumna suspension bridge, the largest at the time in India, with a central span of 250 ft.

Royal Engineers continued to be employed on railway work in India until after the Second World War. The Khyber Railway was another great technical achievement, for which most of the credit is due to the remarkable survey and alignment work of Lieutenant-Colonel (later Colonel Sir Gordon) Hearn DSO RE.

The importance of railways in both the World Wars scarcely needs stressing, but there is not the space to devote more than the briefest reference to it. The Palestine Railway was built during the First World War from Qantara on the Suez Canal to Haifa in Northern Palestine, over 250 miles of double standard gauge track. Without it Allenby's advance into Palestine would have been impossible. This was perhaps the last example of the mobility of an army depending solely upon a single railway line.

The Southampton Rail Ferry Terminal was built in 1917, entirely by the Royal Engineers. Together with a new terminal at Richborough, it proved invaluable for the transport of locomotives, rolling stock, heavy guns and tanks to France.

The bridge over the Rhine at Spyck provided the first rail link over the river after the crossing in March 1945. By dint of working round the clock, using floodlighting and searchlights at night, it was completed in a month. It was 2,368 feet long, with 33 piers, each formed of 477 sixty foot timber piles, and involved erecting 1,200 tons of steel-work and moving 50,000 cubic yards of earth.

Huge numbers were involved in railway work in the Second World War. Transportation (including Inland Water Transport and Port Operating and Construction) employed a third of the total strength of the Corps, amounting to over 90,000 all ranks in 1945.

Railway construction remains a responsibility of the Royal Engineers today, although railway operating became the responsibility of the Royal Corps of Transport in 1965.

LINES OF COMMUNICATION IN WAR

This display is intended to illustrate the part played by major engineering projects, carried out by the Royal Engineers or under their direction, in the two World Wars.

It was decided in January 1916 to develop Richborough, Kent, as a depot and base for inland water transport. At this time the place had only one house and a short length of quay for barges. By 1918 it had become a large, well equipped sea port, with some 60 miles of railway sidings, and capable of handling 30,000 tons of traffic per week. The River Stour was diverted by cutting a new channel. This made possible the construction of 2,300 ft of new wharf for the cross-Channel barge service, in which, at the end of the war, 242 barges were employed, including ten of over 1,000 ton capacity. The Richborough train ferry terminal came into operation in February 1918.

The "Mulberry" Harbour, built at Arromanches in June 1944, was the work of the Transportation Branch RE, assisted by a panel of civil engineers. The breakwaters were formed by blockships and special concrete caissons, known as "Phoenix", ranging in size from 2,000 to 6,000 tons. Facilities for the discharge of ships were provided by the special pier heads, known as "Whales", formed of steel pontoons, which were connected with the shore by pre-fabricated floating roadways up to three-quarters of a mile long. The equipment was assembled on the South Coast, much of it at Marchwood, and towed across the Channel from there, the floating roadways in lengths of about 600 feet. About a quarter of all the stores delivered to Normandy came through the "Mulberry".

The "Pluto" pipeline was also designed for the Normandy invasion, and laid on the seabed from the Isle of Wight to Cherbourg. The work was undertaken by civil engineers under the Chief Engineer of the Anglo-Iranian Oil Company, the actual laying being mainly the responsibility of the Navy. The Royal Engineers constructed the complicated terminal required on the beach at Cherbourg, as well as hundreds of miles of pipeline, and pumping and storage equipment, to deliver the fuel carried by it to the Army in the field. A second system, known as "Dumbo", was laid from Dungeness to Boulogne, linking with a pipeline on shore, which was eventually built as far as Bocholt in Germany. This second system, at its peak, carried 3,500 tons of fuel a day. The total length of pipe laid by the Royal Engineers in the two systems was more than 1,100 miles, with storage for 100,000 tons. The total weight of stores distributed and installed was over 90,000 tons. The pipes were laid at an average speed of $3\frac{1}{4}$ miles a day.

The town of Rees was the scene of some of the heaviest fighting in the crossing of the Rhine in March 1945. The first bridges and rafts of XXX Corps came under observed fire whilst they were under construction and there were many Royal Engineer casualties. Subsequently two high level Bailey bridges were constructed on steel piles, between 20th April and 30th May. These two bridges, each more than three-quarters of a mile long, were the longest fixed span Bailey bridges built during the war.

Donald Bailey, Chief Designer at the Experimental Bridging Establishment, Christchurch, produced the idea for his bridge in 1941. His staff completed the finished design in the astonishingly short period of two months. The first production bridges were in the hands of the troops in December. It quickly superseded all other types of military bridging, with the exception of the Folding Boat Equipment, for light loads, and special raft equipments, and 80 feet of it was held as standard in every divisional field park company. During the course of the war 200 miles of fixed and 40 miles of floating Bailey bridge were manufactured in Britain alone; more was produced in the United States.

ELECTRICAL AND MECHANICAL ENGINEERING

The Royal Engineers first became involved with electrical work in connection with telegraphy and by 1869 all officers underwent a course in the Electrical School at the School of Military Engineering. The electric lights used by the Submarine Mining Service for port defence created a demand for power on a larger scale, and in 1894 generators were first brought into use for this purpose.

The Mangin projector was purchased from France in about 1885. Captain Cardew RE, the Chief Instructor in Electricity at Chatham, introduced a modification which greatly reduced its cost, by employing a simpler spherical mirror which he arranged to have manufactured in England.

In 1897 a new volunteer corps, the Corps of Electrical Engineers, was formed, to assist in the Submarine Mining Service, particularly in the operation of electric lights. Its officers were leading men of the electrical profession and the rank and file were practical electricians or students of electrical engineering. It was this new Corps which provided a searchlight unit for the South African War, equipped with traction engines and generators, and in the First World War it expanded to provide most of the Anti-Aircraft Searchlight Companies deployed in Britain and in France. By the end of the war there were ninety-three Anti-Aircraft Searchlight Sections. The anti-aircraft searchlight commitment was handed over to the Royal Artillery in 1938.

Some of the greatest achievements of the Royal Engineers in electrical and mechanical engineering were in Public Works in India. Captain (later Major-General) Joly de Lotbiniere RE designed and supervised the construction of the Cauvery Hydro-Electric Scheme in Mysore, completed in 1902 at a cost of £340,000. This was the first of its kind in India. Subsequently he was asked to do similar work in Kashmir, where the key feature of his design was a flume for water from the Jhelum River, 6½ miles long and about 8 ft square in cross section, at the time one of the largest in the world. The section shown in the photograph was built of heavy wooden planking held together by wooden frames. It passed through six tunnels and over or under eleven streams. This tradition was carried on by Colonel B C Battye DSO, who directed the Simla Hydro-Electric Scheme before the First World War, and, from 1922 to 1933, was responsible for the Uhl River Scheme in the Punjab, which included the first steel-mantled tunnel to be built in Asia, 2 2/3 miles long, and provided electricity for an area almost as large as England and Wales.

Considerable experience of mechanical engineering was also built up in the Submarine Mining Service, in barrack works and in other work, covering such diverse fields as the Brennan torpedo, engines for driving generators, mechanical transport, and heating and pumping plant. Nonetheless the resources of the Corps in 1914 had to be expanded enormously to meet the needs of the Army in the field. By far the largest commitment was for water supply and the single Electrical and Mechanical Company then in existence had to be augmented by seven further companies by August 1917, to maintain and operate pumping plant in France. Well Boring Sections were also employed on the Western Front, whilst in the Middle East there were two further Electrical and Mechanical Companies in Mesopotamia and three special Water Supply Companies in Egypt, by the end of the war.

The most remarkable achievement of the First World War was the building of the water pipeline from Quantara to El Arish, to support General Allenby's advance into Palestine. This was 96 miles long and built of 10 and 12 inch screwed steel pipe, in lengths which weighed about half a ton each. It was laid by local labour gangs under RE supervision at the average rate of $\frac{3}{4}$ mile a day, during the winter of 1916/17. It was subsequently extended a further 60 miles into Palestine. At its peak it delivered 900,000 gallons of water per day. It had a storage capacity of $1\frac{1}{2}$ million gallons in reservoirs at its three pumping stations.

This feat was paralleled in the Second World War by the construction of the water pipeline in the Western Desert. This was 270 miles long and the major part of it was laid in only two months, to support the advance to relieve Tobruk, in the autumn of 1941. It delivered 135,000 gallons a day and incorporated seven pumping stations and ten large reservoirs with a total capacity of nearly 2 million gallons.

The famous "Pluto" fuel pipeline is included in the display headed "Lines of Communication in War". The Corps continues to maintain a capability for this form of bulk fuel supply with its Emergency Fuel Handling Equipment.

During the Second World War the restoration of electric power for both civil and military use became of great importance. This was a particularly large commitment in Italy, initially in Naples, where, amongst other projects, the generators of three Italian submarines were coupled together; their output was converted to AC by inverting a converter set, and used to operate the town water supply. In central Italy 90% of the civil power supply was out of commission and five Electrical and Mechanical Companies were employed on re-establishing transmission lines. A floating power station was also improvised on a landing craft, intended to be brought up the Tiber to Rome, but eventually used at Leghorn.

In North West Europe the heavily damaged power stations at Caen and in the Antwerp area were repaired and recommissioned, and power lines and distribution cables were relaid. In the course of this campaign the Royal Engineers installed or recommissioned over 400 generators, erected 280 miles of overhead transmission line and laid over 3,000 miles of distribution cable.

Since the war they have been responsible for the installation of a generating capacity of 4,200 kws on Christmas Island, the nuclear test site in the Pacific, with 7 miles of overhead power line, and for smaller installations at the British Gurkha Depot in Nepal, in the Malacca Cantonment in Malaya, in Hamala Camp, Bahrein, and on airfield construction projects in Thailand and in the West Indies. Water supply schemes and well drilling have also played an important part in many projects, including both military and civil aid tasks.

SURVEY

During the 1745 rebellion the urgent need for a good military map of Scotland became apparent to an engineer officer on the staff of the Duke of Cumberland. The Board of Ordnance sent engineers to build roads and map the Highlands of Scotland. Later the threat of invasion from France made necessary a national survey and thus the Ordnance Survey was born and named. Once the provision of an accurate military map of the British Isles had been assured an extension of the department to include colonies and foreign countries followed. In 1803 a Department with the title "Depot of Military Knowledge" was formed. In the period from 1815 until the Crimean war little was done in the field of mapping. In the Crimean War Major T B Jervis reproduced at his own expense, copies of a Russian map and only then was the value of such information fully realised. In 1855 a separate department in the War Office called the Topographical and Statistical Department was formed.

From the time the Ordnance Survey was formed, RE officers have been involved in its work. The first military survey companies were formed in 1824 to assist the Ordnance Survey in Ireland.

In 1870 the survey of an area was carried out by the classical methods, measurement of a base line to establish scale, astronomical observations to determine latitude, longitude and azimuth and triangulation to provide accurately determined positions. The map detail was inserted by chain survey or by field sketching. This system changed little over the next half century, the major developments being limited to refinements of equipment.

Base lines were measured using composite bars of iron and brass, each 10 feet in length, six to a set which were placed on wooden trestles. Although Ramsden's two Great Theodolites each with horizontal circles of 36 inches diameter had been used up to 1862 in the triangulation of Great Britain, smaller theodolites with 5 inch horizontal circles were being used. The vernier, invented as long ago as 1631, was used to read the circles. Computation was by use of logarithms.

Maps were reduced successively from larger to smaller scales using a camera, the process having been proved accurate and adopted by the Ordnance Survey in 1854. Printing plates were prepared in a number of ways, the most common being direct engraving on a copper plate. Printing of maps was carried out entirely by the Ordnance Survey on hand printing presses.

The British Army was sent to South Africa at the outbreak of the Boer War with neither military surveyors nor maps. Although maps were available commercially their existence was not discovered until the war had been in progress some time. In 1904 as a result of the experiences of the Boer War and the formation of the General Staff the importance of the Topographical Section became recognised and in 1905 it was designated Geographical Section General Staff. Forward planning was introduced and for the first time the British Army included maps in its mobilisation equipment.

In 1914 the organisation for map provision in war was based on the anticipated needs of a small Expeditionary Force operating under favourable conditions and on the supply of maps printed in England. This organisation was extremely small and totally inadequate. The growth of the Military Survey

Service was extensive and by 1918 comprised nearly 5000 men. Originally the main task was the provision of large scale maps for forward areas, but, later, the fixation of enemy gun positions and other targets for our own artillery became a most important function. For this,new techniques had to be developed including sound ranging and flash spotting. Aerial photography was also used to provide up to date intelligence and mapping information. Another development was the introduction of the grid, formerly map references were made by referring to lettered and numbered squares drawn arbitrarily on the map, a method applicable only to individual maps.

At the end of 1918 all RE Survey Units were disbanded except for one located near the Ordnance Survey office at Southampton. The responsibility for Artillery Survey which had developed to become one of military survey's major tasks was passed to the Royal Artillery.

During the 1914-18 war the Military Survey Service provided maps for the Royal Flying Corps and this arrangement continues today for the Royal Air Force.

The period between the wars was noted for improvements in the design of theodolites, notably the Tavistock theodolite and developments in air survey. New ideas and instruments for plotting from air photographs became available and permitted mapping from air photographs using graphical methods.

The pre-war organisation of the Geographical Section of the General Staff was inadequate for a major war. In 1941 the Directorate of Military Survey was formed and Survey Directorates were established in commands at home and abroad. The Military Survey Service grew during the Second World War to a peak of 10 000 officers and men.

There have been major advances in ground survey techniques with the introduction of electro-magnetic distance measuring equipment which has made possible the rapid measurement of long lines. Tri-lateration, that is the measurement of all the sides, instead of the angles of a triangulation, and traversing with these instruments are now accepted methods.

The threat of inter-continental missiles has caused a closer military interest in the size and shape of the earth. It is now possible to link continents with the aid of satellites and two methods of fixing positions are in use. The SECOR method relies on radio ranging, whilst the BC4 method relies on simultaneous photography of a satellite against a star background. Both methods are used by 512 Specialist Team RE (Geodetic Satellite Survey).

Calculating machines which were first introduced in the 1940s have given way to electric desk calculators and in recent years to electronic computers. Survey calculations which previously took a great deal of time and effort can now be performed in a matter of hours.

In a modern technological age there are many developments which can be used to assist the survey service in its work. Developments in storing data using computers, in providing data for modern weapon systems and for rapid printing are all under consideration.

THE ROYAL ENGINEERS IN 1975

In 1975 the Royal Engineers have 57 squadrons, of which 32 are overseas. There are 2 squadrons of the Gurkha Engineers stationed in Hong Kong.

The majority of units are stationed in the United Kingdom and in Germany in support of our commitments to the North Atlantic Treaty Organisation. The requirement for field squadrons to serve in Belize, Cyprus, including the United Nations Force, Gibraltar and Oman is met by units from the United Kingdom on four month emergency tours. In addition units from Great Britain and Germany are provided for operations in Northern Ireland. Specialist engineer squadrons are provided in support of the Parachute Brigade and of the Commando Brigade.

Explosive Ordnance Disposal has been a continuous requirement since the end of World War II. The Explosive Ordnance Disposal Regiment has carried out battle area clearance work in the United Kingdom, Cyprus and the Falkland Islands as well as dealing with a variety of German bombs.

During the year units have served in Northern Ireland in both the engineer and infantry role. There has been a continual work load in rebuilding temporary sangars, sight screens and the whole range of defences in more permanent form. There is a continuing requirement for search teams to look for weapons, explosives and devices. Royal Engineer Search teams are tasked whenever Improvised Explosive Devices are suspected. The heavy goods vehicle search areas are also manned by Royal Engineers. There is a continuing requirement to train search teams and search advisers for all Arms and this training is done at both the Royal School of Military Engineering and in Germany.

The Military Engineer Services, consists of two CREs and the Construction, Bulk Petroleum and Well Drilling Specialist Teams. These are stationed in the United Kingdom but are very active overseas in support of exercises, in carrying out reconnaissance planning, design and execution of work for the military communities and in support of the Foreign and Commonwealth Office. Military Engineer Services (Works) provides staff for the Area Works Offices in Berlin and Nepal as well as the sub depot in Salalah. Other military staff are provided in posts within the Property Services Agency and with Civil Firms and Public Attachments.

In Malta the Specialist Team continues to assist the Maltese Government with development projects. The works and responsibilities are great and of considerable training value. The team has been particularly involved this year on housing development, hospital improvements and on the construction of the Laboratory Wharf.

In Gibraltar the Fortress Squadron runs the power station and there is a considerable amount of Electrical and Mechanical practical work. Here there has been a considerable effort by the Corps to assist the Property Services Agency of the Department of the Environment in carrying out Works Services for the three Services. Such work gives the Corps practice in planning, designing and carrying out construction tasks, provides valuable opportunities for tradesmen to practice their skills and can save considerable sums of money.

In the Far East the Gurkha Engineers and the Royal Engineers in Hong Kong continue to undertake a wide variety of tasks, including construction of camps and ranges. On Ping Chau, an island off the North East corner of Hong Kong, close to the Chinese mainland a permanent company camp is being built. The remaining forces in Singapore were withdrawn in October 1975, the last Royal Engineer unit was 28 ANZUK Independent Field Troop.

Overseas training is carried out by battle-groups from the British Army of the Rhine at the Suffield Training Area in Canada. Field squadrons have carried out a road building exercise in Kenya; in Sudan, bridge building, an airstrip and minor tasks for the local community. The parachute squadron has exercised in Canada and Sardinia and the commando squadron in Norway and Turkey, with their brigades.

Survey squadrons have carried out survey work in Belize, Cyprus, Kenya and Norway and on the North Sea Oil Rigs. The satellite survey detachments of 512 Specialist Team have been deployed in Anguilla, Ascension, the Amirante Islands, Cyprus, Gibraltar, Kenya, Norway, Sudan, St Helena and the United States of America.

Postal and Courier Communications units operate wherever the three services are stationed. Postal detachments accompany all units on overseas exercises and the postal service is truly world wide in handling mail for the Royal Navy ships at sea.

In the year 1975, the Corps has provided 23 General Officers for the Army. The senior serving officer is General Sir William Jackson the Quarter Master General. General Jackson is a Colonel Commandant of the Royal Engineers, the Colonel of the Gurkha Engineers, and a Colonel Commandant of the Royal Army Ordnance Corps. He is the fourth member of the Army Board to be provided by the Corps in recent years.

Lieutenant General Sir David Willison has just completed a tour as Deputy Chief of the Defence Staff Intelligence and Lieutenant General Sir John Read has been the Director of the International Military Staff of the North Atlantic Treaty Organisation.

The major training establishments of the Army are commanded by Sapper officers; Major General W G H Beach is Commandant of the Staff College Camberley and Major General M E Tickell is Commandant of the Royal Military College of Science. The President of the Ordnance Board, an historic post which has for many years been provided by an officer from the Royal Artillery is filled for the first time by an engineer officer, Major General P J M Pellereau.

In addition the Corps provides its full share of officers in staff appointments. Major General J Kelsey is the Director of Military Survey and the Director of Postal and Courier Communications is Brigadier L P Bennett.

Several officers are filling attache posts in embassies abroad. Junior officers are undergoing Professional Engineer Training in the United States of America and Australia, and the Corps continues to serve worldwide.

1975 COMBAT ENGINEER EQUIPMENT

The armoured engineer squadrons in the British Army of the Rhine are equipped with the Centurion Armoured Vehicle Royal Engineers and the Chieftain Armoured Vehicle Launched Bridge. The bridgelayer has entered service with units this year, it can operate the No 8 bridge, this is a scissors type bridge, which can span a gap of 75 feet or alternatively the No 9 bridge which can cover a 40 foot gap.

The Combat Engineer Tractor (FV 180) has been on user trials both in the United Kingdom and Germany. This is an armoured amphibian designed to give support for the battle group. Its mobility is equivalent to that of the current armoured personnel carrier, it is a good swimmer and has an excellent river exiting capability. The machine has an earthmoving bucket and an output very similar to that of a medium wheeled tractor, it can also mount a crane and is fitted with a winch. It is intended that the tractor will come into service in 1978.

The amphibious engineer squadrons in Germany are equipped with the M2 Bridging Rig. This is a self contained wheeled amphibious equipment whose bridge superstructure enables it to be formed into bridges or self propelled ferries. It is used for the rapid construction of crossings over major water obstacles and can carry any vehicle up to and including the main battle tank.

The Medium Girder Bridge is a light alloy panel bridge which can be assembled in several ways. It is a hand erected bridge capable of rapid construction and able to carry the main battle tank. For larger spans a double storey bridge is required and for spans beyond 100 feet a pier is required.