VOL. LXVI. No. 2 JUNE, 1952

THE ROYAL ENGINEERS JOURNAL

CONTENTS

PUBLISHED QUARTERLY BY THE INSTITUTION OF ROYAL ENGINEERS
CHATHAM, KENT Telephone: Chatham 2669

AGEN ... AM

THE ROYAL ENGINEERS JOURNAL—JUNE, 1952

VOL. LXVI. No. 2

THE ROYAL ENGINEERS JOURNAL

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

VOL. LXVI — CONTENTS — JUNE, 1952

balloon had been made and tried on Salisbury Plain in 1899, as an approach to the kite-balloon, but the trials were inconclusive, and further experiments were abandoned on account of the South African War, when every available balloonist had to be sent on active service and all efforts in the Balloon Factory and depot had to be devoted to raising and equipping balloon sections and maintaining them in the field. Subsequently the appearance of the Cody kites had turned attention to this method of increasing the utility of the balloon units.

An account of this unique kite system which, although copied, was not successfully introduced into any other army, may, it is thought, be of interest.

The winch portion of the balloon wagon (in which the special kite winch apparatus, equally suitable for balloons, replaced the balloon cable drum and gear), was unlimbered and aligned in the direction of the wind ; it was securely anchored with the trail spade driven into the ground, and by being picketed down if necessary with trail ropes and screw pickets. The trail was easily traversed to meet changes in wind direction. Limbering up to move off, with the kites in tow or packed up, was a matter of moments.

A light pilot kite was first sent up on a 1,000-ft. 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 dispatched 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, progressively decreasing in size from the top, on which cleats of proportionately diminishing size, attached to the kite bridles, caught. 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 ft. 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.

The observer could adjust the angle of the carrier kite, to ascend, halt, or descend, by control lines from the bottom and top of the kite ; the trolley was fitted with a brake on the cable, by means of which the observer could clamp himself in position, or lessen the speed of descent, or pull up, when sliding down the cable and approaching the ground.

At levels much above half the altitude of the flight of kites, the angle of the cable, which approached the vertical towards the top, and the periodical swooping of the kites in a gusty wind, accompanied by occasional revolutions on the cable which were communicated to the carrier when near the flight, made the situation of the observer increasingly unstable the higher he went. The use

THE COUNCIL OF THE INSTITUTION OF ROYAL ENGINEERS

(Incorporated by Royal Charter, 27th February, 1923)

President

Major-General Sir Horace E. Roome, K.C.I.E., C.B., C.B.E., M.C., D.L. ...	1951

Vice-Presidents

Major-General J. C. F. Holland, C.B., D.F.C.	1951
Major-General G. N. Tuck, C.B., O.B.E.	1952

Elected

Brigadier J. S. W. Stone, C.B.E., M.C.	1949
Brigadier C. D. Steel, O.B.E.	1949
Major W. M. Inglis	1949
Brigadier C. G. Martin, V.C., C.B.E., D.S.O.	1950
Lieut.-Colonel F. A. Rayfield	1950
Colonel R. M. A. Welchman	1950
Captain J. L. Stevens	1950
Brigadier R. Gardiner, C.B.E	1950
Lieut.-Colonel W. H. Bond	1951
Major-General C. de L. Gaussen, C.B., M.C.	1951
Major J. R. E. Hamilton-Baillie, M.C.	1951
Colonel A. R. Mais, O.B.E., T.D.	1951
Major-General I. S. O. Playfair, C.B., D.S.O., M.C.	1951
Colonel G. F. Hutchinson, D.S.O.	1951

Ex-Officio

Brigadier F. C. W. Fosbery	... D/E.-in-C., W.O.
Colonel I. G. Loch, O.B.E.	A.A.G., R.E.
Brigadier C. E. A. Browning, C.B.E., M.C.	Comd., S.M.E.
Brigadier C. E. M. Herbert, C.B.E.	D.Tn.
Major-General L. D. Grand, C.B., C.I.E., C.B.E.	D.F.W.
Brigadier J. C. T. Willis, O.B.E.	Dir. of Mil. Survey
Colonel C. M. Maclachlan, O.B.E.	... D/Comd., S.M.E.
Brigadier R. P. G. Anderson	Comd., Trg. Bde., R.E.

Corresponding Members

Lieut.-Colonel A. R. Currie, D.S.O., *New Zealand Military Forces*	1st January, 1949
Brigadier J. Mann, D.S.O., *Australian Military Forces*	1st March, 1949
Colonel J. R. B. Jones, D.S.O., O.B.E., *Canadian Army*	1st May, 1951
Colonel K. T. Gilson, D.S.O. *Union Defence Force, South Africa* ...	1st January, 1952

Secretary and Editor R.E. Journal

Brigadier C. C. Phipps, C.B.E., M.C.	13th January, 1945

Bankers

Lloyds Bank, Ltd., Cox's and King's Branch, 6 Pall Mall, S.W.1.

3,750. 1.6.52.

Photo 8.—Filling a balloon at Aldershot, 1903.

Early British Military Aeronautics 8

THE HISTORY OF EARLY BRITISH MILITARY AERONAUTICS

(*Continued*)

By Brigadier P. W. L. Broke-Smith, C.I.E., D.S.O., O.B.E.

CHAPTER III

FROM AFTER THE SOUTH AFRICAN WAR TO THE MOVE TO FARNBOROUGH, 1902-1906

Ballooning establishment after S. African War—Replacement of Balloon Sections by Balloon Companies—Arrival of Colonel Capper—Developments in training and equipment—Ballooning experiments at Malta and Gibraltar—Mobility of balloon units—Man-lifting kites—Commencement of dirigible balloon—Negotiations with the Wright brothers—Free runs—The move to Farnborough.

After the South African War the peace establishment of the ballooning branch was fixed at five sections, with one officer each when available, plus a small cadre section and depot. Four riding and thirty-two draught horses, with mounted N.C.Os. and drivers, were now included, an essential provision for efficient balloon training; they were nominally distributed between four of the sections, as nuclei for war expansion. The establishment of personnel was not fully maintained, and the total strength was never sufficient to operate more than three balloons, or two balloons independently, plus providing a signal balloon detachment. Signal balloons were used to assist the directing staff in controlling army manœuvres. Additional horses had to be borrowed or hired when a section attended manœuvres or training camps.

In April, 1905, the designation of the ballooning unit was changed from Balloon Section to Balloon Company, one company being allotted per Army Corps on mobilization. The war establishment of a Balloon Company (which was much the same as that of the previous section), comprised three officers (normally a captain and two subalterns), thirty-one dismounted and thirty-five mounted N.C.Os. and men, with ten riding horses, forty-four draught horses, and ten vehicles (balloon wagon, six tube wagons, two G.S. wagons, and a water cart).

In 1903 Bt. Lieut.-Colonel J. E. Capper, C.B., R.E.,* joined as O.C. Balloon Sections (subsequently companies). Since the South African War the senior officer with balloons had been a subaltern, and there had not been a field officer in command in peace since 1889. The appointment of Colonel Capper put new life into the branch, the scope and importance of which were so much to increase.

* Later Major-General Sir John Capper, K.C.B., K.C.V.O.

Balloon training was systematically developed. But great difficulty was still to be experienced, to the time when airships and aeroplanes superseded balloons for reconnaissance, in preventing balloon units from being disregarded, and in getting them brought into the picture and properly used in combined training and manœuvres.

A summer training camp was established annually on Salisbury Plain, ballooning courses for officers of all arms (including a high proportion of artillery officers) were revived, and attendance at artillery practice camps was expanded, co-operation being practised with heavy, medium, and field artillery, at Lydd, Rhayader, Okehampton, and Larkhill.

The balloons were improved by fitting a running bridle attachment between the balloon and a point on the cable a short distance below it, which was known as the windguy attachment. This checked the obnoxious gyratory motion of the spherical balloon, steadied the balloon in a wind, and enabled it to ascend in stronger winds. Useful captive ascents could now be relied upon in winds up to 25 m.p.h. The use of this device necessitated strengthening the balloon net, to which the wind guys were attached, in order to take the additional strains involved, and many years later General Capper reminded the officer who was his partner in the balloon when the expedient was first tried, how he noticed that the net was breaking under the strain, and they had to come down hurriedly before the balloon escaped from the net and left them behind.

To secure better altitudes for captive balloon work and to ensure the requisite lifting power over country considerably above sea level, in the light of the experiences in the South African War, the 11,500 cu. ft. balloon replaced the old 10,000 cu. ft. balloon as the normal size, and the 13,000 cu. ft. balloon was also included in the regular equipment for alternative use, the standard length of the cable being at the same time increased from 2,000 to 4,000 ft.

Two light aeronauts could make captive ascents in fair weather, but to ensure a good lift it was common practice for one man only to be sent up, particularly in windy conditions.

Whilst in suitable conditions greater heights could be attained if required, a standard observation altitude of 1,500 ft. above the ground was now regularly available. From this height the radius of observation over normal ground and in normal weather was from four to six miles, and observation of artillery fire could be relied upon up to 7,000 yds.

Other improvements to equipment included the improvement in reliability of telephone communication between the balloon and the ground. Indirect artillery fire could now be very efficiently directed by telephone between the balloon and the battery commander. The balloon observer, using coloured flags, first aligned two men on the ground on the target, and subsequently ranged the shots, in approximate distance and direction, with a very small margin of error.

In the winter of 1903–04 detachments of the 1st and 2nd Balloon Sections, under Lieutenants T. H. L. Spaight and P. W. L. Broke-Smith, conducted ballooning experiments at Malta and Gibraltar. At Gibraltar, where Colonel Capper, who paid the section a visit, and Lieutenant G. F. Wells continued the experiments the following winter, in conjunction with the Navy, a balloon being put up from a destroyer, the utility of the balloons on calm days was shown, when captive ascents were made up to nearly 4,000 ft., for such tasks as the detection of mines or submarines from above the sea, in addition to general reconnaissance. But the very small proportion of suitable days limited their usefulness, and the maintenance of observation balloons at such places was not considered worth while.

During the years immediately following the South African War, mobility and the quick handling of balloons were further developed and practised. This was much facilitated by the provision of a mounted establishment. The balloon detachment (eventually increased to twenty-one N.C.Os. and men) could be carried on the wagons for moderate distances at a trot, and a balloon could be filled and put up in the air from the line of march in twenty minutes. The old balloon drill was expanded, and all the manœuvres of filling, operating, and deflating a balloon were now made a matter of drill in which each man and horse played his part. The trained teams rapidly manœuvred the wagons into position for a fill, and the N.C.Os'. riding horses, equipped with light traces, were trained to draw the hauling-down pole at a trot. A limbered balloon and winch wagon was produced. This, with a six-horse team, could negotiate ditches like field artillery, and move up to a gallop across open country ; these advantages much facilitated the manœuvring of balloons, and dodging enemy fire.

In order to supplement the balloons in winds which were too strong for them, the man-lifting kite system of Mr. S. F. Cody was purchased, and his kites were added to the regular equipment of the Balloon Companies in 1906, after successful trials and performance on manœuvres in 1904–05. Mr. Cody was engaged as Chief Instructor in Kiting, and was employed in the Balloon Factory on the construction of his kites. The possibilities of kites for military purposes had long been envisaged, and as far back as 1894 a system of man-lifting kites, devised by Major B. F. S. Baden-Powell, Scots Guards, who succeeded in raising a man one hundred feet by these means, had been considered ; but practical success in this field was not possible until Mr. Cody's invention arrived on the scene.

Mr. Cody, although he had been in England for some years, of a cable much longer than 4,000 feet would have unduly complicated the equipment and the operation of the kites in the field. The normal height for ascents was therefore fixed at about 1,500 feet (which corresponded to the normal balloon observation height).

The original Cody outfit (which was modified in various respects to suit military requirements, for example by substituting a balloon car, fitted with a telephone and other accessories, for the inventor's trapeze seat), included a small rough and ready trailer motor winch mounted on small iron wheels; but this was not suitable for the field, and it was found feasible and satisfactory to haul down the kites similarly to the balloons, until the introduction of field motor transport should become possible. The strain on the cable being much greater than in the case of balloons, the hauling down pole could not be used, and the flight of kites was brought to earth by bearing down the cable by means of a snatch block fastened to the equipment wagon, or by pulling the cable in, through a fixed snatch block, by moving the balloon-winch wagon. As was the practice with balloons, hauling down could be rapidly done at the trot, or at the canter when the winch wagon was used. Over suitable country the kites could be readily towed against the wind; during the 1905 manœuvres Colonel Capper was thus towed several miles in the air, whilst he observed and reported on the course of the battle and the enemy positions and movements.

As the transport was eventually organized, the kites were carried, together with a reduced quantity of spare ballooning stores, in the technical equipment wagon. This was added to the normal first echelon transport of balloon-winch wagon and three tube wagons, and used for hauling down. The addition of the kites involved no increase in the establishment or transport of a Balloon Company.

In the latter years of the nineteenth century, the advent of the internal combustion engine, coupled with the gliding experiments of Lilienthal, Pilcher and Chanute, and the airship experiments of Colonel Renard and others, had made it apparent that it was only a matter of time before the conquest of the air by power-driven aircraft should be achieved. But the little interest taken by the War Office in the subject and the perpetual restriction of funds from which the Balloon Factory suffered prevented any attempts at the development of airships or flying machines.

The success of the Zeppelin airship in 1900, M. Santos Dumont's feats over Paris in his miniature dirigible balloons in 1901, and the achievement of practical flight by the Wright brothers in America on 17th December, 1903, when they flew under power for 59 seconds, showed that power-driven aircraft were now becoming a practical proposition. In August, 1903, the persistent efforts of Colonel Templer since his return from South Africa, now reinforced by Colonel Capper, resulted in sanction being given to proceeding with the construction of a small dirigible balloon, and an initial expenditure of the large sum of £2,000 was approved Colonel Templer already had in hand an elongated balloon for the purpose. This proved to be too heavy, and a second balloon was made containing fewer layers of goldbeater's skin ; it was of the same shape as the original balloon, over which it was modelled, and was eventually used in the airship. With a view to the future, some officers and mechanics had been trained in the maintenance and operation of internal combustion engines on an engine and two second-hand motor-cars which Colonel Templer had acquired for the Factory, and experiments in the design and construction of aero engines were now instituted. But limitations of funds and delay in the necessary expansion of facilities, which will be described later, postponed attempts at proceeding with the structure of the airship.

In pursuance of their mechanical training, Colonel Templer, who was a great sportsman and had in his day been a keen horseman, allowed one or two of the officers to take one of the cars (a converted Wolseley searchlight car) to meets. Motor-cars were few and far between in 1903, and this gave the balloonists a popularity in the R.E. Mess on hunting days, which, however, was evanescent, as it was not long before authority took cognizance of such an irregular practice, and it had to be terminated.

The progress of the flying experiments of the Wright brothers in America was watched, and in December, 1904, Colonel Capper, after attending the St. Louis exhibition on behalf of the War Office to report on anything of military interest, visited the Wrights at Dayton. He had not been commissioned to do this as, with the exception of Brigadier-General Ruck, the Director of Fortifications and Works, who did all he could to support the development of aeronautics, few if any of those in authority at the War Office took any interest in the subject, and many of them had probably not even heard of the Wrights, concerning whose activities little information was published. When Colonel Capper arrived at Dayton the Wrights had finished flying for the season, after attaining two flights of five minutes' duration. They were closing down for the winter, during which they constructed a new machine embodying modifications resulting from their experiences, for trial the following summer. Colonel Capper, however, was able to satisfy himself that the Wrights had discovered a great deal about the art of flying and that with adequate resources great progress might be made. He sounded them informally as to the sort of terms on which they might be prepared to come to England and work under the War Office. They said that they were prepared to do so for a sum of £20,000 ; they would work solely for the British Government for four years, giving it the benefit of all their knowledge, and imparting that knowledge to no one else except their own country if that was in need of it.

Colonel Capper reported this on returning to England, and strongly recommended that the Wrights should be engaged on these or similar terms, but the proposal was rejected. The Wrights subsequently made an approach to the War Office and prolonged correspondence ensued, which resulted in tentative negotiations directed towards the supply of a machine and instruction in flying it; but no agreement was reached and in December, 1906, the negotiations were abandoned, the War Office informing the Wrights that it had been decided not to buy an aeroplane.

On their part the Wrights, as it turned out, were in the first instance not in any hurry to come to terms until their experiments had progressed further (Wilbur Wright made a flight of 24 miles in October, 1905), and in any case they desired that their own Government, which they were approaching at the same time, should have the first refusal of the rights in their invention. But the U.S. Government at the time was quite uninterested,* and if the British authorities had realized the possibilities of flying, listened to the advice of Colonel Capper, and taken up negotiations with the Wrights whole-heartedly, the British army might have been the first in the field in developing military aviation.

With the arrival of power-driven aircraft, free balloon runs, which were fundamentally at the mercy of the wind as regards direction, ceased to have the reconnaissance, dispatch-carrying or bombing value formerly attributed to them. But against the day when power-driven aircraft should become available, special attention was now paid to free runs, as affording essential preliminary practice in the aeronautical management of airships, and also as providing excellent preliminary training in finding the way across country, and in becoming familiar with high altitudes and with landings, for any form of flying.

Lengthy free runs were never possible, in contradistinction to sporting civilian practice, in which, with the large balloons specially built for the purpose, long distances, often across the sea, were covered in competitive events. British military balloons were made as small as possible, they could carry but little ballast, which limited the length of the runs, and in any case it was forbidden for them to leave the country and cross the sea. The longest free run made was to a distance of 152 miles, from Aldershot to Louth, by Captain H. B. Jones, R.E., and Lieutenant H. C. Prichard, Northampton Regiment, in November, 1894.

* The U.S. Government eventually contracted for the purchase of a machine in February, 1908.

remained an American citizen until he became a naturalized British subject in October, 1909. In his early days he had been a cowboy, and assisted by his sons he performed " Wild West " feats of lassoing, shooting and horsemanship, to which he added stage entertainments and kite ascents, but he had no connexion with Colonel Cody of " Buffalo Bill " fame. He was a natural genius and a picturesque personality ; at first he wore his hair long, tied in a topknot, a large cowboy hat, and thigh boots with enormous spurs for his equestrian performances, but later he adopted a more conventional appearance, although he was always an individualist. The demonstrations of his circus feats, including shooting down glass balls or coins thrown into the air, when riding at full gallop, provided light relief for the Sappers during the early army trials of his kites and variety for the annual sports of the balloon companies. A fervent believer in the possibilities of the air, he had first experimented with kites, developing his man-lifting system, and he subsequently became one of the earliest pioneer aviators, after assisting in the completion and mechanical operation of the first British military dirigible balloon or airship.

Lieutenant R. V. Doherty Holwell, R.E., was detailed for the initial trials of the kites ; he suffered many crashes in the early experiments. The record altitude of over 3,000 ft. was attained by Lieutenant Broke-Smith in an experimental ascent up to the flight of kites in 1905.

These kites were reliable in practice to lift an observer to a height of 1,500 ft. above the ground, and could be operated in winds between 20 and 50 m.p.h. 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.

The Balloon Companies, with their combined equipment of balloons and kites, were now able to provide static aerial reconnaissance in conditions from a calm to winds up to 50 m.p.h.

The elongated kite-balloon, originated in Germany, which by 1905 was being tried in several foreign armies, was not adopted as the Cody kites could provide aerial observation in much stronger winds than the kite-balloon ; also not only did the British equipment need about one-third of the personnel and half the transport required for a kite-balloon, but the small balloon or flight of kites was much less vulnerable. Kite balloons, moreover, were very unsuccessful in the Russo-Japanese war of 1904–05. A small elongated

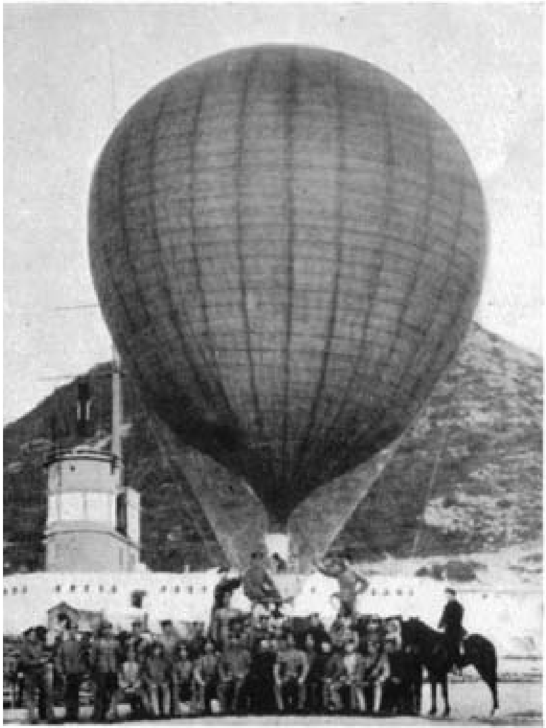


Photo 9.—2nd Balloon Section at Gibraltar, 1904.

Photo 10.—Experimental Balloon Section, Bengal Sappers & Miners

Early British Military Aeronautics 9,10

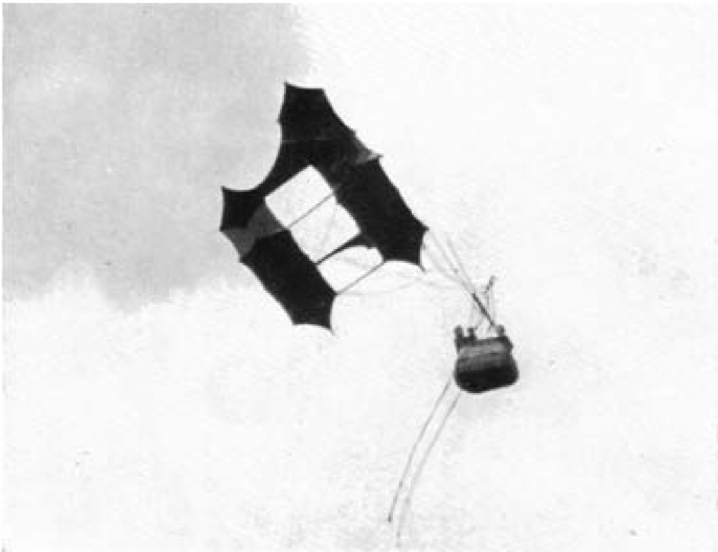


Photo 11.—Cody man-lifting kite.

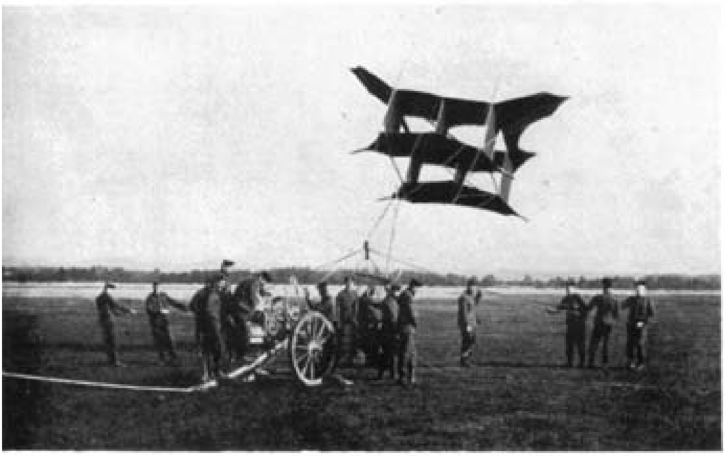


Photo 12.—Balloon and kite winch with kite.

Early British Military Aeronautics 11,12

Photo 13.—Limbered balloon winch wagon with balloon.

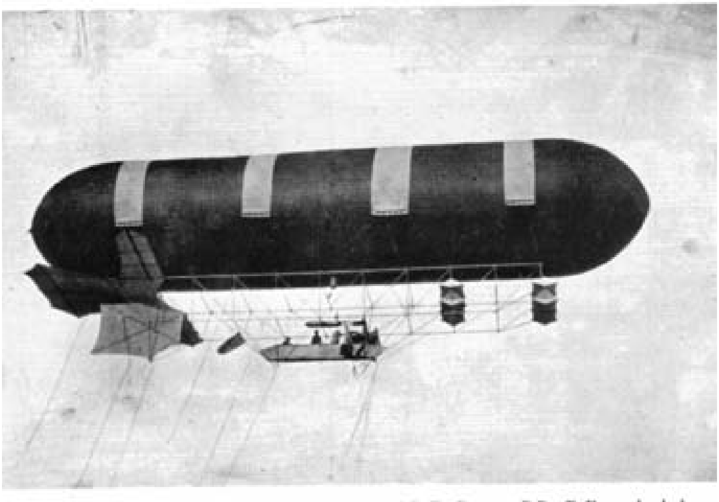


Photo 14.—*Nulli Secundus* Airship, 1907. Colonel J. E. Capper C.B., R.E. at the helm.

Early British Military Aeronautics 13,14

Photo 15.—Cody Army Biplane, 1908.

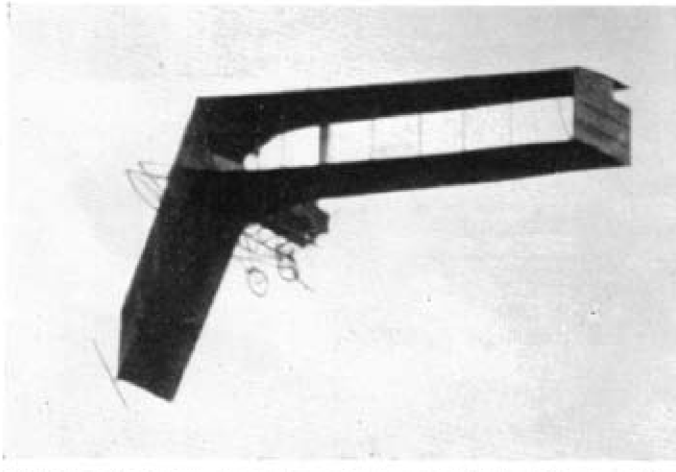


Photo 16.—Dunne Biplane being flown by Captain A. D. Carden, R.E., when taking his pilot's certificate.

Early British Military Aeronautics 15,16

Colonel Capper, who had his own balloon, and other officers of the ballooning branch took part in private free runs from Ranelagh, promoted by the Royal Aero Club,* of which they were members. The reciprocation of interests was close, and on one occasion the founder of the Royal Aero Club, Mr. F. Hedges Butler, an enthusiastic aeronaut, was taken in a military balloon on a night run from Aldershot. The largest size of balloon was used. But, owing to the large weight of the guest and consequent limitation of ballast, absence of wind, a considerable night drop in temperature, and the weighting effect of a heavy dew on the balloon, the run, after several hours of drifting, ended ignominiously with the basket nicely balanced on the surface of a lake in the dark ; when daylight came the balloon and aeronauts were salvaged by a boat, none the worse. The tedium of waiting was relieved by the enjoyment of an excellent veal and ham pie and champagne which had been brought by Mr. Butler.

At the beginning of 1903 Colonel Templer had put forward a scheme for the immediate removal of the Balloon Factory from the restricted and enclosed site at Aldershot, which was quite unsuitable for the development and operation of airships and aeroplanes, to a site adjoining Farnborough Common, and with open clearable ground behind to the wide expanse of Laffans Plain and the Long Valley. Here the considerable expansion foreseen would be possible, and the necessary large sheds could be erected, at the doors of which aircraft could operate.

To induce sanction to this move, requirements were restricted to little beyond the transfer or replacement of the existing buildings and the provision of a dirigible balloon shed which was immediately necessary. To keep down the cost further, the balloon companies were employed on clearing trees and levelling the site in the early months of 1905. The move was not sanctioned until then, and the transfer could not be effected until the winter of 1905–06. The Balloon Companies were moved to barracks in Aldershot North Camp, about a mile away (with the exception of the officers, who continued to be quartered in the R.E. Mess unless they were married).

* Named The Aero Club from its foundation in 1901 until 1911, when the Royal prefix was sanctioned.

CHAPTER IV

BALLOON SCHOOL AND FACTORY AT SOUTH FARNBOROUGH, UNDER COMBINED ADMINISTRATION 1906–9

Transfer to S. Farnborough—Formation of Balloon School—Combination of administration of Factory and School—Retirement of Colonel Templer—Technical experiments and studies—First aeroplane experiments—Veto of aeroplane trials—Further history of Cody and Dunne machines—Start of aircraft wireless experiments—Free balloon disaster—*Nulli Secundus* airship—Naval airship "No. 1."—Airship *Baby*—London Balloon Company T. F.

IN 1906 the ballooning branch was fully established at South Farnborough, the new factory having been sufficiently completed, and the expansion of air activities, including the construction of the first experimental airship, could proceed.

The new factory included an airship shed 160 ft. in length and with a maximum height of 72 ft.—a large hangar for that time, but small in comparison with what was needed later. A larger electrolysis plant for the manufacture of hydrogen was also installed.

Since the spring of 1905 Colonel Capper's command had been known as the Balloon School and Companies, and in April, 1906, the Balloon School was formally constituted, absorbing and replacing the collection of miniature balloon companies ; Colonel Capper was appointed Commandant, and Captain W. A. de C. King, R.E., became Instructor and acting Adjutant. The establishment was seven officers, including a Quartermaster, Lieutenant R. Friar, R.E., and 149 other ranks, with thirty-six horses.

The Balloon School was recognized for experiments with power-driven aircraft as well as for the handling of balloons and kites, and it was to be capable of providing two balloon companies (the only recognized air units at that time), for manœuvres or war.

In May, Colonel Capper became Superintendent, Balloon Factory, as well as being Commandant, Balloon School. Colonel Templer retired on reaching the age of 60, but remained attached as Consulting Engineer for another two years. In 1907 Captain A. D. Carden, R.E., was appointed Assistant Superintendent, primarily for experimental work.

The departure of Colonel Templer marked an epoch in the history of the British air service. He was called the "father of ballooning," * and much was due to his indefatigable energy and determination, in face of discouragement and set-backs. He had

* This title, however, might justifiably be attributed to Colonel G. E. Grover, R.E., who achieved the first official British military ballooning experiments at Aldershot in 1863, and whose persistent efforts led to the official formation of the Balloon Committee in 1871 and the practical steps taken in 1878, when the "Balloon Equipment Store" was started in Woolwich Arsenal.

considerable mechanical ingenuity, and latterly he had evolved an engine which conserved the products of its combustion, to counterbalance the reduction of the load in an airship due to the consumption of fuel, and thus reduce wastage of gas and ballast; unfortunately this engine proved too heavy. He took the greatest interest in the advent of power-driven aircraft, which occurred towards the end of his tenure, and was responsible for the inception of the first British military airship, which was brought to practical fruition by Colonel Capper.

Technical studies and experiments at this time included the items mentioned below, but the funds available would not allow of the purchase of sufficient equipment or the employment of sufficiently trained personnel to carry out really scientific tests.

A small wind tunnel was constructed in the Factory, in which rough tests were made of air resistance and stability of models, and various designs of propellers were made and tested. Other work included strength tests of various fabrics and trials of such instruments as could be purchased. Meteorological work was developed, including the systematic measurement of wind velocity, temperature, and pressure at considerable altitudes, using Dines anemometers and small free balloons. Instruments to enable bombs and other objects to be dropped from airships with as much accuracy as possible were experimented with, but such apparatus was then in its infancy.

Aerial photography had been practised since the earliest days; as far back as 1883 Captain H. Elsdale, R.E., who was one of the pioneers in this field, had made successful experiments at Halifax, Nova Scotia. But financial conditions ever limited the trial and development of apparatus as the science of photography advanced. Specially devised, wide aperture, speed cameras were tried, telephoto and panorama cameras were experimented with, and a field-developing apparatus was produced. Practical success, however, was not to be achieved until the rapid production of prints in the field should become possible.

In 1905 Colonel Capper had met Lieutenant J. W. Dunne of the Wiltshire Regiment, who had been invalided from the army after the South African War, and had devised model gliders on novel principles, which exhibited a remarkable degree of inherent stability in flight. Seeing the possibilities of Lieutenant Dunne's ideas, Colonel Capper obtained sanction to his attachment to the Balloon School and Factory in 1906, and a full-scale glider was made. This was a biplane with the planes set back like an arrow head in plan; the camber and also the angle of incidence of the planes changed progressively between the roots and the wing tips, the angle of incidence at the wing tips being negative, and the only controls were trailing flaps at the ends of the wings. It was considered that this unique design, if successful, would be of vital importance, so it was decided to conduct the experiments in a remote place where secrecy could be preserved. The Marquess of Tullibardine arranged for the experiments to be carried out on the Duke of Atholl's estate at Blair Atholl, where keepers and gillies of the Duke's private army kept intruders at bay.

Experiments were conducted at Blair Atholl during the summer months of 1907 and 1908, Lieutenant F. C. Westland, R.E., with a party of sappers from the Balloon School assisting Lieutenant Dunne. The machine was tried first as a glider and then fitted with an engine and propeller, and in the second year the experiments were continued with a new glider and a new aeroplane which had been built in the Balloon Factory during the winter. But although Colonel Capper succeeded in making a soaring flight in the first summer and Lieutenant L. D. L. Gibbs, R.F.A.(T), who was then attached, made a number of soaring flights the following year, power-driven flight was limited to a hop of 40 yds. This was made by Lieutenant Gibbs in the autumn of 1908, and, ending in a crash, brought the experiments for the year to an end. The broken country of the Highlands, in which the trials were conducted for reasons of secrecy, and the air conditions over it were unfavourable for early flying experiments, and contributed to crashes which delayed progress ; also the engines which were available (in the first year a pair of 12 h.p. Buchet motors which gave only 16 h.p. between them and in the second year a R.E.P.* motor rated at 20–25 h.p.), were inefficient and inadequate.

The experiments with the Dunne machines were accompanied by the construction and trial at Farnborough of an aeroplane designed by Mr. Cody. After making gliding experiments and flying a modified kite fitted with a small engine and propeller, Mr. Cody built a full-scale machine in the Balloon Factory. This was a pusher biplane somewhat akin to the Wright pattern, which depended for fore and aft stability on a large front elevator and had no supporting surface in the tail. The machine had many individualistic features. One of these was the employment of large bamboos for the main spars and outriggers ; Mr. Cody was a great believer in the virtues of bamboo, which was used in his kites. On 16th May, 1908, Mr. Cody got off the ground for a distance of 50 yds. and at a height of 5 to 8 ft., on his first attempt to fly the machine, after making several shorter hops; this was the first recorded aeroplane flight in Great Britain. A collision with a horse trough when he was turning round on the ground postponed further trials, and before repairs could be completed the 50 h.p. Antoinette engine had to be returned

* Brought out by and named after Robert Esnault-Pelterie, one of the early French aviation pioneers.

to the first Army airship (the *Nulli Secundus*)*, from which it had been borrowed—an example of the makeshift expedients which had to be adopted. Resuming the trials when the engine became available again, after the conclusion of the experiments with *Nulli Secundus*, on 5th October Mr. Cody made a flight of 496 yds., which was witnessed by members of the Balloon School and Factory staff and was the first officially observed flight in Great Britain.

In April, 1909, the War Office prohibited further experiments with aeroplanes as the expenditure incurred on the Dunne and Cody trials, £2,500 in all, was considered to be too great. Proceeding as they naturally had to by trial and error, neither Mr. Dunne nor Mr. Cody had yet achieved complete success, although Mr. Cody had flown distances of over a quarter of a mile. But both types, after further experience and modification, and when more powerful and reliable motors could be obtained, were successfully flown later. Some of the highest military authorities still had no faith in the aeroplane, in spite of the performances of Wilbur Wright in France in the previous year which culminated on 31st December, 1908, in a flight of over two hours, covering a distance of 90 miles, and the progress which Henry Farman, Louis Blériot and others were making with other types of machines.

After his machine, which, following upon crashes, had been reconstructed in the Factory and improved, was discarded by the Army, Mr. Cody continued to develop and fly it at his own expense. From June, 1909, he was flying regularly on Laffans Plain, where he had been allowed to erect his own hangar, and officers of the Balloon School and others went up with him. On 8th September, 1909, he flew a distance of over forty miles; his speed was then a little under forty miles per hour. He gained the first prize in the British military aeroplane trials in July 1912;† and the winning machine was purchased for the R.F.C. (a condition of success in the competition), followed by a second one of the same pattern. He designed and built a monoplane, but for financial reasons was unable to develop it, and he continued with his own pattern of biplane, in which he made many notable flights. In August, 1913, Mr. Cody was killed whilst testing a new machine designed for alternative use with floats as a hydroplane or with an undercarriage as a land-plane. After this the Cody biplane, the design of which was peculiar to Cody, and was of the early "tail first" type which had had its day, died out.

The Cody biplane, which owing to its comparatively large size and massive construction was popularly known as the "flying

* See p. 119.

† The requirements which the winning machine had to fulfil included the following :—To carry a crew of two ; speed 55 m.p.h. ; fuel capacity for 4½ hours ; to fly for 3 hours fully loaded and to maintain an altitude of 4,500 ft. for 1 hour ; to be able to rise in a short distance from long grass or harrowed ground, and to land on rough ploughed land without damage ; to be readily adaptable to travel in tow on its own wheels or on a lorry, on the road.

cathedral,"* had been credited with a speed of 70 m.p.h. when equipped with a 120 h.p. engine, no negligible speed at the time, and Mr. Cody had won a number of competitions and created in his day several current records.

From 1910 to 1913 the Dunne type was being successfully flown under the auspices of a private syndicate, which included the Marquess of Tullibardine, Colonel Capper, and Captain Carden, but limited financial resources prevented progress in the development of the design and the construction of new models as a result of experience. To get better speed and efficiency, a monoplane was built for Colonel Capper, with which he and Lieutenant R. A. Cammell, R.E., of the Balloon School experimented. After modification this machine was successfully flown by Lieutenant Dunne in 1911–12; but owing to lack of funds the design could not be pursued—in 1912 also, monoplanes fell into disrepute. In 1912 the French manufacturing rights were acquired by the Astra company, and in 1913 a Dunne biplane was flown across the Channel; the British rights were bought by Armstrong Whitworth. These manufacturers, however, were more interested in other designs, and did not pursue the development of the Dunne.

A Dunne biplane was purchased by the War Office and tried in 1914. The directional stability of this machine was overdone and the controls were not powerful enough. These faults could have been corrected, but the 1914–18 war started soon afterwards and further experiments were abandoned. With the outbreak of the war and concentration upon production of orthodox types the Dunne design was dropped. It had considerable possibilities if fully developed and adequately powered, although its very stability, which made it impossible for the machine to be nose-dived, side-slipped, etc., rendered it unsuitable for aerial combat.†

The stability and ease of handling of the Dunne aeroplane are demonstrated by the fact that a one-armed man, Captain Carden, gained his pilot's certificate in it. In 1910 the inventor, an unpractised aviator, who had been forbidden to fly owing to his ill health, flew distances up to two miles without touching the controls except when ascending and landing; during these flights he made written notes which necessitated the use of both hands.

Although full success with his aeroplane design was denied him, Mr. Dunne was recognized as an aviation pioneer, and he was further compensated by the world fame which he later achieved as a philosopher, with his book *An Experiment with Time* and other works.

* This nickname originated from the fact that the angle between the wings, which inclined downwards towards the tips, was a kata-hedral.

† Some of Dunne's ideas have been perpetuated in the tail-less type of aeroplanes with swept-back wings of forty years later.

In 1903, Colonel Capper had asked for a grant for aircraft wireless experiments, but it was not approved. In 1907 he was permitted to initiate experiments with Lieutenant Ll. Evans, R.E., O.C. 1st Wireless Company, R.E. Lieutenant C. J. Aston, R.E., of the Wireless Company was detailed for the work; after developing his apparatus in captive balloons he was taken with his instruments on free runs, and in 1908 the practicability of both receiving and transmitting from the air was demonstrated in free balloons, signals being received and transmitted up to distances of 20 and 8 miles respectively. The experiments were then discontinued, as all energies of the Wireless Company had to be devoted to the production of ground wireless apparatus for the Army.

In May, 1907, Lieutenants T. E. Martin-Leake and W. T. M. Caulfeild, R.E., on a free balloon run, came down in the sea off the Dorset coast near Bridport, and were drowned. Both officers were experienced aeronauts, they had ballast in hand, and the reason for the disaster, which was possibly due to poor visibility in the failing evening light, was obscure. This was the only free ballooning fatality connected with the R.E. air branch, besides Colonel Templer's *Saladin* disaster in 1881.

The first British Army airship, Dirigible No. 1, popularly called *Nulli Secundus*, appeared on 10th September, 1907. She was piloted by Colonel Capper, the other members of the crew being Captain King and Mr. Cody, who was in charge of the engine. The balloon, made of goldbeater's skin, was cylindrical in shape, with rounded ends, 122 ft. long by 26 ft. in diameter, and of capacity 55,000 cu. ft. The airship was of non-rigid type, but had a stiffening framework hung below the envelope, underneath which was a small car carrying the crew and machinery. The suspension was by cord netting and fabric bands round the envelope, as it was very difficult to attach suspension lines to goldbeater's skin. The airship had a 50-h.p. Antoinette engine which Colonel Capper had managed to buy in Paris, no aero engine of British make being yet available. She carried a crew of two or three, and developed a speed of 16 m.p.h.

The trials were successful, and on 5th October, 1907, Colonel Capper, accompanied by Mr. Cody, flew the airship to London, encircling St. Paul's Cathedral. This created great excitement, as although there had previously been a few private efforts at producing airships in Britain, this was the first practical one. A strong head wind prevented progress on the return journey and the airship had to be landed in the grounds of the Crystal Palace pending an improvement in the weather. After five days of waiting a storm got up; to avoid serious damage the N.C.O. in charge, Sergeant Ramsey, R.E., deflated the balloon, and the airship was dismantled and brought back to Farnborough by road. *Nulli Secundus* was in the air for 3½ hours, which constituted an endurance record for a non-rigid airship at the time.

The airship was reconstructed, and reappeared in July, 1908; the crew on the first trial flight were Captain King, Captain Carden, and Lieutenant Westland. She was now modified to semi-rigid type, and remodelled in other respects to improve the speed and controllability. The ends of the envelope were now slightly more pointed, and the capacity had in consequence been increased to 56,000 cu. ft. A triangular keel was fitted under the envelope and faired in with fabric covering. The unsatisfactory netting inherent in the original design, which caused resistance and absorbed moisture rapidly, increasing the weight, was replaced by a silk covering over the envelope, which, together with fabric bands round the envelope, supported the car.

The airship now attained a speed of 22 m.p.h. After a few flights, in which various mishaps occurred, she was deflated at the end of August, and was not used again. Her construction, in which a cylindrical goldbeater's skin balloon designed by Colonel Templer in 1902, and now of obsolete shape, had to be used, was perforce rudimentary, and Colonel Capper never expected much of her. But the completion of *Nulli Secundus* had enabled a start to be made, and useful experience had been gained.

The Navy were now to take up the operation of rigid airships, and in anticipation of the completion of Naval Airship No. 1, the construction of which was being commenced by Vickers Maxim at Barrow, a party of Naval personnel was given some instruction in airship handling at Farnborough during the brief trials of the reconstructed *Nulli Secundus*. In the event, this airship, named the *Mayfly*, which was of 700,000 cu. ft. capacity, and was fitted with two 200 h.p. Wolseley engines, was unfortunate; it broke its back when being towed to its moorings in September, 1911, and never flew. Airship development by the Navy was then vetoed for two years.

In 1908, Naval personnel were also instructed in flying Cody kites, and subsequently experiments were carried out in the use of kites from ships, under the supervision of Mr. Cody, but kiting for Naval reconnaissance purposes was impracticable.

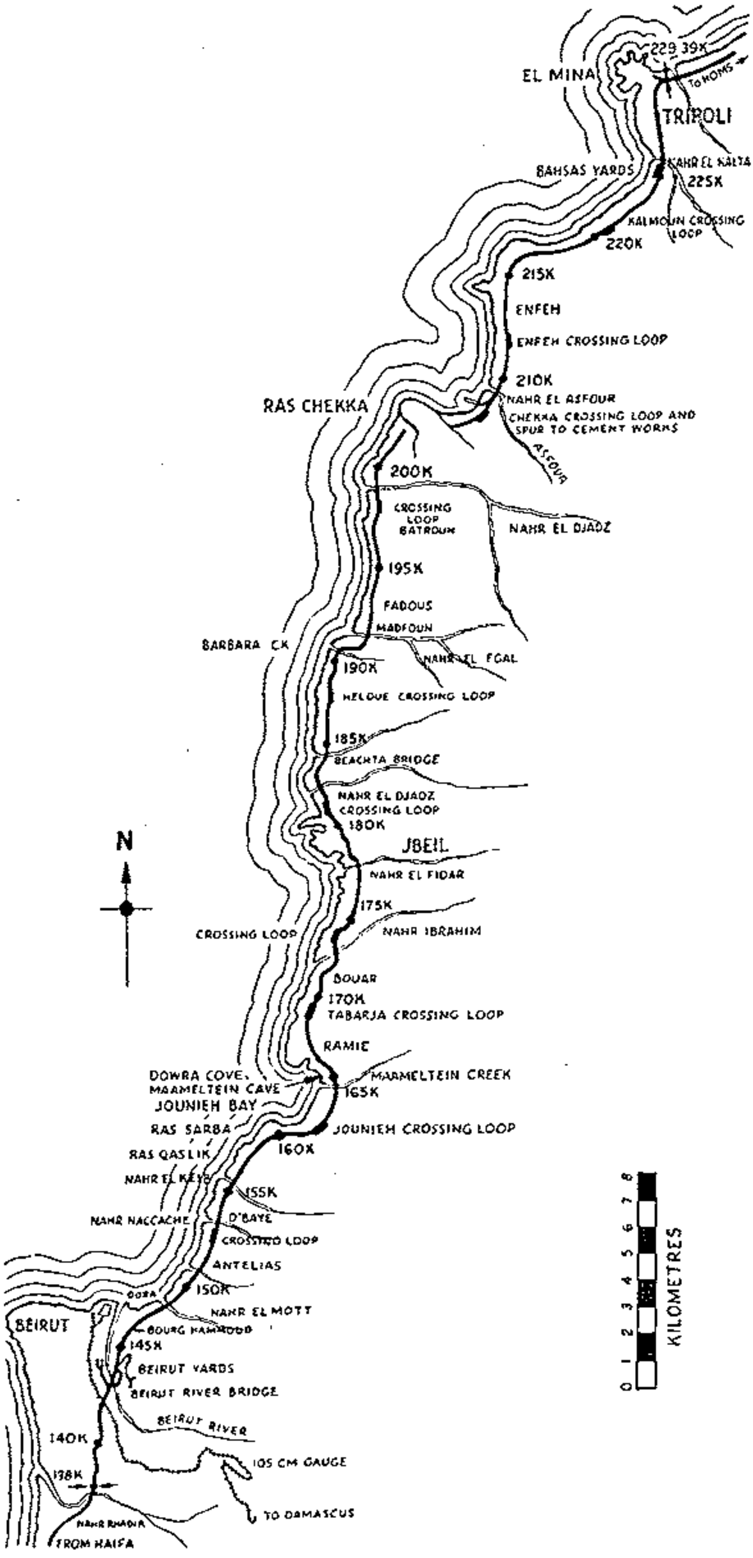
In May, 1909, the second experimental airship, Dirigible No. II, popularly called *Baby*, and subsequently, after reconstruction and enlargement, designated H.M.A. *Beta*, was launched. (The defunct *Nulli Secundus* represented *Alpha* in the series.) This airship was deliberately made very small, to ascertain if the shape of the balloon was sound. *Baby* had a goldbeater's skin envelope of pisciform shape, to lessen resistance, 84 ft. long by 24 ft. 8 in. maximum diameter, and of 22,000 cu. ft. capacity. It was non-rigid, and the machinery and crew of two were carried in a long tubular framework slung under the envelope. A more satisfactory method of suspension from the goldbeater's skin envelope had been evolved ; the car or chassis framework was suspended from the balloon by cables attached to a series of silk loops built into the balloon along its meridian.

Insufficiently powered at first with two old 8-h.p. three cylinder air-cooled Buchet motors (previously used in the Cody motor kite and the Dunne aeroplane experiments), which drove a single propeller positioned between the chassis and the balloon, *Baby* was eventually equipped with the 20–25 h.p. radial air-cooled R.E.P. engine, which had been fitted to the second Dunne aeroplane, and with two propellers abeam of the chassis (as in *Nulli Secundus*), when it achieved a speed of 20 m.p.h. The shape of the balloon was found to be too squat for stability, and it was decided to enlarge the airship and lengthen the envelope.

Great difficulty was experienced in these early days in getting reliable and not too heavy engines for aircraft, and the funds allotted to the Balloon Factory remained too exiguous to admit of rapid developments, or any attempt, pending the anticipated day when aeroplanes should supplant them, at making airships of the requisite capacity and speed for war. There was no large private initiative, encouraged by Government support, as was the case abroad, to promote the construction of full-scale airships in Britain. The grant for 1908–09 was £13,750, a minute fraction of the amounts being spent upon aircraft by other great nations, which already ran into six figures.

In 1908 a Territorial Force air unit, the London Balloon Company R.E. (T), was formed. For convenience its history may be summarized here. The company attended annual camps at Farnborough practising ballooning and kiting, and assisting in handling airships when opportunity offered. The unit was very keen, but its practical training was confined to these camping periods, and it was never given any transport or technical equipment of its own. In August, 1911, 2nd Lieutenant T. J. Ridge of the company secured an aeroplane pilot's certificate, but he was killed shortly afterwards in a flying accident, when flying in a civilian capacity in an experimental aeroplane to which he was unaccustomed. During the following winter several other members of the company were instructed in flying at Eastchurch, where tuition and an aeroplane were gratuitously provided by members of the Royal Aero Club. In February, 1912, however, the War Office decided that the company was not to be trained in aviation. About six of the officers and other ranks learnt to fly at Eastchurch, and most of these, together with some other members of the company subsequently joined the Royal Flying Corps (the formation of which in May, 1912, will be described later). After this the establishment of the company was not kept up, and it was finally abolished in 1913.

(*to be continued*)


229.39K
EL MINA
TO HOMS
TRIPOLI
BAHSAS YARDS
NAHR EL KALTA
225K
KALMOUN CROSSING LOOP
220K
215K
ENFEH
ENFEH CROSSING LOOP
210K
NAHR EL ASFOUR
RAS CHEKKA
CHEKKA CROSSING LOOP AND SPUR TO CEMENT WORKS
ASFOUR
200K
CROSSING LOOP BATROUN
NAHR EL DJAOZ
195K
FADOUS
MADFOUN
BARBARA CK
NAHR EL FGAL
190K
HELOUE CROSSING LOOP
185K
BLACHTA BRIDGE
NAHR EL DJAOZ CROSSING LOOP
180K
JBEIL
NAHR EL FIDAR
N
175K
CROSSING LOOP
NAHR IBRAHIM
BOUAR
170K
TABARJA CROSSING LOOP
RAMIE
DOWRA COVE
MAAMELTEIN CAVE
MAAMELTEIN CREEK
165K
JOUNIEH BAY
RAS SARBA
JOUNIEH CROSSING LOOP
RAS QASLIK
160K
NAHR EL KELB
155K
NAHR NACCACHE
D'BAYE
CROSSING LOOP
ANTELIAS
150K
DORA
NAHR EL MOTT
BEIRUT
BOURG HAMMOUD
145K
BEIRUT YARDS
BEIRUT RIVER BRIDGE
BEIRUT RIVER
140K
105 CM GAUGE
138K
TO DAMASCUS
NAHR GHADIR
FROM HAIFA
0 1 2 3 4 5 6 7 8
KILOMETRES

THE HAIFA–BEIRUT–TRIPOLI RAILWAY

With Special Reference to the Australian Portion

By Major D. H. Eakins, M.C.E., M.I.E.Aust.

Condensed from a paper read before the Kiewa Valley Group of the Melbourne Division, Institution of Engineers, Australia, on 5th September, 1951

Synopsis

THE extract quoted below from the recently published War Office Transportation history of the war gives an excellent idea of the subject of the paper.

Syria and the Lebanon

"The need for a direct connexion between the standard gauge railway systems of Egypt and Palestine in the south and of the Lebanon, Syria and Turkey in the north became increasingly obvious, and in 1940 and 1941 routes were surveyed as far as the Lebanese frontier. The route favoured at first was from Haifa, with many variations, to the Jordan north of the Sea of Galilee, and thence to Rayak, but very heavy rock cutting in basalt caused this route to be ruled out. An alternative up the coast from Haifa to the mouth of the Litani river and thence to Rayak was examined and subsequently ruled out owing to heavy work on the Litani Gorge. The final choice was a coastal line from Haifa to Tripoli ; this also included heavy work, including small tunnels at Naqura and Bayada headlands, and about a mile of tunnelling at the Chekka headland. Several major bridges and heavy works were necessary, particularly on the Beirut–Tripoli section. On the other hand, this route had the advantage of serving Beirut and the Chekka cement works, and the rock work was not in basalt. (The map opposite shows the Beirut–Tripoli section, which is described fully in this article.)

"Work began in December, 1941, and the construction troops were faced with a formidable task. South African railway construction units took charge of the Haifa–Beirut section, with a special company of miners from the Rand to go through the Chekka tunnel ; Australian units took on the Beirut–Tripoli section. Hundreds of Arab labourers were employed with scores of Arab masons, the latter being ideal for the heavy masonry work, required in bridge piers, abutments and retaining walls ; as much mechanical plant as possible was pressed into service to accelerate the work. In some places, cuttings sixty feet deep and embankments eighty feet high were needed to keep the grade line within reasonable limits.

"In spite of these difficulties, work proceeded at high speed. The Haifa–Beirut section was opened in August, 1942, and the whole line to Tripoli was completed by December, 1942. Thus a total length of 176 miles was finished in a year, that is, at the rate of approximately half a mile a day. This rapid railway construction through semi-mountainous country ranks among the more remarkable engineering achievements of the war."

Introduction

Strategical

"The more I have seen of war," wrote Wavell, "the more I realize how it all depends on administration and transportation (what our American allies call 'logistics'). It takes little skill or imagination to see *where* you would like your army to be and *when*; it takes much knowledge and hard work to know where you can place your forces and whether you can maintain them there. A real knowledge of supply and movement factors must be the basis of every leader's plan; only then can he know how and when to take risks with those factors; and battles and wars are won only by taking risks."

And in the Middle East, an area which he commanded in the perilous times of 1940–1, a standard gauge railway was planned to connect the railways of Egypt and Turkey.

A 4 ft. 8½ in. standard gauge railway ran from Cairo to Haifa, and from Turkey there was standard gauge down to Tripoli and Rayak. From Haifa by way of the Plain of Esdraelon, around the Sea of Tiberias, up the Yarmuk Gorge, through Deraa and Damascus to Rayak there was a 105 cm. gauge railway with a branch over the mountains by rack railway to Beirut. This railway had heavy grades, sharp curves, was incapable of carrying heavy traffic and was vulnerable to attack.

Topography and Climate

Between Haifa and Tripoli along the coast is a narrow coastal plain vanishing in parts, particularly at Ras Nakura and Ras Bayada not far from Haifa, Nahr el Kelb near Beirut and the Chekka Headland near Tripoli, all places where the mountains plunge into the sea. From the plain the foothills rise to some 3,000 feet and culminate in the range of mountains known as the Lebanons with the peaks of 10,000 feet. After crossing the range by continuing in an easterly direction there is flat plain country, most unexpected and of considerable extent, the Plain of the Bekaa, bounded on the eastern side by the Anti-Lebanon Mountains, with Mount Hermon 9,000 feet high as the highest point. The Lebanons are drained to the west by seasonal streams which, with few exceptions, are dry or nearly so in summer but become raging torrents in winter. The

Bekaa is drained and watered by the Litani River in the south and the River Orontes in the north. On the eastern slopes of the Anti-Lebanons is the Damascene Oasis and further east is the Syrian Desert which stretches across to the Euphrates. Further north than Tripoli and inland is the Plain of Aleppo, an extensive wheat growing area.

In the winter the mountains are covered with snow and occasionally there is snow on the plains. In the summer humidity is high on the coast. The rainfall, regularly confined to six months of the year, averages twenty to forty inches on the coast and rises to sixty inches in the mountains ; Aleppo has ten inches and Damascus less.

Population and Resources of the Lebanon

The population was a million ; Moslems, mostly Arab, totalled 40 per cent, with about the same percentage of Maronites, the rest being Druzes, Greeks, Armenians and Assyrians, with some French and Turks. Beirut, the capital had a population of 180,000 and Tripoli 68,000. The rural population showed obvious signs of the long period of subservience to many conquerors. They did not appear capable of hard work. Malaria was common among them. Sandfly fever was prevalent, with dysentery less so. The main native language of both countries was Arabic, but French was widely known and spoken, with English not so well known.

Where there was soil it grew most crops ; from bananas by the coast to apples and apricots in the mountains ; olives, grapes and citrus fruits, sugar cane, tobacco and cereals. Much of the foothill country had been terraced at enormous labour. But insufficient foodstuff was grown and the people depended on imports. The starvation and consequent death roll after the 1914–18 war were still remembered.

Chekka had large cement works and Beirut quite an amount of light industry.

Two indigenous industries, shipbuilding and stonemason's work, had a history of at least 4,000 years and were still practised.

Location of the Railway

The Australian Railway Survey Company reconnoitred many proposals to connect Haifa and Rayak. As Syria and the Lebanon were then under Vichy French rule, the reconnaissance could not be pursued in detail over the border of Palestine. The route first favoured was by way of the Plain of Esdraelon, past the Lake of Tiberias and along the Jordan Valley towards Rayak. The Huleh Valley salient allowed exploration of the route for a distance of seventy-five miles to Metulla, about fifty-eight miles from Rayak, and many variations were examined.

Control of Syria was obtained by conquest in July, 1941. The reconnaissance of the Haifa–Metulla Rayak route was completed immediately. This route, 133 miles in length, was found to involve heavy rock cutting in basalt, heavy ruling grades and sharp curves because of the descent to 700 ft. below sea level at Lake Tiberias and an ascent of 3,300 ft. before reaching Rayak at 3,034 ft. The route was not served by roads except at a few points, and this together with the heavy work through basalt precluded rapid construction—a war-time necessity. In July, 1941, too, the route along the coast to the mouth of the Litani River and thence to Rayak was reconnoitred. At the border of Palestine is the formidable Naqura headland and a few miles further the Bayada headland : then easy country to the Litani. But the remainder of the route is along winding gorges through the Lebanons, a way quite impracticable for rapid war-time construction.

The coastal route through Beirut to Tripoli was next investigated. Apart from the headlands of Naqura and Bayada the coastal plain provided for easy construction to Beirut about eighty-seven miles from Haifa. From there along to Tripoli quite heavy country was found with numerous river crossings and mountains down to the water's edge. At one place where the mountains met the sea, the Chekka Headland, a tunnel was found to be necessary. The length of this route was 138 miles. Despite the difficulties of the route, and its slightly longer length than the Rayak connexion, the coastal route had the advantage of an excellent road with a bituminous surface along its whole length, an advantage of very great value for rapid construction. Moreover the route served the city of Beirut, a seaport of useful size, and a large cement works at Chekka ; also the rockwork was in limestone, not basalt. So this route was the final choice. From the 28th to 30th August, 1941, a quick appreciation was made of the country between Beirut and Tripoli by Colonel Simner, C.B.E., D.D.Tn.(Constn.) at G.H.Q., and Lieut.-Colonel K. A. Fraser, the Railway Construction Engineer, and the decision to survey a railway from Haifa to Tripoli resulted.

On the 12th September, 1941, No. 1 Section of the Australian Railway Survey Company moved into camp at Az-zib and commenced a location survey around Ras Naqura and Ras Bayada. On the 17th October the work thus far completed was handed over to the South African Railway Survey Company, as by then G.H.Q. had detailed the South African Engineering Corps to construct the section from Haifa to near Beirut. No. 1 Australian Railway Survey Section then moved to Maameltein for the location survey from Jounieh to Heloue. On the 13th September, 1941, No. 2 Section moved into camp at Herry, and concentrated primarily on a detailed topographical survey with the object of designing a line around the face of Ras Chekka. This place was one of special difficulty and

Colonel Simner arranged for the 61st Tunnelling Company, S.A.E.C. to be specially recruited from miners of the Rand for the tunnel. On arrival of the S.A.E.C. Tunnel Survey Section the survey work for the tunnel length was handed over. The Australian No. 2 and 3 Survey Sections then completed the survey of the rest of the line.

To conclude this story of railway location some recent thoughts of a surveyor responsible for the excellent work done are now quoted :—

"Our attitude has changed, of course, looking back on it. It is obvious now that we had a perfect set-up to do the job. What I mean about the Group is that we had the reputation established by our railway blokes in the first war ; the Englishmen believed in us ; we had a Survey boss who knew his men, knew that they had done miles of location (number one job) in civil life, had seen them do it, had seen their finished work, gave them control, the limits, the grades, curves, all the factors, and let 'em go ; they went, possibly not always in the 100 per cent best spot, but near enough for war and a hurry-up job. Survey had enough young men, some keen on the job, some keen on promotion, some keen to beat the other bloke, but enough of one sort and another to push it through.

"Then, in a way, the job was an easy one, to the extent that we had the Frenchman's plans, which by disclosing the bad spots and by allowing the planner to see along, so to speak, from end to end, helped enormously. The story of Ras Chekka Tunnel you know. I lived there for two months, was sent a month ahead of Farley (the Construction Company's O.C.). I imagine it was the hard nut in the minds of the Tommies. We located from there right through to Tripoli and back to Batroun ; and contoured the Mountain. Then Cuttin (officer in charge) arrived with an African survey section. They arrived without a knife, fork or spoon—thought they were to stay at hotels. I didn't even laugh, to my everlasting satisfaction ; took them by the hand up to an A.I.F. 'Q' bloke I knew in Tripoli and persuaded him to cut the bull and imagine they were A.I.F., so got Cuttin tents, blankets, personal and cook-house gear and arranged for rations. Cuttin was really a great bloke, had been all his life in the mines in Jo-burg ; had Carl Zeiss equipment, and the best survey gear imaginable. I persuaded him that Australians knew about survey in the same way he did. I rocked him with a close round the sea side of Ras Chekka—along a goat track, the sea under your feet (but about 500 feet down), against a road tunnel traverse. He took the stuff away, plans and calculations, brought them back in the morning and from that time until the job was finished he never referred to the work again. He, I think, satisfied himself that the figures I had were dinkum, adopted that method (and the figures) rather than attempt the almost impossible job of staking the alignment on the surface ; fixed his height and alignment from our survey, also his side openings (adits or some such word) and before the Basutos had time to unpack they were back in the mines.

" It is worth remembering that the day the tunnel joined up, and alignment doubts were over, Cuttin mounted a bulldozer, and from then on he was a full shift operator."

Construction

The Plan

As construction was to proceed without delay, the plan was developed as the survey and the work progressed. The railway was designed to be a first-class military railway of standard gauge to carry 20-ton axle loads. The ruling grade was fixed at 1 in 50 and the minimum radius of curvature at 10 chains. Passing loops were to be provided each 5 miles. Formation was to be 16 ft. wide on banks and 15 ft. wide in cuttings. The structure gauge was the Australian one for 4 ft. 8½ in. and 5 ft. 3 in. gauges—approximately the International one. To save bridging, road crossings were to be level with the rails. The line was to be located to keep demolition of houses to a minimum.

Rails and fastenings, sleepers and bridges were to be obtained through transportation stores from England, South Africa, India, and America ; ballast, stone and cement with a few sleepers from local sources. Plant was to be supplied as available from the Middle East pool and from local R.E. resources of the Ninth Army holding the area. The Royal Engineers of the Ninth Army were also relied on for erection of camps where required and the supply of engineer stores.

The work was directly under the D.D.Tn. (Constn.), G.H.Q., Cairo, and was apportioned to the South African Engineer Corps and the Australian Railway Construction and Maintenance Group, R.A.E. The S.A.E.C. were allotted the length from Haifa East to Kilometre 137.6 at Nahr Rhadir, a distance of 86 route miles, and in addition the tunnelling work at Chekka from 201.4 km. to 207.7 km. The A.R.C. & M. Group were given the section of 57 route miles from Nahr Radir to El Mina, at Tripoli, 229.4 km., including terminal facilities at Beirut and at Bahsas but excluding the Chekka tunnelling. Labour was to be drawn from the locality and reinforced by pioneer companies of Basutos, Bechuanas and Swazis from South Africa. The British War Office requested that the work be completed in eighteen months.

The S.A.E.C. Portion

Construction work by the S.A.E.C. commenced in December, 1941, and considerable difficulty was met with in rounding the Naqura and

Bayada headlands in wintry weather with gales lashing the coast. In spite of the difficulties, work proceeded at high speed. The Haifa–Beirut section was opened in August, 1942, 86 route miles of standard gauge railway in eight months.

The tunnelling work at Chekka was begun in February, 1942, by the 61st Tunnelling Company. Used to hard rock on the Rand, the compressor strength consisted of two units, each capable of supplying full power for the drills operating, so work need suffer no interruption if one unit broke down ; in addition there was a much smaller unit for supplying air for ancillary work that might be needed. In the event, the big units were not needed, as the small unit supplied all the air necessary. The rock was mostly chalk and marl. Drilling was easy, so that with one sharpening, 15 ft. of hole was drilled instead of the 18 in. usual on the Rand. No timbering was necessary. Work proceeded on the full tunnel section at five faces at once—one at each end, one at the adit nearer to the north end and two from an adit nearer the centre. The spoil was loaded by a special machine, operated by cable from a winch on to dump trucks running on narrow gauge construction track. Most of the rock was dumped in the sea near by.

The full length of the tunnel was 4,800 ft. and it was driven at a level about one hundred feet lower than the 1,500 ft. long road tunnel on the main coastal road. The services of air-power, ventilation, water and electric light were supplied along the full length of the work in a most orderly fashion. All the material to the smallest bolt and nut were brought from South Africa with the company and this helped to avoid the delays usually met with. Work proceeded in three shifts in spite of the glare that caused the face of the headland to shine far out to sea. The risk taken proved to be justified and as a result the work was done in the extraordinarily short time of eight months. The tunnel was handed over to the Australian Company for plate-laying at the end of September, 1942. After completing the main tunnel and a short one of 900 ft. near by, the 61st Tunnelling Company was then transferred to improve the alignment and safety of the track at Naqura Headland by driving a 1,000-ft. tunnel through it.

The A.R.C. & M.G. Portion

This section of the work will be dealt with in more detail only because it was more familiar to the author. Early in 1942 the three Railway Construction Companies gathered their scattered sections from Egypt, Transjordan, Palestine and Syria to concentrate on the H.B.T. Railway. The work was allotted in orderly military style with approximately equal lengths of thirty kilometres to each company ; the first length to No. 1 Company, the second to No. 2 Company, and the third to No. 3 Company. Some rearrangement was made later as the second length proved to be particularly heavy. The formation and the bridges constituted the bulk of the work. Once the formation was completed the tracklaying was a relatively simple matter to the troops who had had extensive experience at it.

Each company could be organized to have four sections and a headquarters. Each section could act independently and was generally employed in this way. A section consisted of an officer, two sergeants, four corporals and fifty-eight men ; five-twelfths of them platelayers and one-twelfth each blacksmiths, strikers, carpenters, riggers, and pioneers ; the rest included surveyor, draughtsman, clerk, drivers, riveters, welder and stokers. The organization provided for a dilution by unskilled labour of four to one. This was never seen in practice as the dilution was generally ten to one and frequently a sapper became a ganger with a team of thirty.

The officers commanding the companies had ample power to arrange matters as suited the work and themselves and exhibited the initiative usual among Australians away from home. No. 1 and No. 2 Companies had some sections working independently, while No. 3 Company was concentrated as a unit. To illustrate the dovetailing of organization to the work in hand, No. 2 Company's method will be described. One of the sections, No. 4, was organized as a bridging unit to deal with the several major bridges in the length. It worked from Headquarters at Jbeil, the centre of the length. Also from this place No. 3 section dealt with earthworks, rock and platelaying for the central half. This section was finally well equipped with heavy construction plant for the deep earth cuttings involved. The outlying northern quarter of the length through broken rocky country was the care of No. 1 section with its camp at Madfoun. Similarly the heavy rock section on the south end was allotted to No. 2 section with its camp at Ramie.

On arrival in February the only tools available were picks, shovels and crowbars. On the first morning No. 2 section, fresh from the Sinai Desert, where an 8-ft. cutting in sand was a major work, was taken for a stroll over the centre line. The start was at a side cutting leading into ¼ mile of rock excavation 30 ft. deep, next a bank 80 ft. high, another rock excavation 35 ft. deep, followed by a 46-ft. bank and one more rock cutting of 35 ft., all within a mile of the camp. The rocks were hard after the sand, the hills were high and the crowbars and the picks looked futile. But we started where cuttings met the big bank and on the road deviation near by cut a goat track on grade. That made a show and was quite economical. Then the plant began to arrive, first a bulldozer which was kept at it night and day for six months, then compressors and rock drills, decauville track and wagons, till at the end of September the section was well equipped. This story of the increasing amount of plant was parallelled throughout the group. In No. 2 Company it led to a reorganization, because of the need to keep the mechanical plant at work. The first improvement was to arrange for the attachment of several details, skilled in the use and maintenance of mechanical equipment, from neighbouring Royal Electrical and Mechanical Engineer Companies, and then the attachment of a light aid detachment truck equipped with a skilled M.T. fitter. Finally, all the mechanical equipment and transport was formed into a fifth section and allotted as required to the various parts of the work. Because of the large labour force employed and as survey work was completed and reinforcements came, more officers were allotted to construction work, almost doubling the number available.

The Australian Work in Detail

Labour

In all, with attachments, the group numbered about 1,000. Of these, half were allotted duties on operation and maintenance of plant and transport and on administration and stores work, and the other half were available for supervision of labour. Military personnel had to spend a portion of their time and energy on purely military duties to be able to give a good account of themselves should the enemy come down from the north or land from the sea. The health of the troops was generally good, mainly because of the help received from the near by Australian C.C.S. and the New Zealand General Hospital, as well as the untiring efforts of the M.O. and his team of medical orderlies. Malaria was less than expected and only fifteen cases of dysentery failed to respond to treatment at camp hospitals. Sandfly fever was particularly bad but was quickly dealt with in the two camp hospitals at No. 1 and No. 2 Companies. The work was hard and long but billets and food were good so the men came through well. There were only three fatal accidents, two caused during blasting operations and one road accident.

The labour came from two sources, South African natives from Basutoland, Bechuanaland and Swaziland, and local civilians of many races and capacities. The South African natives were organized in African Auxiliary Pioneer Companies and numbered 2,100 at the peak. Their value depended very largely on their officers but was never great. Some of the officers were quite enthusiastic, but their troops wished to bear arms and were the reverse. When shovelling ballast, the Basuto found it impossible to concentrate on both ends of the cycle ; either he got a full shovel and some of it landed in the right place, or he took what fell into his shovel while he concentrated on placing it in the proper position. Their wrists, too, seemed weak. Manual labour was really beneath them. If an element of fun could be injected into the work good results could be achieved for a time. Some were known to work quite well on plant, such as a concrete mixer, where they tried to match its efforts. Machinery seemed to wield a weird fascination over them, sometimes dangerously so, as understanding it was beyond them. Others performed well as riveters, or riggers' assistants, blacksmiths' strikers, and the men of one company did well as platelayers and lifters. Some Swazis under a good officer did good muck work on side drains. In other cases, attempts were made to introduce task work on excavation at the rate of 1½ cu. yds. per man-day, but the rate could not be achieved. One instance is on record where 130 Basutos excavated 150 cu. yds. in five days. Generally the South African natives were poor labourers and showed a great deal more interest in military drill and parade movements. Company cooks were to be seen teaching their helpers and drudges how to slope arms with soup ladles and brooms. Exclusion from parades was viewed by them as a greater hardship than a day's work. For best results all Sappers called on to supervise these men should have had at the least a thorough training as anthropologists. All the same the Africans' happy dispositions, their singing at night, and particularly on Christmas morning, remain very pleasant memories.

The civilian unskilled labourers were of the usual standard found in the Middle East. They knew more ways of cheating the boss than the Australian has ever dreamed. In the Lebanon they were generally better fed than in Egypt. A train journey from Kantara to Damascus showed a gradual increase in plumpness from the desert bitten Bedouin of Sinai to the fat gentlemen of the well-watered oasis of Damascus. The Arab had two qualities in common along all that way. He wore a somewhat lordly air and had an all-embracing faith in the providence of Allah.

At times our civilians suffered from lack of flour which finally was distributed by the Army to ensure fair distribution. Language proved a bar, particularly at first, till reliable interpreters could be obtained. Of course, the universal sign language proved useful. Though never accustomed to hard work, the capacity of the workmen increased as time went on. Motor transport had to be used each day to bring men down to the railway from their villages in the mountains and return them. When the farms were cropped the owners and relatives were absent from time to time. As the normal army rate of pay was only 2s. 4d. sterling per 8-hour day, it did not require much expenditure to tempt them off the railway. The labour was engaged through the Pioneer Labour Corps officers, often locals, and care was taken to see that these men did not defraud the labourers or the Army.

Women labourers, generally under women gangers, were employed on carrying baskets of ballast to the track. We had Christian Arabs

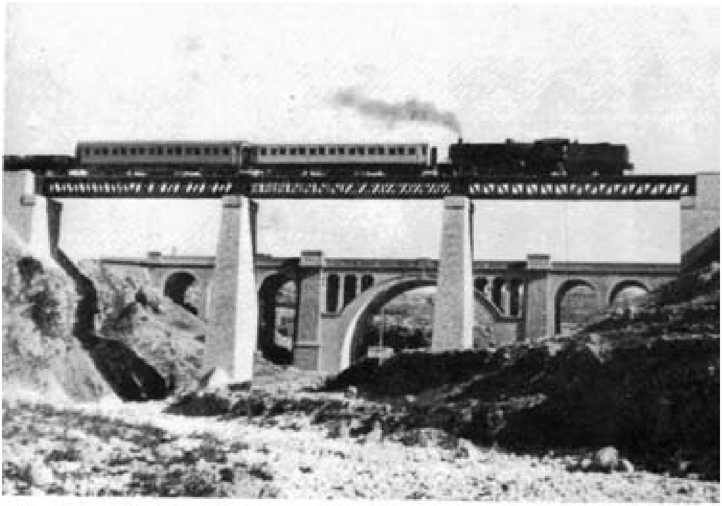


Photo 1.—Djadz Bridge, 3/80 ft. spans (standard Middle East spans).
Invert to rail, No. 2 Pier 98 ft.

Photo 2.—Djadz Bridge under construction. Launching spans 2 and 3 together.

The Haifa-Beirut-Tripoli Railway 1,2

Photo 3.—The Big Bank at Dowra, near Ramie, 86 feet from the water. Formation complete. Basutos on side drains.

Photo 4.—Tracklaying by Basutos, North of Maameltein.

The Haifa-Beirut-Tripoli Railway 3,4

Photo 5.—Road and Railway North of Beachta.

Photo 6.—Nahr Ibrahim Bridge under construction.

The Haifa-Beirut-Tripoli Railway 5,6

Photo 7.—The Chekka Railway Tunnel, Southern entrance, Roadway above.

Photo 8.—The Chekka Railway Tunnel, Northern exit.

The Haifa-Beirut-Tripoli Railway 7,8

and Moslem Arabs. On one occasion to improve output it was found an advantage to dispense with the services of those under seventeen and over seventy.

Skilled and unskilled labour reached a peak of 8,000 but more could have been usefully employed if available. The skilled labour consisted mostly of stonemasons, some of them really ranking as architects. These were all particularly skilful and took great pride in their work ; the craft was highly organized with many grades depending on skill.

It was found that the ways to get work from men are the same irrespective of colour, creed and race—study them, follow the golden rule, deal fairly, tolerate no nonsense, protect them from exploitation, set a high standard—in short, treat them as men.

The Way

From Nahr Rhadir to the Beirut River the line traversed olive groves, cultivation and orchards in chocolate soil with several waterways and irrigation channels. From the Beirut River to the old Maameltein Tramway at Dora the route was through easy country, thence it followed the tramway to Nahr el Kelb, deviated from it through orchards to Qaslik Headland and through bananas to Sarba Headland, where the tramway route was again adopted and followed to Maameltein. From Maameltein to Bouar there was considerable heavy rock cutting and the high bank at Dowra near Ramie. Formation through Tabarja, Bouar and Jbeil was in the dark chocolate soil of banana plantations, intersected by numerous small water channels and irrigation ditches. There were rock cuttings at Tabarja and at Fidar where a deep wadi was crossed by a high bridge.

Construction was almost continuously in rock from Jbeil to Fadous, with large cuttings at Beachta and Madfoun. High bridges were needed across Nahr Djadz, Nahr Fgal and numerous smaller bridges at water courses in between. From Fadous to Batroun alternate rock and soil were traversed to the bridge at the second Nahr Djadz. From here to the S.A.E.C. tunnel section at Chekka the construction was wholly in limestone rock. From Chekka to Enfeh the formation was again in chocolate soil with many water courses but from Enfeh to Bahsas was practically all in rock. Bahsas Yard was constructed on sand adjacent to the sea. From there to El Mina, the junction with the D.H.P. standard gauge, the line traversed sandy country through orchards.

Earthwork

Earthwork was hampered by wet weather till April. The ground was waterlogged by the winter rains ; in some banana plantations a man would sink to his thighs in the sodden ground. Work was commenced with local civilians using hand baskets and donkeys with panniers, mostly made of kerosene cases with a hinged bottom tied in place quite simply by a light rope. Supervision was necessary to see that the panniers were filled and that donkeys were strong enough to carry them. Dispensing with several flagrant loafers would keep things going well for a week or so, when the treatment had to be repeated. Basutos also were employed on low banks with picks, shovels and barrows in the early stages. Horses and scoops with horse-drawn ploughs were hired where they could be got, and were employed where suitable. Mechanical plant was gradually supplied and put to full use on delivery. Shift work was inaugurated and arrangements were made for regular servicing and maintenance. The plant for the most part comprised D6, D7 and D8 caterpillar tractors, with bulldozers, carryall scrapers and rooters. All did excellent work. Heavier plant was supplied later and included RB37 shovels, RB10, 17 and 19, Lima and Bucyrus Erie shovels and draglines, all of which proved invaluable in the deeper cuttings. Frequently, as no tipping lorries were available, the spoil was left beside the cuttings and the banks were built from borrow pits. D6 tractors with roll-over scoops were most successful in loam and sand on short leads. In some cases hired trucks were used. These had fixed bodies and after the load had been dumped in the trucks the soil had to be loosened with picks again before discharging with shovels. As at least two of the native-born were necessary to man a shovel the operation was costly and tedious. The lack of suitable motor tipping lorries was a severe handicap, as if they had been available the formation would have been completed earlier. Low banks were generally well consolidated by construction traffic. High banks received no special treatment and considerable settlement was expected for at least two winters. Towards the end of 1942 after the winter rains began in earnest there were many indications that this expectation would be realized.

Rock Work

Difficult rock excavation was necessary at the Kelb headland. The main Beirut–Tripoli road had been cut out of this rocky promontory and perforce the railway was located further inland and therefore much deeper in the rock—the depth was 70 ft. Disposal of the spoil to the sea, across the road carrying heavy Ninth Army and civilian traffic, was a problem and made work slow, as well as troubling the traffic. Heavy work, too, was occasioned by Maameltein Headland near Ramie. This section has been mentioned earlier and required 35,000 cu. yds. excavation wholly in rock. The excavated material, with a further 5,000 cu. yds., was used to make the big bank and the road diversion at Dowra. The excavation and spoil removal was done by hand with the aid of decauville track. Three shifts were worked and the job took six months. The fill, 86 ft. high, was faced on the sea side with random rubble on a 1 to 1 batter and was stepped half-way to make a berm for carrying the roadway. Other heavy rock cutting was encountered north of Beachta ; at Madfoun where the railway went under the main road ; north of Enfeh and along the Tripoli Road from Kalmoun. The holes were drilled with rock drills, using air supplied by portable compressors. The limestone rock was mostly soft but had frequent fissures and pockets often clay filled ; in these the steels used to jam and cause delays. Blasting was done with gelignite, ammonal and some blasting powder. Owing to the general shortage of detonators and fuses, much larger shots were fired than desirable in railway work. These caused damage to the roofs of near-by houses and telephone lines and to slopes of the cuttings. Instantaneous detonating fuse and guncotton primers were used extensively, but in some cases firing was done electrically.

Minor Bridges and Works

These comprised structures for crossing the many small streams, gullies and irrigation channels, sea walls to protect embankments, lining portion of the Chekka Tunnel, road diversions, house repairs and station buildings.

Major Bridges

The major bridges were probably the most important items in the construction work. The longest were those over the Beirut River, three 100-ft. spans ; Nahr el Kelb, two 100-ft. and one 70 ft. ; Nahr Ibrahim, one 100-ft. and one 70-ft. ; Nahr Fidar, four 75-ft. ; Nahr Djadz, three 80-ft. Others in this category ranged from 20 ft. to 80 ft. spans. Each crossing required study, which included a knowledge of the bridge material available. Timber for formwork was not obtainable but skilled masons and suitable stone abounded, so it was decided to face piers and abutments with stone built to act as formwork. The stone was usually laid in 10-in. courses with lifts of 4 ft. and the method proved most successful. Construction had to be completed during the summer to avoid the trouble of flooded watercourses and fortunately the work was done in time.

The *Beirut River Bridge* had abutments clear of the stream bed and they were founded on a bed of clean gravel about nine feet below river level. The excavation was in the open. The pier caissons were sunk in gravel and loam to a clean gravel bed 20 ft. below water level. Piers and abutments were built to girder seat level in concrete. The 105 ft. through lattice girders from South Africa were erected on falsework built up of standard light steel trestle founded on the dry river bed. The lattice girders were received in sections up to 4½ tons weight. After erection on the falsework the sections were riveted. On completion the girders were lowered into position.

Construction work for the *Bridge at Nahr el Kelb* was similar to that at the Beirut River except that much more water was encountered and this required all the pumps available. The piers and the southern abutment had to be taken down to 24 ft. below water level. At about nine feet below water level a band of heavy loam was met and the extra skin friction held the caissons up. The cutting edges were cleared of obstructions, the caissons allowed to fill with water and charges of gelignite were ignited and dropped into the caisson wells. This produced the desired result and sinking was then continued till a safe depth was reached. When the pumps could no longer de-water the wells a diver and grabs were used for the final stages of sinking. All caissons were then sealed underwater using a crane and grab bucket ; after the concrete had set the caissons were pumped dry. This bridge and the previous one were erected by No. 1 Company.

The *Nahr Ibrahim Bridge* was a little unfortunate as one of the spans for it was sunk on the way from South Africa and the substitute, a U.C.R.B.* through span, did not match the lattice span which had arrived safely.

The northern abutment was founded on rock; the southern abutment, founded at 13 ft. below, and the pier, 20 ft. below water level, were of the caisson type. A heavy flow of water was struck at the pier and the services of a diver and grab were needed to clear the cutting edge and the spoil from the wells during the latter stages of sinking. Masonry was used in the normal way, but was notable for the particularly fine work done by the masons. Some of the limestone delivered was a slate blue in contrast to the usual white or ivory shade, and this slate blue stone was laid in a most artistic pattern. The steelwork was erected on falsework as in the bridges described previously. It so happened that on the night of the day the trusses had been made self-supporting the rain came down and the flood washed out the trestles. Excellent judgement on the part of No. 3 Company.

The *Nahr Djadz Bridge* was the occasion for some experimental work of interest. It was the first attempt in the field to launch a U.C.R.B. by the cantilever method using a launching nose. The foundations were all dry and were on rock. The higher pier was 80 ft. above its foundation. No scaffolding was required on the outside of the piers as the masonry was laid from the inside and access to the working level was by ladders attached to steel rungs set in a pier side. On completion of the work the rungs were removed. To facilitate the placing of concrete and stone in the piers, a flying fox was erected with a 1-in. wire rope right across the wadi ; the lifting and hauling operations were done with a double-barrel winch.

* See Vol. 1 *The Civil Engineer in War,* published in 1948 by the Institution of Civil Engineers—one paper on General Design of Standard Bridging Equipment by Everall and Russell and another paper on Erection of Standard Bridging Equipment by Everall and Ball.

While the piers and abutments were being completed, the trackwork adjacent to the abutments was laid and that on the south side particularly well packed. The trusses, 80 ft. long deck type U.C.R.B., for the first span were assembled together with a launching nose, on three bogies running on the track. The nose was about fifty-five feet long and of light construction. When all was made ready a rope from a winch on the north side was attached to the nose on the south side and the signal given to start hauling. With ease, at a sure and steady pace, the unit was hauled across till No. 1 span was in position immediately above the opening. The dismantling of the nose 70 ft. in the air was accomplished with difficulty by the aid of the flying fox. This experience caused the officer in charge to think seriously and he obtained the Colonel's consent to launch No. 2 and No. 3 span together, thus bringing the nose on to the north side for dismantling. The two spans with the launching nose were assembled on the south abutment on five bogies, the track completed on No. 1 span and the long assembly hauled across it and over temporary supports on to No. 2 pier to rest in position under the lowering gantries on the piers and the north abutment. The experiment was a success. This particular example was described in articles in the *Railway Gazette* in 1945–6.

The next bridge ready for erection by No. 2 Company was close by at *Nahr el Fidar*, requiring four 75-ft. U.C.R.B. deck spans on high piers. The foundations were on rock or gravel and excavation was practically all in the dry. The highest pier was 62 ft. above foundation level. Construction of the piers and abutments and the method of erection were the same as for Nahr el Djadz. In this case, the four spans and the launching nose were coupled together and the whole hauled across in one operation. The assembly, launching, jacking down, and dismantling the nose was executed in 389 man-hours including native labour and Australian supervision.

Another bridge of much interest was the 80-ft. U.C.R.B. deck span over *Nahr el Fgal*, a wadi 69 ft. deep. The high and large abutments with their splayed wing walls each required much stone facing and 2,000 tons of concrete. Erection was by cantilever method as at Nahr el Djadz.

Three shifts were worked on all these bridges. Another eight wadis or streams required major bridges. All bridge piers of importance were equipped with chambers to facilitate demolition if that should prove necessary.

Trackwork

The construction companies laid a total length of 66.2 miles of track. Forty-six miles were 75-lb. flat bottomed American rails and 20 miles bull-headed English 85-lb. rails. Sleepers were 9 in. × 5 in. × 9 ft. Indian hardwood and 8 in. × 6 in. × 8 ft.

American pine untreated. In station yards and crossing loops local pine and Turkish katrani pine sleepers were used. All F.B. rails were laid on single rib rolled steel tie plates and fastened with dog-spikes. The bull-headed track was supported on cast-iron chairs spiked to the sleepers, and was fastened with local timber keys. The keys had a short life if not driven home and kept tight as the local inhabitants suffered from a chronic shortage of firewood. As the timber had been cut green much energy was used to keep the wedges tight. Rail joints on the straight were laid with a 3-ft. 11-in. stagger and on curves with a half rail length stagger. Sleeper spacing was approximately 2 ft. 5 in.

Speedy earthwork at the Tripoli end by No. 3 Company was followed by their platelaying, with the result that the track from El Mina to Chekka, passing loops at Bahsas, Kalmoun, Enfeh and Chekka and a spur to the cement works, was opened to traffic on 22nd July, 1942.

Trackwork is mainly a matter of material supply and distribution. So it was at this stage, when the formation was discontinuous, that the main Haifa–Tripoli road proved to have much value. The job was really a race to get the bulk of the material out before the rains came. Transport of all the sorts available was pressed into service and the job went on night and day. By this time each company had a plant officer and the R.S.M., too, concentrated on the transport. It is well to note here that the main road was also the main line of communication for the British Ninth Army.

Ten crossing loops, each 450 metres long with 180 metres for crippled trucks, were laid as well as the terminal facilities at Beirut, and Bahsas near Tripoli. Water columns were provided at Bahsas, Batroun and Nahr Ibrahim. Ballasting was obtained in many ways and for the most part from adjacent hard limestone rock. On some lengths of track the stone was napped to size on the formation. In others the aid of donkeys was needed to transport the stone to the track. Colourfully dressed, with many in long crimson trousers, gangs of Arab women carried ballast, some of it produced by nature, to the site. And we were provided with small portable crushers all the way from Australia with Southern Cross engines and Jacques jaws. They were awkward to move except on rails and had a low output. Six native labourers using one of them could produce as much ballast, about three cubic yards per hour, as the same six labourers napping stones. Another arrangement, this one said to be ideal, was to set up several crushers in a wadi about one hundred feet from the railway. Over the hoppers, at road level, was erected a platform on which M.T. dumped stone from the beach. With two natives pushing boulders into the hoppers, a dozer pushing the ballast from the crushers towards the railway, and a dragline shovel loading the ballast into the waiting railway trucks, the scene exhibited much activity.

Four large crushers, 10 cu. yds. per hour, were installed at suitable places. Delivery from them was effected by self unloading M.T. and by railway trucks converted with side and end doors for placing the ballast where required. Power shovels and grabs were used for the loading. The total quantity required was 140,000 cu. yds. and about half of this total was obtained by local contract. Rails and ballast were completed from each end so that construction trains could operate.

The last gap in the rails was at the section near the heavy rock work at Maameltein Headland and was closed on 17th December, 1942. That day Jimmy Yorston, a locomotive driver of the section responsible for constructing that length of track, cautiously drove the first locomotive from Tabarja to Jounieh. Completion of the ballasting followed quickly and the line was made ready for the opening.

The Opening

The driving of the last spike was planned for Sunday the 20th December, 1942, and on the Saturday, the R.C.E. conducted Major-General Morshead over the route on a petrol driven inspection car ; each officer accompanied the party over his length.

The place selected for the opening ceremony was Nahr el Kelb—the Dog River ; the scene of many memorials of conquest. There is a band of hard limestone rock with a vertical face provided by nature for commemorative inscriptions. The earliest inscriptions celebrate the conquests of the country by Pharaoh Rameses II, Asarhaddon of Assyria, Nebuchadnezzar and the Greeks. Later ones include the French in 1860, and the Australians in 1918. The country up till 1941 had been free for 40 years in 3,000.

A rock was carved with a suitable inscription. A special guard of honour selected from our Sappers was well drilled for the occasion. A large Baldwin locomotive decorated with Australian and Lebanese flags and a full-sized passenger train were provided.

The day was fine and General Alexander drove the last spike home after inspecting the Guard of Honour, made a suitable speech, unveiled the inscription, and declared the railway open for traffic on the 20th December, 1942, thus completing the standard gauge railway between London and Cairo. The train was boarded and travelled the remaining length of the line to Bahsas, past groups of Sappers, Basutos and Swazis stationed on their respective lengths. The Australian Survey at Chekka was most surprised when the big Baldwin came through the tunnel without a scratch. The job was done, and *next day* it was put to use, carrying armour to the north and wheat to the south.

In conclusion I desire to acknowledge with gratitude the ready help given by Lieut.-Colonel K. A. Fraser, O.B.E., Brigadier C. E. M. Herbert of the War Office, Sergeant Telford, Captain W. Chadwick and Major E. L. Walpole in the collection of data for this paper; my indebtedness to Major Walpole for the use of his photographs; and to pay tribute to the many who worked hard on the job and brought it to a successful conclusion. And finally after serving with it in a very humble capacity, I salute the British Army which may lose battles but not campaigns.

APPENDIX I

Experience With Plant

1. *Tractors.*—D2, D6, D7, D8 caterpillar, and T.D.40 Allis Chalmers all gave good service. The thrust bearings of the main engine governor of caterpillar machines failed persistently and were apparently too light. The Allis Chalmers machines gave persistent clutch trouble as vibration caused lubrication failure through breakage of the flexible grease pipe.

2. *Bulldozers.*—Did excellent work in earth and clay. When used to remove blasted material from rock cuttings several bracket arms were broken by striking the solid rock. The lugs were welded electrically and reinforced, but weakness then developed in the main triangular frames and some had to be replaced. Some trouble, was caused through wear of the hydraulic equipment.

3. *Carryall Scrapers.*—12 cu. yd. and 9 cu. yd. capacity were ideal for picking up, transporting and dumping earth and sand and gave practically no trouble.

4. *Rooters.*—Le Tourneau type proved excellent. The axle retainers in the five-tine Britstand machine gave trouble.

5. *Dumpers.*—Only a few Aveling and Muirhill machines were available but gave endless mechanical trouble, probably because the engine was exposed. Their loss was severely felt.

6. *Shovels and Draglines.*—R.B.37, R.B.19, R.B.17 and R.B.10, Bucyrus Erie and Lima. All gave excellent service. Two R.B.37 were brought to Tripoli by ship from Port Said and did good work in rock excavation at the Tripoli end. They were too heavy to be transferred to other big cuttings further away. At first rope breakages were frequent on all machines, probably because of learner-drivers.

7. *Compressors.*—Southern Cross, Worthington and Ingersoll Rand. The Southern Cross machines gave considerable trouble because of the inadequate cooling system and other faults in design—the heads were frail and the water jacket too small. Leakage occurred because the bearing keeper of the pump assembly could not be kept tight. No spare parts for these machines were available. The Worthington and Ingersoll Rand machines gave little trouble, though the radiator cores of both engine and compressor on the former could have been more robust, while on the latter the fibre magneto coupling was the only persistent failure.

8. *Rock Drills.*—Ingersoll Rand Jackhamers, Gardner-Denver, and Climax. The two first gave good service but the Climax machines were altogether too light for the work.

9. *Concrete Mixers.*—Many types of new, second-hand and rebuilt machines from 3 cu. ft. to 14 cu. ft. capacity were used and gave reasonable serivce. The newer mixers of Gilson and Dandie makes were excellent.

10. *Pumps.*—Southern Cross and other makes with 2 to 10-in. delivery pipes were used. The Southern Cross machines all had inherent weaknesses due to faults in design and materials. Much time was spent on their repair and maintenance.

11. *Workshop and Small Items.*—Electric welding sets, riveting hammers, wood boring machines were usefully employed. The light aid detachment equipment proved invaluable, but was rather light for the repair of parts for heavy machinery. In order to improve plant maintenance and expedite repairs, company or group workshops should be supplied with such items as 8-ft. gap bed lathe, milling machine, power hammer, heavy duty electric welding sets, seat and depth cutters and additional emery wheels.

12. *Motor Transport.*—Approximately 200 vehicles of all types were used by the group and had a full time job in transporting men and material for construction. A very large tonnage of plant, tools and equipment had to be brought from Egypt and Palestine by road and this kept a fleet of lorries constantly engaged. This fleet included two 25-ton low-loaders for the transport of heavy machines, both from Egypt or Haifa and about the job. The bulk of the fleet were 1½ ton capacity with 2- and 3-ton vehicles and six 10-ton trucks. On the narrow and winding roads often carrying heavy traffic, accidents were frequent and the consequent repair and maintenance problem proved too heavy for the companies. Many trucks were sent to Advanced Ordnance Workshops for repairs. Local M.T. was hired but proved most unsatisfactory as it required more supervision than was available; many of the trucks, too, were not properly maintained. The lack of tipping trucks was severely felt and caused delays in the completion of earthwork.

APPENDIX II

Principal Quantities

Excavation, earth and sand	630,000 cu. yds.
Excavation, rock	343,000 cu. yds.
Pipe culverts	11,050 lin. ft.
Arch culverts up to 6 ft. diameter	135 No.
Flat slab reinforced concrete	30 openings
Sea and retaining walls	4,500 lin. ft.
Bridging, major	1,833 lin. ft.
Masonry in walls	20,900 sq. yds.
Concrete in bridges, culverts, walls	39,990 cu. yds.
Riveted shellwork in bridges	950 tons
Rivets	56,700 No.
Unit steel trestling (temporary)	250 tons
Track-work	66.2 miles
Ballast	140,000 cu. yds.

ROYAL ENGINEER OFFICER TRAINING

By CAPTAIN F. W. E. FURSDON, R.E.

THE PRESENT POLICY ON Y.O. TRAINING

THE latest War Office policy on the training of the Regular R.E. Y.O. has recently been published. It has been explained very fully with detailed appendices showing exactly what should be studied, to what degree and at what particular stage in the training.

In general, after passing the Army Entrance Examination, he should do an initial period of four months O.R. service at a Training Regiment R.E. He then enters the R.M.A. Sandhurst, where he spends approximately eighteen months at military studies, such as morale and leadership, military law, drill, basic tactics, etc., and at academic studies, such as mathematics, chemistry and electricity.

After commissioning leave, he passes on to the Y.O. Stage I Course—basic field engineering, which consists of eighteen weeks at the S.M.E., designed to teach him to take his place as a troop officer. Apart from such subjects as fieldworks and bridging, he is taught something of the organization and rôle of the Field Engineer Regiment, and of the history of the Corps.

The Y.O. Stage II course of Regimental Duty follows, which may vary from fifteen to twenty-one months with a Field Engineer Regiment or Field Park Squadron, giving him a background of practical experience, not only technically, but of man management and of duties in a unit, and all that it involves.

During this Stage II tour, the Y.O. may be selected either to attend the S.M.E. four-week refresher course for the Cambridge Qualifying Examination, or the six-month Inter B.Sc. refresher course at the Military College of Science.

Y.O. Stage III training is designed to give all officers that vital engineering background and " know-how," which is the key to the appreciation and understanding of all military engineering problems.

There are three types of Stage III courses at present in operation. Firstly, there is the two-year degree course at Cambridge reading for the Mechanical Sciences Tripos, followed by a seven-month post-university course at the S.M.E. The normal annual allotment to R.E. at Cambridge is only twelve places. The second type is the three-year degree course at the Military College of Science, reading for the London University External B.Sc. degree in either engineering or science, followed by a seven-month post-university S.M.E. course. The London B.Sc. course used to be only two years, but under the University New Regulations introduced in 1950, this was increased to three years. Amongst the changes thus introduced were that of the inclusion of chemistry into Inter. B.Sc., and the inclusion of engineer drawing into B.Sc. Part I from the Inter. B.Sc. syllabus.

The third type of course, for those not selected either for Cambridge or the Military College of Science consists of approximately one year at the S.M.E.

The one-year course at the S.M.E. does not reach any recognized standard of civil, mechanical or electrical engineering knowledge, but the War Office has indicated that in the near future a special two-year diploma course may be instituted at the Military College of Science, designed to enable officers who do not achieve a degree-type course to attain a pass in Sections A and B of the examinations of the professional engineering institutions. This diploma will then be the minimum standard of academic knowledge for all R.E. officers, and the normal one-year S.M.E.-type course will be eliminated.

It is not stated, though, what particular form the diploma syllabus will take, nor if it will be followed by a post-diploma course of say seven months at the S.M.E. If the diploma is purely academic, then a post-diploma course on military engineering subjects will be necessary. The over-all times spent on training by the various categories of Y.O. from commissioning can, therefore, be calculated as below :—

1. " Cambridge " Type Y.O.	$4\frac{1}{2}$ years approx.
2. " Military College of Science " Type Y.O.	$5\frac{1}{2}$ years approx.
3. " Normal S.M.E. " Type Y.O.	3 years approx.
4. " M.C. of S. Diploma " Type Y.O.	4 or $4\frac{1}{2}$ years approx.

As the minimum number of R.E. Y.Os. at present expected to take a degree course is 60 per cent, it is logical to assume that the majority of R.E. Y.Os. will eventually be of the " Military College of Science " type, who will take the full $5\frac{1}{2}$ years training. This will mean that there will be a large proportion of officers coming " on the market " who have only just completed their official training, but who are already within six months of being promoted substantive captain.

Academic Qualifications of Present Regular R.E. Officers

In view of the present shortage of manpower in the Services, and the increasing number of our overseas military commitments, one is bound to ask whether we can really afford the extra year on training, which the new London University B.Sc. course demands. After all, is it so vitally important for the Regular R.E. officer to hold a B.Sc. (Eng.) London? Would it not be sufficient for the needs of the Corps to have a small nucleus of officers with a Cambridge degree, and all the remainder with some other more practical standard of military engineering knowledge which, diluted with plain common sense and sound judgement, would make them first-class Sapper officers ?

Let us start by reviewing the present academic qualifications of the regular officers of the Corps, as shown in the November, 1951, (Unofficial) *R.E. List*, published by the Institution of Royal Engineers. They can be shown in the form of a table, as below, or else, using percentage figures (to eliminate the rank pyramid) they can be plotted as a graph between " percentage qualified " and " substantive rank," as shown in Appendix " A."

ANALYSIS OF ACADEMIC QUALIFICATIONS
PERMANENT COMMISSIONED OFFICERS, ROYAL ENGINEERS
NOVEMBER 1951

Substantive Rank	Total No. of offrs.	M.A., B.A., B.Sc. or B. Eng.		M.I.C.E. or A.M.I.C.E.		M.I.Mech.E. or A.M.I.Mech.E.		M.I.E.E. or A.M.I.E.E.	
		No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total
General Officers	20	2	10	—	—	—	—	—	—
Brigadiers ..	18	1	5.5	1	5.5	—	—	1	5.5
Colonels ..	96	12	12.5	2	2	7	7.3	5	5.2
Lieut.-Colonels	142	64	45	3	2	3	2	4	2.8
Majors.. ..	343	249	72.6	19	5.5	6	1.1	8	2.3
Captains ..	480	131	27.3	3	.6	1	.2	1	.2
Lieutenants ..	376	25	6.6	—	—	—	—	1	.26
2nd Lieutenants	126	—	—	—	—	—	—	—	—
TOTALS ..	1,601	484	30.2	28	1.7	17	1	20	1.2

Notes.—

(*a*) Twenty-nine officers hold degrees, who also hold associate or full memberships of the institutions.

(*b*) Six officers hold associate or full membership of two of the institutions, and two officers hold associate memberships of all three.

This analysis gives some rather interesting information, perhaps the most important of which is that 72.6 per cent of all the majors in the Corps hold a degree, as opposed to only 27.3 per cent for captains, and 6.6 per cent for lieutenants. It also shows that pure academic qualification is no passport to high rank. As time goes on, however, the peak of the degree curve will travel steadily towards the higher ranks, and it will be followed by a rather deep depression springing from the present captains and those lieutenants (mainly temporary captains) who are considered to have completed their " backlog " training. If, as is planned, at least 60 per cent of new Y.Os. obtain their degrees through Cambridge or London, the period of depression will pass, and, looking some thirty years ahead, the graph should approximate to a straight line at 60 per cent, parallel with the " rank " axis.

As regards memberships of the three major professional institutions, the table shows what a pitiful representation we have. The only small point of interest here is the way that the " civils " predominate with majors, whereas, in general, membership of the " mechanicals " or " electricals " is greater with the more senior ranks. This is partly accounted for by the fact that after the first World War those officers who did not go to a university had to qualify in the A and B papers of the Institution of Electrical Engineers before obtaining their engineer pay.

Looking to the future, it is doubtful whether many Y.Os. will ever carry on even to associate membership of the institutions, mainly because the majority of sapper tasks and appointments, particularly on the regimental and staff side, are rightly not considered suitable training for higher membership in the somewhat specialized professional institutions.

It is obvious, therefore, that all the 40 per cent Sapper officers who do not get a degree will never achieve membership of the institutions. The present figure over all is 5 per cent. The most that can be expected, provided the sapper's rôle remains as at present, is only about 20 per cent.

The Examinations of the I.C.E., I. Mech.E., and I.E.E.

It is presumed that the idea of the diploma is to give proof that a certain standard of engineering knowledge has been reached, and that the diploma be accepted by the institutions as providing exemption from Sections A and B of their examinations. In this way, besides training R.E. Y.O. officers to an agreed minimum standard, it will give them a good start should they desire to obtain a civilian professional status, which would not only help them immediately, by enabling them to participate in the various institutions' activities, but perhaps more particularly when they retire from the Army.

Appendix " B " shows what is required for the various sections of the examinations of the three major professional engineering institutions, and also, by comparison, what is required for the external B.Sc. (Eng.) of London University.

A Diploma Course as Related to the Institutions

It can easily be seen from Appendix " B " that it is no easy task to design a two-year diploma course " to enable officers to attain a pass in Sections A and B of the professional engineering institutions." It must also be realized that the examination approach and breadth of syllabus of the professional institutions is fundamentally different from that of the university degree authorities, even though many of the subjects taken are similar. The former is concerned with the practical application of knowledge to the engineering profession, whilst the latter would appear to be more concerned with the subject as a science in itself. Which approach is more worth while to the normal military engineer? Having decided this, there arises a difficulty. Is it a really sound policy to institute a complicated diploma course to fit such diverse syllabuses as the different institutions demand?

The complicated time-table needed to ensure that each individual has a completely free choice of combination of subjects would surely be most uneconomical. The only answer might be to rule out certain combinations of subjects—but this is obviously unfair to the officer, who might feel very strongly about it. This official restriction on certain combinations was applied at the Military College of Science in Part II of the B.Sc. (Eng.) examination, and, although it may have been imperative from the point of view of the lecturing staff and laboratory shortages, it was naturally unpopular.

Furthermore, accepting the fact that such a course could readily be arranged, is it really the best answer to aim this diploma at passing institution examinations, when the majority of the Y.Os. will never attain nor enjoy the privileges of associate membership of these institutions?

After all, there is no easy road to an A.M.I.C.E., A.M.I.Mech.E., or A.M.I.E.E. In order to be allowed to take the actual A and B examinations, one should have already been elected, or have been accepted as a student of the institution concerned, subject to fulfilling the examination requirement.

Having passed Sections A and B, and having produced other satisfactory evidence of practical experience, one is eligible for election to the grade of a graduate. Lastly to be eligible for election to associate membership one must possess the following qualifications:—

- (i) be of a certain minimum age, varying with the particular institution and individual circumstances;
- (ii) have passed, or be exempted from, Section C;
- (iii) have held a responsible position for a sufficiently long period and carried out such recognizable work as to be recommended by suitable sponsors.

Suggested Alternative Form of Examination

The Institution of Royal Engineers, according to its Charter, has for its objects "the general advancement of Military Science, and more particularly for promoting the acquisition of historical and scientific knowledge in relation to Engineering as applied to military purposes."

Is not, then, the Institution of Royal Engineers ideally suited for becoming the examining body for Royal Engineer officers? Why not a Section A and B of the examination of the Institution of Royal Engineers?

As a new examination takes time in order to be known and accepted by all, such an examination would lose nothing over a new M.C. of S. Diploma.

It would obviously be impossible, in view of the existing rules for membership, for the Institution to make the passing of any section of the examination a condition of membership, nor would this " closed shop " be desirable. In the long view, however, by the normal process of time, the majority of members would be qualified, including those holders of a M.A., B.A., B.Sc. (Eng.) or B. Eng. who could obtain exemption from Sections A and B only.

Again, the object of the Institution, as stated in Bye-law I (1) of the Schedule is specifically " . . . for promoting . . . scientific knowledge such as is of paramount importance to the military engineer." Thus by interpreting this into terms of suitable subjects for study, we at once eliminate the problem caused by trying to arrange a diploma course to embrace the wide variations in the three professional syllabuses. After all, the R.E. Y.O. should be made to realize that the art of the military engineer is unique, and as such, is worthy of specialized study. The syllabus should be framed, it is granted, with one eye on the civilian institutions, to give the Y.O. every possible advantage, should his ambitions ultimately turn civilian.

The actual setting and carrying out of the examination could be undertaken by the Academic Staff of the Military College of science under the general guidance of the Council of the Institution of Royal Engineers.

Proposed Section A

This section should test the Y.O's. knowledge of the fundamental principles of engineering science. It is suggested that there should be six subjects :—

1. Mathematics.
2. Applied Mechanics.
3. Engineering Drawing.
4. Applied Thermodynamics.
5. Principles of Electricity, with particular reference to electrical machines, their installation, operation and maintenance.
6. Theory of Structures.

It is assumed that exemption from the English paper demanded by the three professional institutions could be obtained by Y.O's. normal school achievements in the General and Advanced Certificates of Education.

Thus this Section A should exempt the Y.O. from the Section A of all the three major institutions.

Proposed Section B. (All subjects compulsory).

1. Properties and Strength of Materials, with particular reference to the treatment of engineering materials.
2. Theory and Design of Machines, with particular reference to actual workshop technique and practice, and the installation, operation and maintenance of machinery.
3. Mechanics of Fluids and Hydraulic Machinery, with particular reference to air compressors, pumps, turbines, and water supply schemes, together with their installation, operation and maintenance.
5. Survey, Soil Mechanics and Simple Engineering Geology, with particular reference to roads and airfields.
6. Theory and Design of Structures, with particular reference to building construction and bridging problems.

Whilst the above choice of subjects offers little to help the officer desirous of an A.M.I.E.E., it will cover, generally speaking, one combination of the Section B requirements of both the A.M.I.C.E. and A.M.I.Mech E. It is assumed, anyway, that the great majority of R.E. officers would " lean " towards one of these two, rather than the A.M.I.E.E., by the nature of their work and environment.

The practical workshops training demanded in (2) might be difficult to implement at the M.C. of S., where at present the T.S.Os. do this part of their course during the long vacation at Loughborough Engineering College. Maybe a similar arrangement might be made for the R.E. Y.O., pending the establishment at Shrivenham of training workshop facilities.

It is suggested that the survey part of the course be carried out at the School of Survey during the long vacation, as is done by the normal R.E. Y.O. degree courses.

The detailed syllabus for the various subjects is not given, but it should stress both the practical and design side as much as the purely theoretical, and in particular the scope of the subject as it affects military engineering.

Proposed Section C

No examination of any professional engineering institution would be complete without a Section C, and it is recommended that the Institution of Royal Engineers be no exception.

In the case of the Institution of Mechanical Engineers this con-consists of a written paper on the engineering aspects of industrial administration, whilst in the other two major institutions it consists of an oral part and a written examination designed to assess functional capacity and suitability for responsible work as a professional civil or electrical engineer.

What, then, for the Institution of Royal Engineers? In Part I of this paper it was shown that the Y.O. ex-Cambridge and Military College of Science is to do a seven month post-university course at the School of Military Engineering. The subjects of this course are, broadly speaking :—

1. Building Construction.
2. Advanced Bridging.
3. Engineer Resources and Survey.
4. Electrical and Mechanical Engineering.
5. Workshops.
6. Soil Mechanics, Roads and Airfields Construction, Plant Management.
7. Survey (including Railway Survey).
8. Engineer Tactics and Staff Duties.
9. Port and Railway Construction, Diving.

Of these subjects, Building Construction, Electrical and Mechanical Engineering, Workshops and Soil Mechanics have been incorporated into the proposed Section B examination. There remain, therefore, only :—

1. Advanced Bridging.
2. Engineer Resources and Survey.
3. Some military aspects of Roads and Airfields, including the actual driving and maintenance of plant.
4. Port and Railway Construction, including diving.
5. Engineer Tactics and Staff Duties.

It is suggested that these, together with :—

6. An Introduction to the R.E. Works Services and Quantity Surveyors' Organizations.
7. An Introduction to Industrial Administration, with particular reference to contracts, trade unions and civilian labour management.

be welded into one comparatively short course, sponsored by the S.M.E., which would constitute the syllabus for Section C of the Institution of Royal Engineers examination.

Additional Benefits to be derived from such an examination

The length of time required for a course at the Military College of Science designed for these Sections A and B would be two years, without a pre-course refresher. This, for a start, would save the six months spent on the Inter B.Sc. (Eng.) refresher course, and so release the harassed Y.O. from some of the rather frightening syllabus of academic work he is meant to do by himself during Stage II training. He would consequently have that much more time for indulging in such activities as sailing, riding and shooting, which many consider are of equal, if not higher, importance in his training. Add to this the one year saved from the full B.Sc. (Eng.) course, and the saving is $1\frac{1}{2}$ years worth of officer manpower! The implementation of this proposed syllabus might well cut down the length of the present Long Civil and E. and M. courses—a further economy in the length of time officers are away from units.

Finally, could it not be agreed that the passing of Sections A and B exempted officers from taking the Mathematics, Science I and Science II papers of the qualifying examination for the Technical Staff course?

Pay for Engineering Qualifications

The Interim Scheme for qualification pay for officers under Army Order 141/46 and A.C.I. 462/48 allowed for officers up to the rank of major, inclusive, to be eligible for qualification pay if :—

1. On or after 1st July, 1946, they possessed the qualification of A.M.I.C.E., A.M.I.Mech.E., or A.M.I.E.E., or
2. Prior to 1st July, 1946, they had
   (*a*) passed the R.E. Long E. and M. or Transportation courses, or
   (*b*) had passed Sections A and B of the A.M.I.C.E. or A.M.I.E.E. examinations, or held a degree, diploma or certificate giving exemption from these examinations.

With the publication of A.C.I. 825/51 (amplifying Articles 165 and 166 of the Pay Warrant), however, all this has changed; the main difference being that the possession of an associate membership no longer counts. The new eligible engineering qualifications are :—

1. Passing the R.E. Long Civil Engineering Course.
2. Passing the R.E. Long E. and M. Course.
3. Passing the R.E. Long Transportation Course.
4. Passing the R.E. Long Survey Course.

The extent to which honours degrees earned by officers of certain arms should qualify is under consideration. Officers who originally qualified under A.C.I. 462/48, however, continue to draw their qualification pay as a personal reserved right.

Special qualification pay for officers of the Royal Engineers was introduced under A.C.I. 953/51 (amplifying Article 166A of the Pay Warrant). A Royal Engineer officer becomes eligible for this new version of the old "Corps Pay" after six months satisfactory commissioned service, and he can draw both the qualification and special qualification pay at the same time.

Should any amendments to these existing regulations be desirable, consequent on the inauguration of an Institution of Royal Engineers examination? It is suggested that there should be two. The first is, that as an incentive and encouragement for Royal Engineer officers to achieve associate membership of the professional institutions, which is obviously highly desirable, the qualifications of A.M.I.C.E., A.M.I.Mech.E., and A.M.I.E.E. be restored again immediately to the list of qualifications in A.C.I. 825/51.

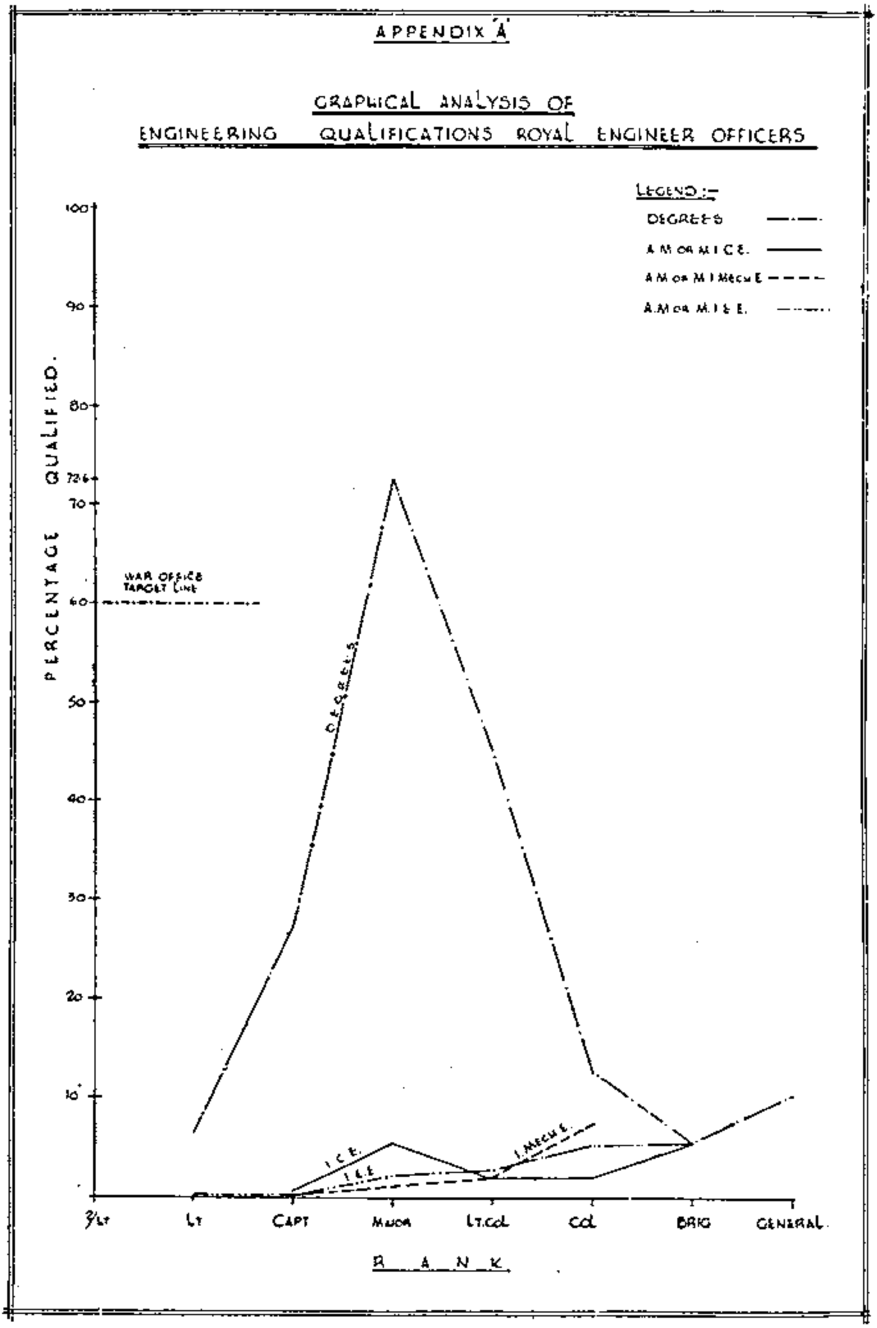
Secondly, that there be two rates of special qualification pay: a lower rate of two shillings per day be granted after six months satisfactory commissioned service, and a higher rate of four shillings per day be granted after the successful completion of Sections A, B and C of the Institution of Royal Engineers examination, both rates to be paid regardless of rank up to and including Lieut.-Colonel.

Summary

Having reviewed and discussed the academic qualifications of the Royal Engineer officer, this paper has tried to show that perhaps the new two-year diploma course to be instituted at the Military College of Science, "designed to attain a pass in Sections A and B of the examinations of the professional engineering institutions," is not the ideal answer. Furthermore, whilst accepting the Cambridge Degree course as very desirable, it is put up for consideration whether the three-year London B.Sc. course has not now become a luxury that can be ill afforded.

As an alternative, it is suggested that the Institution of Royal Engineers should become an examining body, and initiate an examination of its own, consisting of Sections A, B and C. The main object of this being to encourage and promote the study of scientific knowledge such as is of paramount importance to the military engineer, and by examination, ensure that every Royal Engineer officer is thus equipped with such an agreed basic standard of knowledge that will best fit him to follow the path of his chosen profession. As a secondary consideration, the choice of subjects has been made so as to give him the maximum advantage, should he desire to obtain membership of the civilian professional engineering institutions.

It is strongly recommended that the holding of an associate membership of one of the three main engineering institutions be restored to the qualifications eligible for qualification pay, and also that a higher and a lower rate of the new special qualification pay be accepted for Royal Engineer officers, based on the Institution of Royal Engineers examination. By the adoption of these two recommendations, the Army would be recognizing, in a small practical way, the high trust it always places in, and the unflinching service it receives from, its Royal Engineers.


APPENDIX 'A'
GRAPHICAL ANALYSIS OF
ENGINEERING QUALIFICATIONS ROYAL ENGINEER OFFICERS
LEGEND :-
DEGREES
A.M. OR M.I.C.E.
A.M. OR M.I.MECH.E.
A.M. OR M.I.E.E.
PERCENTAGE QUALIFIED.
100
90
80
72.6
70
60
50
40
30
20
10
WAR OFFICE TARGET LINE
DEGREES
I.C.E.
I.E.E.
I.MECH.E.
2/LT
LT
CAPT
MAJOR
LT.COL
COL
BRIG
GENERAL
R A N K

Appendix B

List of subjects required for the examinations of the various engineering institutions.

SECTION A

The Institutions of Civil and Electrical Engineers share a Joint Section A, but candidates for the "Civils" have to take one extra paper.

The subjects of this Joint Section A are :—

1. English.
2. Mathematics.
3. Applied Mechanics.
4. Applied Heat (with Light and Sound).
5. Principles of Electricity.

and the additional subject for the Institution of Civil Engineers candidates is :—

6. Theory of Structures or Theory of Machines.

The Institution of Mechanical Engineers have their own Section A, consisting of the following subjects :—

1. English.
2. Mathematics.
3. Applied Mechanics.
4. Engineering Drawing.

and also two further subjects chosen from :—

5. Applied Heat.
6. Principles of Electricity.
7. Physics (not to be taken with 5 or 6).
8. Chemistry.
9. Workshop Technology.

SECTION B

The subjects for the Institution of Civil Engineers are :—

1. Engineer Drawing } Compulsory papers.
2. Engineering Materials } Compulsory papers.
3. Subjects *a*, *b* and *c* from any one of the following nine groups :—

Group I
(Constructional and Public Works Engineering)

a. Theory and Design of Structures.
b. (1) Surveying *and*
b. (2) Engineering Geology and Soil Mechanics.
c. Hydraulics, *or* Building Construction, *or* Machine Design.

Group II
(Mechanical Engineering)

a. Machine Design.
b. Thermodynamics and Heat-Engines.
c. Hydraulics, *or* Theory and Design of Structures, *or* Heating and Ventilating, *or* Electrical Machinery, Principles and Practice.

Group III
(*Electrical Engineering*)

a. Electrical Machinery, Principles and Practice.
b. Electrical Transmission *or* Electrical Communications.
c. Machine Design, *or* Hydraulics, *or* Thermodynamics and Heat-engines, *or* Theory and Design of Structures.

Group IV
(*Structural and Building Engineering*)

a. Theory and Design of Structures.
b. Building Construction.
c. Surveying *and* Engineering Geology and Soil Mechanics, *or* Heating and Ventilating, *or* Applied Chemistry (Civil), *or* Electrical Installations.

Group V
(*Mining Engineering*)

a. Principles of Mining.
b. (1) Surveying *and*
b. (2) Engineering Geology and Soil Mechanics.
c. Machine Design, *or* Mining Metallurgy, *or* Thermodynamics and Heat-engines, *or* Electrical Machinery, Principles and Practice.

Group VI
(*Chemical Engineering*)

a. Applied Chemistry (Civil).
b. Thermodynamics and Heat-engines.
c. Machine Design, *or* Electrical Machinery, Principles and Practice, *or* Hydraulics.

Group VII
(*Shipbuilding and Marine Engineering*)

a. Stability and Resistance of Ships.
b. Machine Design *or* Theory and Design of Structures.
c. Thermodynamics and Heat-engines, *or* Electrical Machinery, Principles and Practice.

Group VIII
(*Gas Engineering*)

a. Gas Engineering (Manufacture) *or* Gas Engineering (Supply), two papers each.
b. Applied Chemistry (Gas).
c. Thermodynamics and Heat-engines, *or* Heating and Ventilating, *or* Hydraulics *or* Metallurgy.

Group IX
(*Aeronautical Engineering*)

a. Aeronautics.
b. Machine Design *or* Theory and Design of Structures.
c. Thermodynamics and Heat-engines, *or* Electrical Machinery, Principles and Practice.

Candidates entering for the compulsory subjects Surveying and Engineering Geology and Soil Mechanics in Groups I and V, and which are optional in Group IV, or Gas Engineering (Manufacture and Supply) in Group VIII, will not be required to take the second paper in Engineering Drawing.

For the INSTITUTION OF MECHANICAL ENGINEERS (under the new rules to apply from April 1952), the subjects are :—

Group I (compulsory papers)

1. Theory of Machines.
2. Properties and Strength of Materials.

Group II—one or two papers selected from :—

3. Applied Thermodynamics.
4. Mechanics of Fluids.
5. Electrotechnology.
6. Metallurgy.
7. Theory of Structures.

Group III—one selected paper from the following if only one paper has been selected from Group II :—

8. Aeronautics I.
9. Aeronautics II.
10. Metrology and Machine Tools.
11. Hydraulic Engineering.
12. Internal Combustion Engineering.
13. Steam Engineering.
14. Air Conditioning, Heating and Ventilating Engineering.
15. Automobile Engineering.
16. Mechanical Engineering in the Chemical Industry.
17. Refrigeration Engineering.
18. Fuel and Combustion Engineering.
19. Agricultural Engineering.
20. Textile Engineering.

For subjects 8, 9 and 11, subject 4 must have been taken in Group II. For subjects 12, 13, 15 and 17, subject 3 must have been taken in Group II. The syllabuses of 19 and 20 are now under consideration.

THE INSTITUTION OF ELECTRICAL ENGINEERS subjects are :—

1. Electrical Engineering I } Compulsory papers.
2. Electrical Engineering II }

and

3. One of the following special subjects :—

a. Electricity Supply.
b. Electrical Installations.
c. Electrical Plant and Machinery.
d. Electrical Measurements.
e. Line Communication.
f. Radio Communication.

In the case of all the institutions, Section B cannot be taken until Section A has been taken and passed.

By comparison, the External B.Sc. (Eng.) of LONDON UNIVERSITY, under the new regulations, demands the following subjects :—

Part I (*all compulsory subjects*)

1. Strength and Elasticity of Materials and Theory of Structures.
2. Theory of Machines.
3. Applied Heat.
4. Applied Electricity.
5. Mathematics.
6. Mechanics of Fluids.
7. Engineering Drawing.

Part II—any four of the following :—

8. Applied Thermodynamics.
9. Principles and Design of Electrical Machines.
10. Electrical Power.
11. Electrical Measurements and Measuring Instruments.
12. Telecommunications.
13. Theory of Machines.
14. Theory of Structures.
15. Strength and Elasticity of Materials.
16. Mathematics.
17. Mechanics of Fluids.
18. Surveying.
19. Electronics.

SOIL STABILIZATION

WITH PARTICULAR REFERENCE TO SOIL CEMENT FOR ROADS AND AIRFIELDS

by COLONEL E. W. L. WHITEHORN

WHENEVER I discuss soil stabilization with other Sappers, or with Civil Engineers, I find that the gathering is sharply divided into two groups—the confident, who tell me that they have been stabilizing roads and parade grounds all over the world since before I was born, and the doubters, who view the whole business with deep suspicion and distrust.

The purpose of this article is to let the former know what progress has been made in the last few years and to try to disperse the cloud of black magic which the latter imagine surrounds the subject ; but with a big subject such as soil stabilization, the difficulty is not what to write, but what to leave out.

It will be best, first of all, to agree on certain elementary facts so that confident and doubters can start level.

The Soil. What we call soil is mineral matter resulting from the natural disintegration of the rock crust of the earth and organic matter coming from decomposed vegetation. All soil can be divided into five basic types, but any particular soil is usually a combination of some or all of these types which are :—

Gravel—bulky mineral grains over ¼ in. in diameter.

Sand—smaller mineral grains of diameter between ¼ in. and 0.002 in.

Silt—still smaller grains below 0.002 in. diameter which lack plasticity and have little or no dry strength.

Clay—colloidal scale-like particles which are the cause of plasticity.

Organic matter consisting either of partly decomposed vegetation as in peats, or of finely divided vegetable matter as in organic silts and clays.

Water. The proportions of these five ingredients in any particular soil give it its character, but there is one other ingredient, which is usually present, that may alter its nature and bearing capacity overnight. This is, of course, water which may arrive directly in the form of rain, or indirectly by capillary action from a wet subsoil to a dry top soil.

Moisture content is a very important factor in the behaviour of a soil, as anyone will realize who has seen wheeled traffic easily making a cross country journey after a spell of dry weather and then trying to do the same trip after a few days' heavy rain. If peat and other materials, chiefly organic in character, are excluded, cohesive soils have a high load-carrying capacity when dry, but with the granular soils, like sand and gravel, there is some small moisture content—the optimum moisture content—at which they are more stable than when quite dry. This optimum content varies with every particular soil.

As moisture percolates into a soil in excess of its optimum moisture content, the load-bearing capacity falls and with some soils the familiar mud begins to appear.

For the road builder the significant differences in soils are the variations in the proportions of the several sizes of grain and consequently the behaviour of the soils when they carry varying percentages of water.

Soil Stabilization. Soil stabilization has been defined as the process of treating the soil in such a manner that its properties are not appreciably affected by water, or so as to increase its load-bearing capacity.

It will be seen that there are really two different processes—one in which the engineer who has to build a road or airfield seeks to keep the soil that he has to use in the condition in which he finds it, or preferably at its optimum water content, by preventing moisture from reaching it in the form of rain or by the absorption from the subsoil, or in dry climates by ensuring that moisture does reach it by adding a hygroscopic substance such as calcium chloride, and one in which he seeks to add to the natural strength of the soil and in so doing he usually waterproofs it as well.

The first process can be done by sealing the surface of the work with tar or bitumen, or by a membrane such as P.B.S. This, of course, only keeps out rain and it may be necessary, if moisture is likely to come from the subsoil, to wrap the soil needed to form the road in a complete " mattress " of a waterproof membrane.

Waterproofing the soil is usually done, however, by adding small quantities of substances which restrict the absorption of water, or actively repel it, and so lessen the deterioration in load-bearing capacity. Bitumen in fluid form is one of the materials so used—either as a low viscosity cut back, as an asphaltic oil or as a bituminous emulsion—and although this gives primarily a waterproofing effect, there is normally also a gain in strength by reason of the increased internal friction forces caused by the viscosity of the bitumen.

There are also several chemicals whose action is under investigation which can be added in very small proportions—1 per cent or less by weight—and give an excellent waterproofing effect. A number of proprietary substances, such as " Vinsol " and " Pectosol," help the soil to resist the absorption of water.

The second process is to mix with the soil some substance, such as cement, which will increase its maximum natural strength and at the same time greatly reduce the ill effect of water.

It is possible that the ideal solution will be to add a powerful " waterproofer " and a " strengthener " and it is hoped that for a soil needing, say, 10 per cent strengthener alone to give it a particular bearing capacity, a smaller amount, say 7 per cent, of strengthener and waterproofer combined may give the same soil strength. Experiments are being made to see what can be done.

Mechanical Stabilization.—There is a third process called mechanical stabilization, which is the oldest and best known of all, and it is used to increase the bearing capacity of the soil by improving its grading. Where, for example, the soil is all sand or gravel, it will make a better road, without any chemical addition, if some clay is mixed in, and in the same way, a clay soil benefits from the addition of some sand and gravel.

In effect, stability is imparted to the soil by reducing the voids space between mineral particles when clay is added, and this also provides a physical structure favourable to high surface tension on the part of any hygroscopic and capillary moisture present, so that there is a bonding action. The addition of sand and gravel to a clay soil results in increased internal friction and thus an increase in soil strength. Addition is perhaps not the right word, for it is not enough to add the borrowed material to the existing soil ; a thorough mixing and compacting of the two is essential.

Stabilizers

I have mentioned a few of the stabilizers which are in use, but there are many possible ones which have been investigated in this country by the Road Research Laboratory, and in America by the U.S. Army and Navy and various research centres.

The choice of a stabilizer for the Army is governed by a number of factors which restrict us to one or two, and these same factors also apply in general to civil engineering.

The ideal stabilizer :—

(*a*) will work with all soils and over a wide range of temperatures and weather conditions,
(*b*) is cheap,
(*c*) is available in large quantities,
(*d*) has a world-wide distribution,
(*e*) can be transported and stored without deterioration,
(*f*) should be needed in small percentages only,
(*g*) does not need the addition of catalysts or activators to produce the stabilizing reaction,
(*h*) allows time for spreading and compaction of the mixed soil before the setting action takes place.

No known stabilizers will fulfil all these conditions. Bitumen, for instance, is not successful with any clay soils, benefits from the addition of hydrated lime and does not produce a stabilized soil of such high bearing capacity as some other agents.

Chemicals such as calcium acrylate, resorcinol-formaldehyde and aniline furfural produce good results, but need catalysts and activators, are expensive and the control of their setting times is not yet established. Proprietary stabilizers are usually waterproofers only and add little to the strength of the soil.

Portland cement very nearly fills the bill, except that it must be used in comparatively large percentages. A cement stabilized soil is often criticized as being too rigid, and it sometimes needs the addition of another substance which is discussed later.

There is a wide divergence of opinion in this country and in America on the question of the best stabilizer. Bitumen has been satisfactorily used for roads, vehicle standings and airfield taxi strips, particularly where the climate is warm and the soil is sand or gravel. Cement has been used in this country for airfield runway foundations, and since the war for housing-estate roads, while in America there are over 4,000 miles of soil cement roads and thousands of acres of runways, taxi strips and aprons on airports. But failures of airfield runways, particularly of some of those constructed about ten years ago of soil cement, have caused the Americans to look for other and better stabilizers, and they are experimenting with calcium acrylate, aniline furfural and chrome-lignin, among other substances. All these give promising results, particularly the latter, but there is much work yet to be done before they can be accepted as successful stabilizers, and they are all expensive compared with cement and are produced in small quantities only.

It seems, then, that bitumen is a good stabilizer except with clay soils, that chemicals are expensive and need to have more experimental work done on them, and that cement has been much more used than the others, but has failures to its discredit.

My own view is that for the Army, cement should be used as the normal service stabilizer, with bitumen as an alternative for use chiefly in desert conditions where water needed for the hydration of cement is scarce and the soil is sand or gravel. I base this view on the following arguments :—

(*a*) Cement can be used to stabilize all soils except a few with a high organic content.

(*b*) Cement is needed for constructional work in the Army and a new store is not being introduced.

(*c*) The proportion of cement to soil by weight is not excessive, varying as it does from about 5 per cent by weight with sand and gravel, to a maximum of 20 per cent with heavy clay.

(*d*) Cement is comparatively cheap and is manufactured in many parts of the world in large quantities.

(*e*) It can be transported and stored, though it must be protected from moisture.

(*f*) The failures of soil cement in America have not been properly investigated and may well have been caused by poor mixing, wrong proportions, or to the presence of organic matter in the soil.

(*g*) The chemical stabilizers may eventually prove superior to cement, but the chemical industry of this country cannot produce them in sufficient quantities without greatly reducing the output of even more important products.

Cement Stabilzation

So far I have been writing about the addition of cement to a soil, but I have not defined cement, of which there are several main varieties, nor have I made more than one brief reference to other substances to be added with it.

Four types of cement which are available are :—

(*a*) *Normal Portland Cement* manufactured from limestone and clay, and containing about 2 per cent of gypsum.

(*b*) *Rapid Hardening Cement* manufactured from the same materials and differing only from N.P. cement in that it is more finely ground.

(*c*) *Super Rapid Hardening Cement* which is similar to rapid hardening cement except that it contains about 2 per cent of calcium chloride in place of the gypsum.

(*d*) *High Alumina Cement* manufactured from limestone and aluminium oxide (bauxite).

Soil cement specimens made with these cements and with a sand, a silty clay and a clay showed that where high strength is needed after twenty-four hours, the high alumina cement should be used, but that after twenty-eight days it gives a lower strength than any of the other three cements. The rapid hardening cement gives a very slightly higher strength at all ages than normal Portland or super rapid hardening cements.

The choice of a service cement for soil stabilization, therefore, seems to be quite easy—use high alumina cement only if a good strength is wanted very quickly and use normal Portland cement, which is the type supplied for constructional purposes, for all other jobs.

This would be correct if it were not for the fact that many soils contain small proportions of organic matter which can delay or even prevent the hardening of normal Portland cement. In some cases, the percentage of organic matter is as low as 0.3 per cent and it may give no colour to the soil, so that its presence is very hard to detect without elaborate tests.

In much of the work during the past three years at M.E.X.E., lime was added to normal Portland cement in the proportion of six of cement to one of lime, and this gave an improvement when organic soils were found, probably because of a reaction between the lime and the organic matter. In simple terms, the lime kept the organic matter quiet while the cement was setting. Incidentally, 2 per cent lime helps bitumen stabilization and we always add it to the soil before the bitumen is mixed in.

However, in the course of many experimental mixes, we have found that some organic matter is so virulent that even the addition of lime will not prevent a delay in the setting of normal Portland or rapid hardening cements, and we have had to look elsewhere for something better. One of the most successful additives we have so far tried is calcium chloride, which is very effective and this, luckily, is a constituent of super rapid hardening cement.

The Army seems, therefore, to be faced with the supply of three types of cement—normal Portland for general construction work, high alumina for work where high strength is needed after a few hours and super rapid hardening cement for soil stabilization, for active organic matter may be found in many places, even in beach sands.

Even then we are not at the end of our troubles, for calcium chloride is extremely hygroscopic and becomes useless if exposed to moisture. For this reason the Cement Marketing Company do not export their super rapid hardening cement (417 cement), because it is packed in paper bags which cannot be guaranteed to prevent ingress of enough moisture to spoil the calcium chloride during shipping overseas and storage. The only solutions at present available if super rapid hardening cement is wanted abroad are to make it, or purchase it, in the theatre of operations, or to export it in steel drums which must be paper-lined because the calcium chloride attacks the steel of the drums. The problem of packaging is being studied and a better solution may be found.

Also, the proportion of calcium chloride to soil by weight when a 10 per cent cement mix is made is only about 0.2 per cent, and it may well be that a somewhat higher percentage is needed for difficult soils. This involves the addition of extra calcium chloride as well as cement to the soil, which is quite easy if the soil is below the optimum moisture content, for the calcium chloride readily dissolves in water and can be added in solution with water needed to bring the soil to the correct moisture content. If the soil is already wet enough, the problem is more difficult unless the calcium chloride has been ground finely and can be added as a powder with the cement.

Calcium nitrate shows promise of being even more effective than calcium chloride and the final answer may be to use normal Portland cement with calcium nitrate added either in solution in water or as a powder.

It is quite probable that failures of soil cement roads and airfields in the past, which have discouraged contractors, may have been due to the presence of these extremely active and quite invisible organic matters which in extreme cases will completely prevent the setting of cement.

Uses of Soil Stabilization

As already mentioned, soil stabilization has been used for airfield strips, roads and hard standings, but no reason has been given why this process has been chosen instead of well established engineering methods.

Since the days of the Romans we have been making roads by removing the natural soil and substituting stone in the form of slabs, hand pitching, rubble or, of late years, concrete, and then covering this foundation with a wearing surface. The same process has been used for permanent airfields and though during the last war temporary airfields were successfully constructed by laying P.S.P. on the natural soil, the rapidly increasing tyre loadings and pressures of modern aircraft are making this expedient impossible.

Many areas of the world, parts of Northern France for instance, are practically devoid of stone, and when it is realized that a temporary airfield consisting of one landing strip, without taxi tracks, may need 40,000 tons of stone, the magnitude of the supply and transport problem can be realized.

If, therefore, we can retain the existing soil and add, instead of 100 per cent of stone, some 10 per cent of cement, we have effected an immense saving of material to be transported, often for long distances over bad roads. Also, if we can use a stabilization process in which a train of machines moves along the line of a new road or airfield strip at the rate of one mile per day, each producing a foundation 7 ft. wide which will, at a pinch, take wheeled traffic twenty-fours hours after the train has passed, we have gained enormously in speed over conventional methods and, in war, time is usually the most important factor.

In addition, it should be noted that in World War II, the repair and construction of roads and airfields absorbed at times more than 50 per cent of the resources of the Corps, so that any saving in man-power by the use of soil stabilization will be invaluable.

In the last war when called upon to make landings on an enemy coast, we had to move hundreds of tons of stores and many wheeled vehicles across stretches of sand, shingle and mud. We managed with the aid of matting, Sommerfeld track and other expedients, but we spent much time in laying and maintaining the tracks and we lost much equipment. We are now aiming at producing stabilized paths from the water edge inland across the beaches to be open to traffic a few hours after mixing, and experimental work is in progress.

Thus, for military needs soil stabilization will produce foundations for roads, forward airfields, stores dumps and beach tracks with a saving in materials, transport and time, but while these savings are equally appreciated by the civilian engineer, he is also much affected by costs.

Hence the use of soil stabilization, which is greatly interesting the civil engineer in England at present, is for cheap roads for housing estates, for minor country roads and for temporary approaches during contractors building operations. It is interesting to note that the cheap, stabilized, temporary, contractor's approach road, which carries all his traffic during construction, is being used as the foundation of the new road serving the completed factory or housing estate after an extra layer of stabilized soil is laid on top with a wearing surface to complete the job.

In undeveloped areas in the Dominions and Colonies, the stabilized roads should offer considerable savings in costs, materials and transport.

The cost of civilian cement stabilized roads in England for housing estates seems to vary between 2s. 10d. and 7s. per square yard, according to the locality and the specification, and in Australia good soil cement roads are being built at less than one-third the cost of those with stone foundations.

Mixing

It is very easy to say that 10 per cent of cement should be mixed with the soil, it is comparatively easy to do it in a laboratory, but it is very difficult to do it properly in the field, and many of the failures in the past can be attributed to inefficient mixing of the soil with the stabilizer.

It should be obvious that unless the soil is thoroughly broken up and brought in contact with the cement grains, for example, the mixture will consist of lumps of soil coated with cement which have little more strength than the virgin soil, and the stickier and more cohesive the soil, the more difficult becomes the mixing. This is why clay has normally refused to be stabilized and, indeed, it is only in recent years that successful results have been achieved.

Different soils need different methods. Sands and gravels need to be pulverized, but clays will not respond to this treatment, so that with them the best answer seems to be to cut off fine shavings, spread cement on both sides and then knead these coated shavings together.

Very little study seems to have been made either in this country or in America of the design of mixers, nor have thorough comparative trials been carried out as far as I am aware. Work done at M.E.X.E. during the last few years does show, however, that :—

(*a*) Pulverization of granular soils can be done efficiently with a combination of slow forward motion (6–30 ft. per minute) and rapidly rotating blades (200–300 r.p.m. at a radius of 1 ft. 6 in.) and if cement is added a very good mix can be made. The nearest example I can give is an ordinary garden lawn mower, but we are considering a cutter drum of 2–3 ft. diameter and with sixteen or twenty blades instead of six or seven.

(*b*) It is probable that clay can also be efficiently mixed in this way because the rapidity with which the blades attack the soil surface produces very fine shavings presenting a large surface area to cement.

(*c*) The heaviest clay can be thoroughly well mixed with cement in a twin shaft paddle mixer originally designed for a pottery, but the output of such a mixer is comparatively low. This type of mixer will also deal with sands and gravels.

(*d*) The method now used by contractors in this country and in America of spreading cement on the soil before the mixing machine passes over it probably leads to inefficient mixes. We are experimenting with methods which should give far better results.

Mixing Machines

The first machines to be used were, of course, existing ones such as blade graders and agricultural plant, such as harrows and rotary cultivators. These are slow and, quite naturally, inefficient mixers, as they were designed for other purposes, but they have done and are still doing good work. Their output is low because they have to make several passes over the same ground in order to get a reasonable mix, and in doing so they are apt, because of imperfect depth control, to break up some fresh soil at each pass so that the percentage of cement to soil finally obtained is lower than that planned. Also the agricultural machines cannot work to the depths which are needed if heavy loads are to be carried by the completed foundation.

Machines designed for other purposes, such as concrete mixers and bitumen mixers, have also been used, but are not satisfactory because they have a low output and they do not give a good mix, particularly with clay soil.

The Americans who were first in the field with serious work on soil stabilization began to develop big machines with a high output which would carry out the stabilization process in one pass, and of these the Woods road mixer and the P. & H. Single Pass stabilizer are but two examples. The latter is a formidable machine of 260 h.p., weighing 25 tons, with length, width and height of 30 ft., 12 ft. 7 in. and 10 ft. 3 in. respectively. It moves on its own tracks at a maximum speed of 1½ m.p.h., and has a working speed of between 6 and 32 ft./min. When mounted on a transporter it positively droops over the sides and is guaranteed to cause a traffic block in any but the widest road.

It was intended for operation in wide open spaces, and in America it has done exceedingly good work on suitable soils—a daily output of 10,000 sq. yds. of stabilized foundation is obtained by contractors—but both the War Office and the U.S. Corps of Engineers regard it as being too bulky for Service use. Probably as a result, the makers are now producing a smaller model which has not yet been seen in this country.

Travel Mix *v.* Mix in Place

There are two rival types of mixer each of which has staunch adherents who will hear little good of the other. The mix-in-place machine moves over the virgin ground after the top soil has been removed, pulverizes it, adds the stabilizer and water if required, spreads the mixture neatly behind itself all ready for final compaction. The P. & H. is of this type, for it passes a mixing box containing four rotors over the surface of the ground breaking up the soil and mixing it either with cement or bitumen.

The travel-mix machines now in use move along a prepared sub-base, pick up soil which has been deposited there, process it inside themselves and then spread it on the ground ready for compaction. The Woods, Moto Payer and similar machines are of this type, and their chief use is the preparation of bitumen mixes, though they can be used for soil cement.

Those favouring the travel-mix plant say that the additives can be proportioned more accurately and better mixed, and that the plant is more flexible than the mix-in-place type—it can, for instance, work in a borrow pit and deliver good mixed soil to dumpers which carry it to an airfield site where the natural soil is a bad one, or to a congested site such as a bridge abutment where there is not room for a mix-in-place machine to work.

There is much to be said for both types of American machine, but I consider that for Service purposes they are too bulky, too heavy, too expensive and are not really suitable for bad soil such as clays.

There seems to be nothing between these big complicated machines and the small, inefficient agricultural cultivators which were never intended for soil stabilization, and obviously something is needed to fill the gap. The ideal machine :—

(*a*) Must be able to mix all types of soil with an additive in powder form, cement for example, or a liquid such as bitumen, with an efficiency of mix equal at least to 80 per cent of a mix done under ideal conditions in a laboratory.

(*b*) Must do this in one pass over the ground.

(*c*) Must be quite simple with a single rotor only, if possible, to do both the pulverizing of the soil and the mixing in of the stabilizer.

(*d*) Must be robust and easy to maintain.

(*e*) Must be highly mobile so that it can easily be moved from one job to another.

(*f*) Must be comparatively cheap and easy to manufacture.

Nothing exists which will satisfy these conditions, but there are three British machines under development, at least one of which may prove successful.

If an all-purpose machine cannot be produced, there are two possible solutions to the military problem. The first is to have a number of cheap, simple, single rotor machines which will deal with most soils including gravels, sands and sandy clays, and to have a few big expensive machines which will stabilize all types of soil. These would be held as project stores and issued when it was essential to stabilize a difficult soil with which the simple machines would not deal. The second is to have a big machine with a number of rotors of different types, not all of which would be at work at one time. Like the golfer who takes out a niblick when he finds his ball in a deep bunker, the operator will fit his clay mixing rotor or combination of rotors when he has to deal with an area of heavy clay and use others for sands and gravels.

Compaction

The final operation in soil stabilization is the thorough compaction of the mixed soil left by the mixing machine. This is a most important process and if it is done badly much of the effort spent in getting a thorough mix can be wasted.

Compaction can be started immediately behind the mixing machine and the ideal arrangement is to have a single pass compactor working at the same speed as the mixer a few yards behind it. The only compactors likely to be able to do this are the heavily-loaded type on three or four large pneumatic tyres—total weight 40 to 60 tons—and a new impact type now under development at M.E.X.E.

Of the machines at present available in this country steel wheel rollers and vibrating rollers can be used successfully, but they need to make several passes.

Supply of Materials

Whatever the type of machine in use, it will need a continuous supply of stabilizer whether this be cement, bitumen or calcium acrylate, and a fleet of suitable vehicles must be in attendance.

For instance, bitumen can be brought in 1,500 gallon tankers, one of which will be connected to the machine by a flexible hose, while a pump delivers its contents to spray bars over the mixing chamber. When the tanker is empty it goes off to refill and another takes its place, so that about four tankers* will be needed for one machine.

As already stated, cement is usually spread on the ground in front of the P. & H. and the small rotary cultivators, or on a windrow of imported earth in front of the Woods road mixer, and the Americans have developed a machine which hitches on to a tipper filled with loose cement, receives its contents and spreads it accurately in any desired proportion on the ground.

If the soil is below the optimum moisture content, it will be necessary to add water as well as cement, and this is done in the same way as for bitumen, a fleet of water tankers keeping the machine supplied.

Cement delivered to the site in bags is a nuisance, for each bag must be split open and emptied either on to the ground where the

* Depending on the length of haul.

cement must then be spread by hand, or into a hopper fitted on the mixing or spreading machine. Emptying and spreading by hand wastes much time and labour, and it is very difficult to keep to a fixed cement content. The ideal way, from the engineer's point of view, would be to have the cement delivered in bulk in tipper lorries where machine spreading is in use, or in steel containers which are made in capacities varying from one to five tons. These can be carried on a lorry and when lifted by crane will deliver direct into a hopper on the opening of a valve. The difficulties of supply in bulk will have to be balanced against the waste of time and men when bagged cement is sent up to the working site.

Plant Involved

It will be realized by now that a considerable amount of plant is needed in the construction of a stabilized road or airfield, and it does not vary much in type or quantity when different stabilizers are used. For a typical soil cement road on a new alignment, the minimum amount of plant needed would be :—

(*a*) One bulldozer for preliminary earth moving.
(*b*) One grader to take off top soil with vegetable matter and possibly to scarify the ground if hard or full of large stones.
(*c*) One cement spreader.
(*d*) Four or five tipping lorries* keeping cement spreader supplied.
(*e*) Three or four water tankers* providing water for hydrating the cement and bringing dry soil to correct moisture content.
(*f*) One stabilizing machine
(*g*) One roller or compactor to compact stabilized soil.

On a big job such as an airfield, it will be best to have several stabilizing machines working in echelon and each will need its supply lorries and a compactor.

Tests

There is a great need for the development of rapid tests for use before and during a soil stabilizing operation. The soil should first be classified and its bearing capacity determined. It may completely change its nature in a surprisingly short distance, its moisture content will vary with seasonal and daily weather conditions, organic impurities may or may not be present, the content of the stabilizer mixed with the soil must be checked to see that it agrees with the specification, and the strength of the stabilized soil must be measured.

All these tests can be carried out, but at present some of them take far longer than the officer in charge of the work can afford to wait. For instance, though the moisture content of the soil and its cement

* Depending on the length of haul.

content can easily be measured in five minutes for each test, there is, as yet, no satisfactory way of finding out what the bearing capacity of the stabilized soil will be after seven days except by making up specimens and crushing them when they have cured for this time. Experiments are being made to cure the specimens artificially, so that seven-day strength can be measured after, say, one hour, but a satisfactory process has not yet been fully developed.

Work is going on to try to shorten the other tests, which should be simple ones that do not need a skilled chemist to perform, and the apparatus should be robust and not so bulky that a large mobile laboratory is necessary.

The ideal would be to have all the necessary equipment in a jeep trailer with a hood or small tent to give protection in bad weather.

Summary

It is impossible in a single article to go fully into such a controversial subject as soil stabilization, so I propose to summarize some of the results of experimental work which has been going on in this country during the last few years and of constructional work done here and abroad.

(*a*) Practically every soil can be improved either by being made resistant to water or by an increase of bearing capacity, or both.

(*b*) There are a number of stabilizers which give good results and of these cement is the best for Army purposes, with bitumen as an alternative. The chemical stabilizers being developed in America are not yet suitable and are likely to be too expensive and too scarce for our use.

(*c*) Success depends on efficient mixing of the soil with the stabilizer and particularly with clay soils. Mixing plant now under development for soil cement will almost certainly be equally effective with any of the chemical stabilizers, if they eventually replace cement.

(*d*) No existing mixing plant is satisfactory, and a highly mobile machine in size between the large and complicated American mixers and the modified agricultural cultivators, and more efficient as a mixer than either, is needed.

(*e*) With cement stabilization, the following points arise :—

(i) Organic impurities often found in the soil may seriously delay or even completely prevent cement from setting, and an antidote in the form of calcium chloride or calcium nitrate is essential, either in super rapid hardening cement, or as an addition to normal Portland cement.

(ii) Variations in soil are dealt with by variations in cement percentage added. For good sandy gravels, 5 per cent by weight of cement may be enough, for the worst clays the amount will rise to 20 per cent. Hydrated lime added in the proportion of one of lime to six of cement can improve the result, except where virulent organic matter is present in the soil.

(iii) Large quantities of cement will be needed for road and airfield construction, and if full use is to be made of soil stabilizing plant, the cement should be delivered to the site in bulk not in bags.

(iv) The finished soil cement should be regarded as a foundation only. A wearing surface is necessary if much traffic is to traverse it, though in emergency it will give quite a good life under heavy loads. Tar macadam, spraying and blinding or even P.B.S. will give a suitable wearing surface, which will take all military wheeled traffic.

(v) On a sand or gravel subsoil, a 4-in. soil cement foundation can be expected to take all the wheeled traffic for a Corps for at least three months, and probably for much longer. If the subsoil is weak, a 6-in. foundation may be needed, and for a wet, heavy clay soil and heavy wheel loads it may be necessary to provide 12-in. foundations.

(vi) Experimental soil cement roads and airfield strips, which have endured two or three extremely wet winters, have not been affected by water, though no attempt has been made to protect them even by providing a wearing surface. This is true for sand as for clay soils.

(vii) Frost had no effect on these roads, though admittedly the winters were mild ones.

Finally, I have observed that designers who turn from one medium to another ; for example, from wood to metal, from steel to plastics, or from rivetting to welding often fail to make full use of the possibilities of the new medium because they continue to use techniques developed for the old. It may well be that we shall have to find new techniques before we reap the full benefits of soil stabilization.

I should like to express my thanks to the officers of the Road Research Laboratory and, in particular, to Mr. P. J. M. Robinson of M.E.X.E. and his staff, who have taught me all I know about soil stabilization.

Thanks are also due to the Ministry of Supply for permission to publish this article.

DEMOLITIONS AND MINELAYING—SOME GERMAN METHODS

By Major M. L. Crosthwait, M.B.E., R.E.

Introduction

Much time and thought has been given lately to demolitions in the withdrawal, and minelaying. As these subjects are being so much discussed, the time is opportune to suggest any lines of thought which might help those whose task it is to produce our own policies on the subject. This paper discusses some German last war methods. There are possibly some ideas worth developing contained in them. The demolition aspect will be considered first.

Road Denial

During a withdrawal there are two main ways by which, through creating obstacles, an advancing enemy can be delayed. There is first of all the stop line, the river or whatever it may be, when by destroying all the bridges the enemy is forced to deploy and to stage a large-scale bridging operation. This aspect, with its careful arrangements for preparing the bridges for demolition, the arrangements for giving the order to blow, the provision of infantry bridge garrisons, etc., receives a lot of attention both during paper schemes and schemes with troops. The other aspect, how best can an endless series of obstacles be created so that the area between one stop line and another is effectively blocked, receives very much less attention, if any at all.

The latter problem is not an easy one. In short it can be called " Road Denial." It is a problem which the Germans became past masters at solving.

A Little Verge Mining

As for our own methods, the " Infantry Division in Battle, 1950," acknowledges the fact that during a withdrawal mines should be placed along the verges of the road or at bottle-necks, " utilizing a small party of Sappers with the necessary mines and equipment," and that " the rear-guard mobile troops should contain an engineer element for subsidiary demolitions and mining." It would seem, however, that something more than a " small party of Sappers with the necessary mines and equipment " is required, if anything more than a little verge mining is to be produced.

After all the main aim is to secure a respite before the enemy catches up again. The contrast between enemy transport flowing along the axis roads unimpeded and the same transport, reduced to the pace of a Sapper walking on ahead with a mine detector, and lagging many miles behind the enemy spear heads, needs no emphasis. And lag it will if the Engineers are given a real chance to tear the road system to pieces as the withdrawal proceeds.

The German Effect

No one who had first-hand experience of following up a German retreat can forget the thoroughness of the German methods. Every road and side track was blocked. Even the most insignificant cart track was likely to have had a booby-trapped tree felled across it. Culverts, craters, mines, trees, booby traps, endlessly some sort of osbstacle was to be expected. Finally to arrive at a major obstacle—the 250-ft. span broken bridge or whatever it was—was almost a relief. At least everyone knew what they were up against. There was nothing more disheartening to a conscientious Engineer Squadron Commander than to have a vehicle blown up and a life lost in some obscure place, which his Sappers had already checked to the best of their time and ability. How was all this organized?

The Source of Information

It is difficult, seven years after the war, to get hold of German training manuals. German practice can often only be found out by asking a member of the former German Army, if one with the necessary knowledge can be found. The information on which this article is based was given to the author by a former Captain in the German Pioneers.

This man was a member of the " Div. R.E." for most of the war. Some of his experience was with Rommel's armoured division in France, most of it was with a German infantry division in Russia.

The Divisional Pioneer Battalion was organized very similarly to our divisional engineers. It consisted of three companies (each approximately 210 men), each company being made up of three troops, each of forty-eight working members. Each troop had four sections (*Gruppen*), each of one N.C.O. and twelve men. Each company was affiliated to one of the infantry regiments (brigades). There was also a field park element, including bridging train, in the battalion. The tasks of the divisional engineers were similar to those found in British practice.

From the Top Down

One can well imagine from seeing the effect of German withdrawal demolitions, that their execution did not depend, as with us, almost wholly on engineer initiative. The business of creating as much delay as possible was planned from the top and given as much priority and thought as the creation of the next defensive line. The General Staff was well aware that the engineers could not produce obstacles across the whole front—laterally and axially—without being given time and resources, and the requirements and convenience of other arms were often sacrificed so that this could be done. It was done in two main ways.

(*a*) It was an accepted fact that the bulk of the Divisional Engineers would be required initially for this "scattered" demolition work. This would always take priority over the preparation of the next defensive line, and, if it was at all possible, over the preparation of major stop lines. This generally meant that stop lines were prepared for demolition by Army Troops and then handed over to Divisional firing parties.

(*b*) Once the time table of the withdrawal was settled, the General Staff would issue on a very wide scale (as can be well imagined) a map showing which roads would be closed to *all* traffic and the times. This would either be done by showing the roads along which the rear-guard would withdraw in (say) red, roads that would be open until H-8 hrs. (say) in blue, H-16 hrs. in green and so on, or whole areas would be coloured in, areas marked in certain colours being only passable up to certain times.

On receipt of these maps a unit which was harboured in an area which was to be closed at a certain time, would have to move before that time. If it did not, it merely got mined in. Special provision was generally made for gun areas, but all other units had to move their harbour areas in accordance with the map. About this there was no argument, and everyone accepted that fact. The engineers, therefore, had time progressively to create obstacles over the whole front until they were only left with the final withdrawal routes.

Thus the operation was properly phased, the engineers had proper time to carry out their work and by the time the rearmost troops began to move back, only a minimum number of engineers were required in the forward areas, as there was only the minimum of last-minute demolitions left to do. The remainder by this time would have moved back to join in preparing the next defensive positions, or would have taken over the next stop line.

Control During the Final Phase

As the rear-guard began to move back, a typical picture would be as follows. It is assumed that one regiment is conducting the withdrawal and is coming back on two routes. The two routes would still be open, but all demolitions on them would have been prepared. These would include :

(i) Mines in the verges and in the road. These mines would already be in place and camouflaged. All that remained to be done would be to withdraw the safety pins. (*Note.*—This referred to Teller mines only. A Teller mine which had not had the safety pin removed would take the weight of the heaviest vehicle. It was, therefore, safe to bury them in the road. This drill was not possible with some of the later German mines.)

(ii) Craters and trees would be prepared ready for firing.

(iii) Farm carts, etc., would be ready for pulling across the road, with the booby trap in place, only needing it to be connected to the trip wire, etc.

(iv) Side turnings would already have been blocked and mined.

(v) Craters, mines, blocks, etc., would be laid in groups, one group perhaps stretching 80 to 100 yds. Normally two pioneers would be left to look after each group. Thus there might be eight to ten groups (sixteen to twenty pioneers) strung out along the road. No reliefs were provided for the sentries and these men might be on duty a considerable time. They fed themselves as best they could.

(vi) One troop could cover a maximum of fifteen to twenty miles of road. This would naturally mean that the groups of demolitions would be far apart. If the withdrawal was less than twenty miles then the groups could be closer together.

(vii) The first group would include the pioneer officer in charge of the demolitions on that particular road. He would have a wireless set on the rear-guard commander's net. He would also have written firing orders. These would state on whose orders the demolitions were to be fired, mines armed, etc. (Normally the Commander of the rear-guard.) The firing orders would include a space for the signature of the rear-guard commander or the officer who was acting on his behalf.

Firing of the Demolitions

As the rear-guard passed the first group, the rear-guard commander would give orders (in writing) for the demolitions to be carried out and the pioneer officer would then give the orders to blow, arm the mines, etc. The engineer party having carried out the task would then come on back with the rear-guard. They would have their own vehicle, often a tracked armoured troop carrier, which contained a wireless set.

As they went back they picked up the pioneers who had been guarding subsequent groups, and the whole party as required would arm mines, set off demolitions, etc., if to do this quickly was beyond the capacity of the original sentries. The pioneer officer would get his " order to blow " confirmed in writing for each group of demolitions. The time of demolition was always noted.

If the engineer vehicle got too full, any pioneers subsequently picked up were carried on vehicles of the rear-guard, or alternatively another engineer vehicle would be stationed along the road at some convenient spot, to bring them back.

Thus the final picture would be that which so often faced the advancing troops. The routes along which the German rear-guard had withdrawn would be effectively blocked. Side roads and tracks between these routes would also be similarly blocked and mined.

Familiarity and Discipline

This drill, as related by this former German officer, seemed to be very simple and invariably effective. The officer, when questioned more closely as to whether things really went quite so smoothly as this, seemed surprised that anyone could possibly see any snags in it. The German fundamental advantages seemed to have been as follows :—

(*a*) Because the engineer side of " demolitions in the withdrawal " received so much attention from the top, familiarity with the drill spread downwards throughout the division. *Everyone* knew, whatever his arm, exactly how they were carried out, what the method of giving the orders to blow was, the respective responsibilities of the engineers and the rear-guard and so on. It was just as much a part of the divisional battle drills as deployment or movement by road.

(*b*) Apart from this familiarity and because it was so important, everyone took great pains to prevent anything going wrong. There was normally no question of a N.C.O. at an isolated group getting panicky and setting off his demolitions too soon, or of the officer in charge not making sure he was getting his orders correctly. Apart from the fact that he was as familiar with the composition and command of the rear-guard as the rear-guard was familiar with his problems, it was literally as much as his life was worth to allow things to go off too soon. To let a " withdrawal demolition " go wrong due to carelessness, inefficiency or " wind up " could lead to a very quick and early grave.

The Penalty of Disobedience

The following story illustrates this latter point. During the Russian retreat the drill described above was being carried out down a brigade withdrawal route. At one point a small bridge was prepared for demolition. Alongside the bridge was a ford, the approaches to which had been mined. There was a N.C.O. and two men in charge of this " group ". The N.C.O. thought he would save time by arming the mines on the track leading to the ford, leaving only the bridge to be blown when the rear-guard passed. The N.C.O. was unfortunate, in that the Brigade Commander himself came along at that moment and noticed what was happening.

The N.C.O., on admitting that he had had no orders to arm the mines, was immediately found guilty and summarily shot by the Brigade Commander's L.O.

Things have less chance of going wrong if the wages of disobedience is death.

Some Miscellaneous Demolition Points

The drill for the close bridge garrison and the division of responsibility between its commander and the commander of the engineer firing party was almost exactly the same as British present practice. It is interesting to note, however, that the Germans had no equivalent of "A.F. 4012 B." Each German pioneer officer in his *Recce Pocket Book* had a list of points to which he should know the answers before setting out on a demolition task—the sort of points that one finds on the "4012 B"—but otherwise each bridge, etc., was treated on its merits and special orders were issued for it. There was no set pro forma.

The mysteries of "Readiness 'A' & 'B'"—detonators connected, but not pushed home, etc.—had clearly caused the Germans as much bother as it does us—especially making the Staff, etc., fully conscious of the time it takes to change from one to the other and how it varies for different types of bridge.

The German pioneers seemed to have evolved no better system than we have for getting at the underneath of the roadway. Stageings, ladders, etc., had to be improvised from scratch for each bridge. No special made-up gadgets were carried except for rope ladders.

German text-book practice was to make a diagonal cut in the roadway in the same way as a diagonal cut was made in the main girders. This roadway cut being designed to slope from the up-stream side to nearer the abutment on the down-stream side. Normally one complete diagonal cut would be made at one-third span from the home abutment and the *enemy* abutment would be cratered.

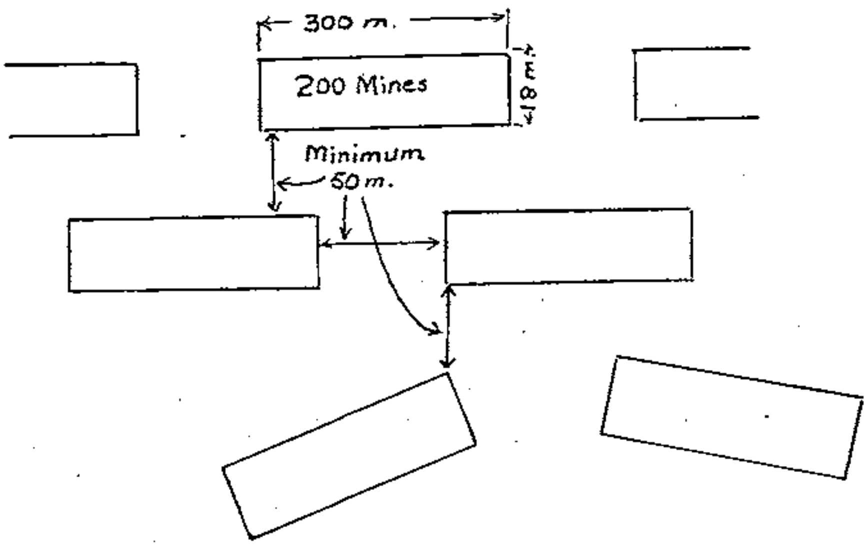
The idea of the diagonal roadway cut was to tilt the bridge. This did not generally work out in practice owing to the difficulty of fitting a diagonal staging under the bridge, so that the one-third span cut was carried out exactly as we would, with a straight cut across the road.

Minelaying

The normal German methods of minelaying are worth describing although they may be familiar to many readers of this journal. They differed from British practice in one fundamental point—basically the drills depended on each man carrying, laying, burying and arming four mines. There was no system of separate carriers, layers, armers and buriers.

Panels

German minefields were, if possible, laid in panels, each panel being 200–300 metres long and consisting of four rows, with 6 metres between mines and rows (200 mines). The 300-metre panels would be laid out in variations of the following pattern :—



As many panels were laid as were necessary to cover the front laterally and in depth. Panels would not be closer to each other than 50 metres, chiefly to minimize the danger of walking into a completed panel when laying further panels. Panels were,of course, sometimes laid shorter than 300 metres, especially if working parties were small.

Method of Laying

The basic laying party for one panel was a troop (fifty men) with one vehicle (200 mines). The vehicle (or sledge in Russia) was manœuvred as near to the location of the panel as possible. Each man then carried four mines up to the site. Two Teller mines could easily be carried by their handles in each hand. A short spade was also carried by each man slung from his waist, like our entrenching tool. The rifle would be slung on the back.

On arrival at the site two laying methods were used.

(1) *Most Favoured Method*

One tape would be laid to show the alignment of the first (home) row only. Lights, which had to be lined up like leading marks, were also sometimes used. The fifty men were then lined up at 6-metre intervals along the tape. On a given signal (torch flashes, whistle, word of command, etc.) each man laid one mine at his feet. The whole line then walked forward six paces turned left (or right), walked three paces and then each man faced his front and laid another mine down at his feet. This process was repeated for the remaining two mines until each man had laid his four mines. At night each mine had a circular piece of white tape laid on it so that it could easily be found again.

The whole line then went back to the first row and buried the mines, similarly treating the second, third and fourth rows, the piece of tape still being used to mark where the mines were buried. When each man had buried his fourth mine, at a given signal the safety pins (these were on a string which would be led to the surface after burial) were withdrawn, followed by the safety pins of the third, second and first rows. The minefield was then complete.

The party then marched to the position of the mine dump or vehicle for the next panel.

If Anti-Personnel Mines were to be laid these were laid by a separate party using a similar drill. No one objected to walking over an armed " T " minefield, so the " T " mines were disregarded by the " A.P." minelayers.

(2) *Alternative Method*

In the most favoured method, only one tape (or one row of light markers) was laid. In the other method a tape or lights was laid for each row and a party of twelve men and an N.C.O. (i.e., one *Gruppe*) would be assigned to each tape. The N.C.O. would then pace along the tape followed by his twelve men. Each man would then lay his four mines on the enemy side of the tape as directed by the N.C.O. Each man then buried his four mines starting with number one. When all the mines were buried the N.C.O. walked back along the tape, reeling it in as he went, and as he came to each man the man would arm his four mines and then walk back along the tape in front of the N.C.O.

This method obviously took much longer than the first, but gave better control in close country.

Timings

Under favourable circumstances with method (1), one 300 × 18 metre panel could be laid in three-quarters of an hour by night. If the country was very difficult then it might take up to an hour and a half. Method (2) (which was only used when the conditions for control, etc., were bad) might take one and a half to two hours per panel If method (2) for some reason was used in favourable country a panel might take an hour or so to lay.

These timings are based on a working party fifty strong. If the party were less the same time would be taken, but the over-all length of panel would be proportionately reduced.

Times do not include the carry from the mine dump. This might be only a few minutes, but one minefield, which this German remembered laying, entailed a carry of about two kilometres.

Reconnaissance and Recording

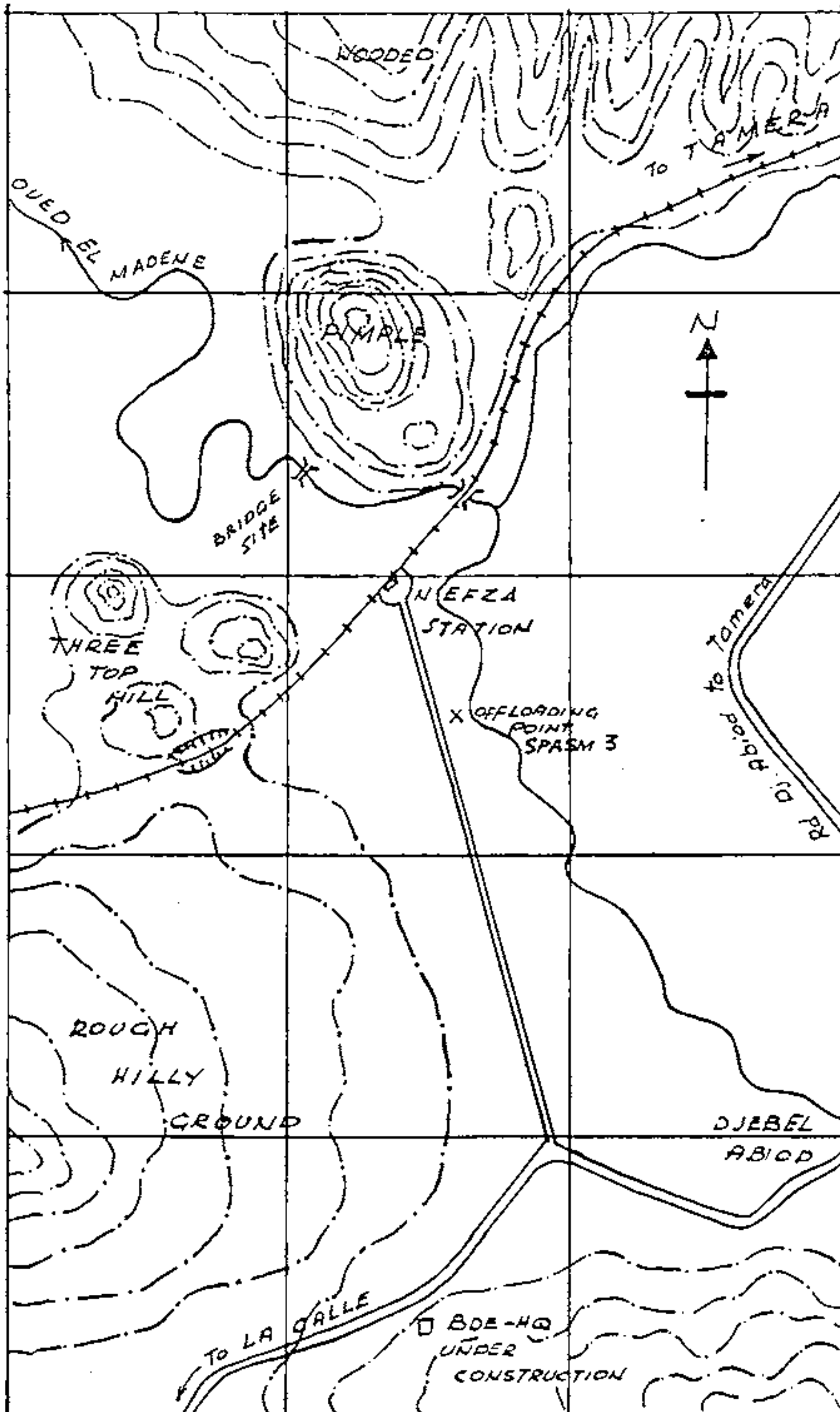
The recce party either taped out the outline of the complete 300 × 18 metre panel, or taped the home row only, or taped all four rows according to which laying method was to be used. Recording was done by " tying in," by bearing and pacing, the two home side corners of the panel to some fixed point or landmark. A record was then made of the numbers and types of mines in the panel. The record included a statement as to how the mines had been laid. In both methods the 200 mines could be laid using any sort of pattern, all depending on the numbers of paces the men were told to take.

These two methods stood the test of being used to lay millions of mines in Russia. They were, so this German said, extremely easy, reliable and the recording and supply of mines were very simple. Even with other types of mine, e.g., Holz mines which had no handles, it was still possible for a man to tuck two mines under each arm. When asked if they had not found a system of carriers, armers, buriers, etc., even easier still, he expressed surprise at the—to him—clumsiness of such a system.

There were other methods—knotted tapes, etc., so the pattern could be accurately varied—but these were not much used.

Conclusion

The above remarks are made for what they are worth. They certainly give food for thought. One can only say that the results were effective. To generalize from the failure at the " Remagen Bridge," described in the June, 1951, *R.E. Journal*, would be unfair ! It should be repeated that they are entirely based on the statement of one former German Pioneer officer.



Scale - 1000 metre squares

DUFFER'S OUED

By "The Duffer"

IT sometimes happens in war that an unlucky man has to make two or three shots at one operation: but more often, after one failure another is given the job. In the little task described in this account, the infantry taking part were from different units each time : but the writer and his Field Company were the sapper elements throughout. Although, as will appear, mistakes were slowly learnt, some idea of what to do had undoubtedly sunk in by the third attempt.

In February, 1943, the First Army had sent some of its units to assist the Americans after Kasserine, and as there were no reserves these units had come out of a line which became even more attenuated than before. The Germans did not take full advantage, but attacked successively at points up and down the front, nowhere breaking through. In the extreme north he came nearest to success. He outflanked the main Green Hill position by bringing a force on foot through the rough hilly country near the sea. There was some really hard fighting at Sedjenane and Tamera, with the 2nd Coldstreams and 1st Parachute Brigade being sent in, after Sedjenane, to plug the gap.

Eventually it became obvious that if the enemy took Djebel Abiod he would have cut 46th Division in two, so a line along the Oued el Madene had to be held. *Oued* is French for wadi, but the Madene was by no means dry at that time of year. We are only concerned with the fraction of the front shown on the sketch map. Here the small hill called "Pimple," forward of the river, had to be held, or the eventual counter offensive would be made a great deal harder to launch.

Pimple was steep and rocky with just a little thin soil here and there. The flat ground in the valleys was cultivated, and in March was still soft from the rainy weather. The little river was a mere trickle in dry weather, but at that time it was running quite swiftly with flood water, about a hundred feet wide between steep high banks. The railway bridge, a Warren girder truss, was intact ; it was in full view of the enemy on the hills to the north. Pimple was held by a company, with the rest of the battalion on what was called Three Top Hill. This battalion had just come back from hard fighting in the south, and most of its complement were newly arrived and unknown to one another. The company held the hill from positions on the home side, but had not dug in properly because of the rocky ground.

The Field Company in support of 1st Parachute Brigade was in a cork forest six miles south-west of Pimple. One of its platoons was making a forward brigade headquarters somewhere south of the road junction, the other two were on the usual jobs on roads and tracks in the brigade area.

On 20th March the Parachute Brigade Commander told the O.C. Field Company that the infantry on Pimple were feeling their isolation, their only communication with the rest of the battalion being across the exposed railway bridge. Could they have a bridge of some sort to take mules—and carriers later when the ground dried up ? The O.C. had a look at the river and found a place where with only a little work the ground could be sloped off to take mules and carriers. This spot is shown on the sketch. The ground was soft between here and the station, making it awkward to get the stores there : but it was out of sight of all but the most distant enemy O.Ps.

Folding Boat Equipment seemed the answer—three floating and two half floating bays. The C.R.E. at Beja was asked for the equipment by wireless, and a rendezvous given. Throughout this affair all requests to the C.R.E. for equipment of any kind were fully met—there were no irritating delays and queries as to whether some item was really necessary.

Building the bridge was only a platoon task, but the long carry made it worth putting two platoons on it. It was to go up that night, the 20th. Let us quickly hear how this first spasm of Duffer's Oued failed.

Nefza Station was a gloomy little place, its yard littered with shot-up British vehicles from earlier in the campaign. These might have served as a warning . . . However, after dark the bridging lorries were brought up to the station and unloaded without incident. At the bridging site no infantry protection had been arranged, as the O.C. had not had time to visit the battalion headquarters during the day ; after dark he went to the forward infantry company, but they had no spare strength for the job. So for protection the sappers building the bridge kept their weapons handy, and two sentries were posted on either side of the river, down stream of the bridge.

Having seen work started the O.C. then went to look at the third platoon and at the transport waiting to take the men back after the job. The platoon was at work on the headquarters. The transport had been at the road junction, but was found a quarter of a mile farther west, having been shelled where it was. While he was there, the O.C. heard and saw mortar and small arms fire on Pimple ; he got on the back of the C.S.M's. motor-cycle and they set off towards the station. Men were seen running at various points on the plain, and at the station the sergeant of the unloading party was found. He was told to collect his men and assemble at the transport.

Dismounting, the pair walked across towards the bridging site. They met the bridging party, which had been forced from its position by mortar fire, which with tracer machine-gun fire was still coming into the valley—some of the tracer from Pimple itself, whence our infantry had apparently been quickly pushed. Infantry stragglers were crossing the river, but no coherent account could be had from them.

The O.C. sent the bridging party also back to the transport, and talked over the situation with his sergeant-major. Probably the enemy strength on Pimple was not large and the hundred sappers might have retaken it. But there were many objections to a counter attack made without reference to the infantry—with whom the sappers were not in touch—so discretion had little difficulty in getting the better of valour.

Spasm one was over. Sapper casualties were one killed, two drowned. Some lessons were there to be learnt ; let us see if spasm two shows any improvement.

The next day, 21st March, the plan was to retake Pimple after dark with the 3rd Parachute Battalion. The railway bridge was intact though prepared for demolition ; it was more exposed to the enemy than ever. The bridging equipment might have been damaged so was not to be counted on for use again. O.C. Field Company advised the Brigade Commander to use a kapok bridge, as it would be difficult with the long carry to get a Folding Boat bridge up before daylight, starting after the assault. It was left to the assaulting Battalion Commander to decide how to use the bridge ; he decided to assault over the railway bridge and have the kapok to bring up reserves and supplies. The assault would go in at 11 p.m., and the bridge probably about midnight. Although the kapok bridge is one the infantry can put up, here was an occasion when all the battalion was assaulting and the sappers could make themselves useful by doing the job instead. The bridging party was to walk up the railway line, and the two bridging lorries were to wait a little west of the road junction for the word to drive down to the station.

The sapper party, which was the platoon that had not been involved the night before, duly trudged the three miles up the railway line and waited in the cutting while the O.C. went to Battalion H.Q. There he got word that he could start after midnight ; he returned to the cutting in time to come under fifteen minutes' mortar fire, nearly all falling short. Two sappers were sent off across country to tell one bridging lorry to go on to the station, and in a lull the platoon itself moved up. When there is only one railway cutting for miles it is a bad place to shelter.

The O.C., platoon officer and three others met the kapok lorry and it was parked at the south-west end of the station building—sheltered as much as possible from enemy fire. As much as possible? Mortar shells fall steeply, and after a few minutes only the driver and O.C. were unhurt. Driving away to safety, with the wounded and some of the kapok on board, the O.C. was reflecting on the folly of choosing obvious defensive fire tasks to shelter in! The wounded were sent back on one of the company lorries, and the second kapok lorry was loaded with the kapok added to its own—the first lorry with all tyres flat deserved a rest. The new lorry was then driven to near the station yard, but not in it this time. The rest of the platoon materialized and the job started again. This time everything was singularly quiet, and the bridge was built. The O.C. sent the platoon home, and went to tell the infantry that the task was done. At the railway bridge he found an officer with a wireless set, in touch with his C.O. The news was an unpleasant surprise. The attack had failed, and the bridge was not now wanted. Furthermore, would the sappers please make sure it was taken away?

By now it was broad daylight, and the best course seemed to be merely to cast off the enemy side of the bridge and allow it to swing round in the current. A disappointed man, the O.C. did this and sadly trudged back to his motor cycle on the main road. No one fired from Pimple—a solitary soldier is not worth the risk of betraying a position. Probably the enemy had all gone behind the hill by daylight anyway.

Was anything to be learnt from spasm two? An effort had been made to be in touch with the infantry, but this touch had been lost when bridging started—just when it should have been maintained. The need to avoid obvious places had at last been driven home, the hard way. The reader can find other lessons too.

Spasm three was put on for the night 23rd March—a pause of one night to enable more elaborate preparations to be made. 1st Parachute Battalion would have the Field Company again, and also the First Parachute Squadron R.E., a somewhat depleted force after much infantry fighting. Ample artillery support was provided. The two sapper commanders hatched out a generous plan for engineer assistance, to include:—

(i) Rebuild the kapok bridge—patrols reported it undamaged.
(ii) Repair the railway bridge to take foot traffic—some of the charges had gone off and it looked very odd.
(iii) Assemble stores for rebuilding the folding boat bridge later.
(iv) Supply large quantities of sandbags to the troops entrenching on Pimple.
(v) Help to make weapon pits by blasting rock.

The Field Company had (i), (iii) and (iv) to do, the Parachute Squadron (ii) and (v).

The Field Company plan was—one platoon walk up the line, wait below the north-west corner of Three Top Hill for orders to replace the kapok bridge ; one platoon was to launch more folding boats well up stream of the railway station, put sandbags and bridging stores in, and float them down to the bridge site. All sappers were then to help the infantry dig in, which was the latter's main anxiety.

The Parachute Brigade was taking this operation seriously, and strenuous protests were made to Divisional H.Q. against the plan to recapture Pimple at all. It was held that the hill was too exposed to occupy in daylight. But Division was adamant, so the plan went ahead. For the sappers, all stores were forthcoming, and they had no complaints.

The infantry operation was rather an anticlimax, it was so successful. The sappers too got through most of their tasks. After the artillery concentrations the O.C. Field Company and his left-hand platoon walked up to the river and the bridge was replaced, with no enemy interference. The parachute sappers placed some F.B.E. decking over the gaps in the railway bridge. O.C. Field Company told the Battalion C.O. that his kapok bridge was ready and the C.O. reluctantly agreed to send his assault across it—he seemed mistrustful of this little bridge and probably pictured his men having to perform balancing feats on it. Three assaulting companies filed across without mishap.

Meanwhile the O.C. had gone to see how his other platoon was faring. Since the night when they started the F.B.E. operation the river had fallen, and the boats had to be manhandled through shallows where they could easily have floated before. It was a very slow job but was eventually done. The bridging stores were in position for the bridge to be built later by the Parachute Squadron. Sandbags were carried up to the infantry, and some blasting of rock was done. At about 4.30 a.m. the Field Company set off for home.

Spasm three was successful ; when things go well faults are not so apparent. Had there been a hitch, the O.C. Field Company would have been found still lacking proper liaison with the infantry. The reader may think that the errors in all three spasms should have been obvious at the time, but factors should be considered which have not been mentioned. The principal adverse one was that visits to brigade and battalion headquarters involved miles of walking, leaving very little time and energy for getting details right. The bridging site was not near any of the infantry positions and any effort to maintain contact again involved long trudges over rock or plough. Time seems to fly at night, and it must seem hardly credible in spasm two, for instance, that it was daylight when the bridge was completed but no longer required. Time can go by at an alarming speed during the early hours of the morning.

BEACH CLEARANCE PARTY

By " SAPPER JACK "

ONE cold day in January the O.C. walked into the mess and said " Well boys, I've sold the Company." The mess stopped eating lunch and clamoured for news. The O.C. had been away for a few days, seeing the " Powers that be " to try to find some interesting rôle for the Company in the invasion of Europe, which everyone knew was bound to happen soon. He had managed to find something which he hoped would lead to better things, and, as events turned out, he was right.

That afternoon the officers assembled for a conference. The O.C. produced an impressive-looking dispatch case, unlocked it and produced a mass of paper, photographs and drawings. There were, he explained, a number of obstacles on the beaches of the Continent, put there by the Germans to try to stop craft from landing. If there was to be an invasion, craft had to land and, therefore, these obstacles had to be removed. There were such things as Elements C, Tetrahedra, Hedgehogs and a variety of wooden posts, many of them with mines attached to them. The Company was to develop a drill to remove these obstacles from the beaches. When a reasonably efficient drill had been produced, the Company was then to become instructors and teach this drill to other units, who would do the job. One of these other units was now on the way home from Italy where they had done the same sort of thing at Salerno. The last bit of news, however, was not very acceptable; "After all," the officers argued " if we produce the drill we will probably be the most efficient users, and we ought to have the job itself. We don't mind letting someone help us, but we certainly ought to have a hand in the invasion."

The next move was to Southampton. Here the Company settled down in tents on the common and started to develop their beach clearance drill. Large lumps of metal would arrive secretly in the camp and these would be taken to deserted parts of the New Forest, where they were bolted, or welded together and ranged in rows for training.

There were, obviously, two methods to eliminate the effect of these obstacles. One was to remove them, the other was to blow them apart. All the obstacles were somewhat bulky objects and to remove them was no easy matter. The smaller ones could be rolled clear with a few men, but that was a slow business. Alternatively, if tanks or bulldozers were available, and had slings, the obstacles could be towed clear. This again would be a slow business if only one obstacle was moved at a time, and it depended on the availability of a certain number of tracked vehicles—an unlikely factor in the opening stages of an invasion. The second method seemed to be the obvious one ; this too had its difficulties. Explosive charges would have to be carried, placed and ignited by hand, all, probably, under fire. An unlimited quantity of explosive could not, therefore, be used, nor would there be time to place all the charges, connect them up and then retire to a safe distance before blowing.

Slowly the drill developed. It was found that a 3-lb. charge, if placed carefully, would demolish one of the smaller obstacles, and two or three charges would suffice for the larger. A line of soldiers, carrying lumps of plastic explosive would advance on a line of obstacles and place their charges. Igniter sets, made up previously, were fitted in and when the job was done, each soldier would raise his hand. The platoon officer, seeing a row of raised hands would then drop his, pins were pulled out and every one sprinted 50 yds. and lay down, presenting the tops of their tin hats towards the explosion. A 10-second fuse was all that was allowed and after the demolition of one line of obstacles, the process was repeated. There was only one accident, No. 2 Platoon Commander, wanted to watch the bang and a lump of metal hit his tin hat, bent the brim down, bruised his nose and broke his pipe ; he was most annoyed.

This drill seemed to be very successful, but it was still very slow. So it was decided that initially only a series of 200-yd. lanes would be cleared and then marked. Later on, the remainder of the obstacles could be removed by towing, pushing, or any other method that presented itself. It was also decided that the Company had earned the right to put their drill into practice on the invasion. As a result they were sent on a large scale rehearsal.

The rehearsal, as far as the Company was concerned, was not a very great success. To start with, there were not enough landing craft to embark the unit, so they made their entry to the beach on jeeps (" on " rather than " in," as there were twelve fully armed Sappers to each jeep, excluding the driver). Perhaps it was really for the best that they were not embarked as many of the landing craft stuck on a bar about 200 yards from the beach. The beach clearance went quite well, but there were only a few obstacles anyway. The real discomfort occurred when it was announced that another rehearsal would take place in a week's time. The Company was not allowed outside the landing area, nor was anything allowed in and they had to live for that week on six one-day ration packs and with only one blanket each. These ration packs, although probably very sustaining, were not exactly filling, nor is March in England a very warm month. However, the next rehearsal was much more successful and a rather hungry Company returned to the luxury of tents and good filling food in Southampton. The rehearsals were by no means wasted and some very useful lessons were learned.

The Company moved, shortly after, to another camp, in woods to the north-west of Southampton, and the training area was changed to the beaches near Stone Point, just over the Solent from Cowes. Here it was found that the tide came in and out, and that obstacles might well be submerged beyond a depth where a soldier could wade out and place a charge on them. A Landing Craft Obstacle Clearance Unit, or L.C.O.C.U. (the pronunciation of the initials has a nice swing) was introduced. This unit consisted of some twenty sailors, dressed in a peculiar garb which is now universally recognized as that of a frog man. The object of this unit was to clear the under-water obstacles, while the Company dealt with those above water. Later another L.C.O.C.U. (a Marine one) was also attached. Another company was initiated into the mysteries of beach clearance and later on they, with their attendant L.C.O.C.Us. cleared another beach in Normandy.

A further exercise followed in May, in glorious sunny weather. This was a very large scale affair, involving a sail round the Isle of Wight and a dawn landing on Hayling Island. The whole drill for the invasion was carried out. The camps for the assault troops were locked and guarded and nobody was allowed out. In secrecy the Company embarked in tank landing craft, together with assault engineers and their tanks, and spent a day or two sunbathing in Southampton water. The trip round the Island was comfortable, although one or two were seasick, and the whole exercise, from the Sappers' viewpoint, was a great success. However, lessons were still being learnt, not least of which, was the weight a soldier can carry if he has to work.

The over-all plan allowed the Company one vehicle, a half-track, in the initial stages of the assault ; no other vehicles would arrive until D + 3 days. Remembering the first exercise, the half-track was to carry, amongst other things, a certain amount of compo rations and two cooks (in any case, it could not possibly carry everyone's kit). This meant that each soldier had to carry sufficient equipment to be able to do his demolition job, fight (if necessary) and live for three days. It was found that 24 lb. of explosive was the most convenient unit of explosive, made up in eight 3-lb. packets, it would just fit into a webbing haversack. In addition each soldier needed a rifle, ammunition, rations and a blanket. On Hayling Island it was found to be impossible to carry all this, and work. The eventual solution was to provide a folding boat to each section. Each folding boat was to be towed ashore by an A.V.R.E. and would carry the section, their personal kit, blankets and a hand trailer containing spare explosive made up into haversacks, towing slings (for towing obstacles), gap marking signs and a rum ration. Thus each soldier on the job would carry only his 24 lb. of explosives, a haversack full of igniter sets and his personal weapon and ammunition. The Company was organized into three platoons, each of four sections of twelve soldiers, making each platoon fifty-one strong with the Platoon Officer, Sergeant and Recce Lance-Sergeant. This involved even such men as the Platoon Clerk and Storeman as demolition numbers. Two sections were to travel on each L.C.T., involving six L.C.Ts. in all, and half the Company, accompanied by an L.C.O.C.U., was to land on each of two beaches. The O.C., therefore, decided to lead one half company, of No. 1 Platoon and half No. 3 Platoon, while the Second-in-Command led the other half company, of No. 2 Platoon and the other half of No. 3 Platoon.

After the Hayling Island exercise the Company said a temporary " Good-bye " to its vehicles, drivers and cooks, and moved off to its final camp near Fawley. Here the time was spent in preparing and waterproofing charges and igniter sets. Finding time heavy on their hands No. 3 Platoon also built an open-air cinema.

On 3rd June, 1944, the Company embarked again into its L.C.Ts. and remet their friends in the Assault Engineers. The landing craft anchored in the Solent, while the soldiers were fully briefed. On 4th June the landing craft started for France, but found the sea very rough as soon as the shelter of the Isle of Wight was left behind. At about eight o'clock the invasion was called off and all ships returned to their anchorages, passing long lines of other invasion craft that had not set sail. This caused great despondency as everyone was keyed up for the invasion and the prevalent feeling was " Let's get it over." However, early on 5th June the Armada started again and, in spite of rough seas, kept going. The Captain of one L.C.T. suggested that, as the officers he was carrying would land in France the next day, they would not need their English money any more and that, therefore, he would take it off them at poker. This he did, but it did not do him much good as he was killed next day.

Everyone was up early the next morning to catch the first glimpse of the coast of France, which seemed strangely quiet from a distance. The noise, however, increased as the coast was approached. Oblique air photographs enabled certain landmarks to be recognized and the O.C. was able to point out to the Captain of his L.C.T. the exact spot where he wanted to be put down. A rum ration was issued and the run in was made. Many soldiers were very seasick (so, indeed, were some of the sailors), but this had the advantage of making them long to land anywhere. At 0725 hrs. the landing was made at almost low water.

Each landing craft party had its difficulties in getting ashore, as in exercises the landing craft had beached in about three feet of water, while in the invasion they grounded in about six feet of water. This made an additional factor to vary the fortunes of the parties. Their individual experiences were as follows :—

JIG GREEN WEST Beach

CRAFT A—carrying No. 1 Platoon Commander and half No. 1 Platoon.

The first A.V.R.E. drove off into very deep water and drowned, half on the ramp of the landing craft. All efforts to remove the tank or to back the L.C.T. were unavailing, and the craft swung, with the rising tide, broadside to the beach, where it hit a number of mines on obstacles and became a target for enemy shore batteries. A number of direct hits were scored causing several casualties. The remainder of the party on this craft were eventually brought off at high tide in a folding boat.

CRAFT " *B* "—carrying No. 1 Platoon Sergeant and the other half of No. 1 Platoon.

The stern of Craft " A " swung in front of the ramp causing a temporary hold-up. One section came ashore riding on an A.V.R.E., leaving the other section to bring the stores ashore. The latter were unable to disembark and had to return to England with the craft. Once in England they were given forty-eight hours leave before returning to France. (The Section Corporal told his father he had been present at the invasion and was called a b—— liar for his pains.) The section eventually rejoined the Company a week later.

CRAFT " *C* "—carrying the O.C., No. 3 Platoon Commander and half No. 3 Platoon.

No. 3 Platoon Commander, with one section, launched their folding boat successfully and were being towed ashore by an A.V.R.E. when the tow-rope broke in the heavy surf. They came ashore rowing their folding boat ; rather a novel method of making an assault landing. The side of the second folding boat was torn during the launch, rendering it unseaworthy. A near-by L.C.A. was hailed, and the O.C. and the other section with their stores, got into that and came ashore. During that time several direct hits were scored on the L.C.T. with resultant casualties.

JIG GREEN EAST Beach

CRAFT " *D* "—carrying the Second-in-Command, No. 3 Platoon Sergeant and the other half of No. 3 Platoon.

Both folding boats got away well in deep water, but one was holed on an obstruction and sank. The Sappers swam ashore.

CRAFT "E"—carrying No. 2 Platoon Commander and half No. 2 Platoon.

The L.C.T. landed rather farther along the coast, away from the beach. The folding boats were towed into the surf at such a fast rate that only five soldiers managed to get into each. The remainder swam ashore.

CRAFT "F"—carrying No. 2 Platoon Sergeant and the other half No. 2 Platoon.

The towing armoured dozer was launched into about seven feet of water and the bottoms of both folding boats were ripped out on the ramp. The Craft Commander was anxious to get back to England and, hailing another L.C.T., transferred the landing party and stores. The second landing craft hit mines in the bows and amidships and sank, about 300 yards out. A distress signal was made and the soldiers were eventually transferred to a third L.C.T., but this one was returning to England. No. 2 Platoon Sergeant, however, was determined to get ashore, and managed to get his party on to a fourth landing craft and eventually reached the beach at high water.

The difficulties in landing meant that the demolition parties were somewhat short of numbers. Small arms and mortar fire added to the confusion. However, a lane was cleared on each beach, although perhaps not quite to a uniform 200 yds. in width, nor, it is feared, were the gaps very adequately marked. Further complications were due to the facts that the German tetrahedra were not of metal, as had been used for practice, but of reinforced concrete ; and the German hedgehogs were of thicker metal than those used for practice. The demolition charges, however, stripped the concrete from the reinforcing and neutralized the mines on top of the tetrahedra, and so weakening them that they provided virtually no obstacle. But the hedgehogs were not cut by the standard 3-lb charge, so, as a quick alternative, double charges had to be used, and this did a satisfactory job. The demolition parties just managed to keep ahead of the rising tide, even though they were often working waist deep in water. At high tide all remaining obstacles were covered, so that demolition had to stop for a while. Some of the Company went off to capture prisoners, while others rescued those of their comrades who were still afloat or were stranded. Notable among the latter were two Gunner drivers who were sitting on the last dry few square inches of the top of a drowned 3-tonner, like shipwrecked mariners on a small island.

Mention must be made of the L.C.O.C.Us. who did sterling work, although the sight of a frogman wearing a tin hat seems somehow slightly ludicrous.

As the tide and the enemy receded, the hand clearance of obstacles started. First the mines were cut off, defused and stacked in shell holes, then the obstacles were gathered together in bundles of about six and finally they were towed off by A.V.R.E. or dozer to one of several large stacks. The mines on these obstacles were either Teller mines or shells fitted with an igniter, but they were so coated with pitch that it was difficult to see what was there. No. 3 Platoon Commander carried off one of these mines to a quiet shell hole and took it to pieces. He was then able to spread the glad tidings that only a simple push igniter had to be unscrewed. Clearance continued until, at the end of the day, some 2,000 yards of beach were free from obstacles.

Meanwhile the half-track vehicle allowed to the Company had been landed, and had found the O.C. The cooks carried on it, prepared a meal, which was thoroughly enjoyed as the first meal of the day (how the lesson of the first exercise was blessed). Blankets and small packs were found, all very wet, but the rations inside were still more or less edible, and the cigarettes smokable. Slit trenches were dug in the sand, and the Company settled down to sleep.

The invasion beaches had been cleared so that they presented no difficulty to the landing of further troops and supplies. The methods of clearance, were in some cases slightly unorthodox, and the safety precautions for demolitions would certainly not have been approved by any authority, particularly in the first few hectic minutes after landing, when several small demolition parties were operating independently within a few yards of each other, with assaulting infantry passing through. The situation, however, was not one which called for extensive safety precautions, and, as a matter of interest, no casualties were observed to have been caused by the demolitions. Casualties in the Company were surprisingly light considering the nature of the task, and in spite of the fact that the West beach was under direct observation and fire from the enemy in the little village of Le Hamel, and the hills behind it, until well on in the afternoon. It was a very tired Company that night, but they felt that the words of the text book had been fulfilled : " The duty of the Engineers is to assist the Army in its advance."

MEMOIRS

COLONEL P. K. BOULNOIS, O.B.E., M.C.

PERCY KENNETH BOULNOIS was born on 12th February, 1889, and was the son of H. P. Boulnois, a civil engineer. Educated at Wellington he passed in top into the R.M.A. Woolwich in 1907 and passed out third, winning five prizes.

Commissioned into the Corps in 1909, he was posted to 57 Field Company at Bulford after completing his Course at the S.M.E. in 1911 and went with this company to France in August, 1914. He was present at the battle of Mons and while carrying out the demolition of the bridges over the Mons Canal he ran into a German patrol, but managed to escape. Later on he had a bad attack of influenza, but carried on till he collapsed and was invalided home in a serious condition early in 1915 with a strained heart. After five months in hospital he was posted as an Instructor at the "Shop" and later became a Company Commander there. In 1917 he went to Italy as O.C. 54 Field Company, where his Company bridged the Piave the following year, and he was awarded the M.C.

In 1919 he served on the German, Polish and Danzig Boundary Commission and was subsequently head of the Danzig Free State and Corridor Commission.

In 1920 he served on the Geographical Section of the Paris Peace Conference. The following year he was posted to 12 Field Company in Ireland, but shortly afterwards he was sent on the Wadai–Darfur Boundary Commission in Central Africa, where 1,000 miles of boundary had to be surveyed. For this work, which lasted three years, he was awarded the O.B.E.

On completion of the Boundary Commission, in 1924, he was appointed G.S.O. 2 in M.I.4 at the War Office and in 1927 he went to Chatham as Chief Instructor in Survey, which he described as "One of the nicest jobs in the Army."

After Chatham he went to the Ordnance Survey at Southampton for four years, returning to the War Office as Colonel-in-Charge of M.I.4.

During the war he was Deputy Director of the Prisoner of War Branch and then served in the Petroleum Warfare Department. In 1942 he was sent by that department first to South Africa and later to Washington. In 1943 he joined the Civil Affairs Staff and went to North Africa and for some months was Military Governor of Sardinia. He retired in 1944.

After retirement he joined a firm on the Stock Exchange and at the Annual General Corps Meetings he took a special interest in the investments of the Corps Funds. He also became Chairman and Managing Director of St. Bride's Press Ltd., a post previously held by his father.

He was President of the West London Branch of the R.E.O.C.A. and came to Chatham with a detachment from this Branch for the dedication of a new Standard only a few days before his death.

As the first post-war Chairman of the Field Survey Association he played a notable part in getting it on its feet after the war.

Hunting and rowing were his favourite sports and while a Y.O. at Chatham in 1910 and 1911 he rowed in the R.E. eight at Henley and was elected to "Leander," which was one of his most prized distinctions. While Chief Instructor in Survey at Chatham he very strongly supported John Marsh's suggestion to start the R.E. Drag and the first Meet was held outside his house in Staff Quarters.

He was also keenly interested in Squash and presented a cup for competition annually in the Gunner and Sapper Match.

Besides being remembered and sadly missed in connexion with the activities already mentioned his cheerfulness and infectious laugh will not be forgotten. In his Y.O. days he was slim and had a chubby face and was always known to his contemporaries as "Perksy." Later, as he matured, this nickname became inappropriate and he was more generally known as "Kenneth" or "P.K.," but his cheerfulness remained to the end.

Whatever he took up he put his whole heart and soul into it and his enthusiasm never flagged. This enthusiasm, combined with a great confidence, carried him successfully through many undertakings.

In 1921 he was married at Khartoum to Violet Vansittart, the daughter of Lieut.-Colonel C. W. Long, R.H.A., and had a son and a daughter, by all of whom he is survived.

He and his wife were firm and faithful friends to many Sapper officers and were always most hospitable, and his sudden death is a great loss to the Corps.

C.C.P.

Colonel PK Boulnois OBE MC

Photo by Hills and Saunders, Cambridge.

Sir Charles E Inglis OBE MA LLD FRS

SIR CHARLES E. INGLIS, O.B.E., M.A., LL.D., F.R.S.

SIR CHARLES INGLIS, who was a Sapper officer during the 1914–18 war, an Honorary Member of the Institution of Royal Engineers, and well known to many officers of the Corps, including all those who passed through Cambridge between the two World Wars, died on 19th April, 1952, at the age of 76.

He was Vice-President of King's College, Cambridge, from 1943 to 1946 and Professor Emeritus of Engineering in the University of Cambridge.

The following notice is reprinted, by permission, from *The Times* of 21st April, 1952 :—

" Charles Edward Inglis was born on July 31, 1875. Educated at Cheltenham College—in the activities of which school he took the keenest interest and was since 1929 enabled to play an active part as a member of the College Council—he was elected to a scholarship at King's College, and went into residence in 1894. In 1897 he was classed as twenty-second Wrangler in the Mathematical Tripos, and in the following year gained a first class in Mechanical Sciences. After taking his degree he joined the famous consulting firm of Sir John Wolfe Barry and Partners.

" It was during this period that he turned his attention to the study of mechanical vibration and, starting as a pioneer in a field of which few but he can at that time have foreseen the ultimate importance, he continued throughout his life with unabated interest, vigour, and freshness of imagination to lead in scientific contribution to this subject, now recognized to be at the root of a wide range of problems facing the engineer. It was this interest also which in a sense dictated his later career, since his early work gained him his Fellowship of King's College and led to his return as a university lecturer to Cambridge, where, interrupted only by the war of 1914–18, his life work lay, though in the widest sense. In 1914 he was commissioned in the Royal Engineers and served with distinction in the War Office, where his originality and ingenuity found scope in the invention and design of military bridges, culminating in the notable Inglis bridge which at that time became an accepted standard of sapper equipment. In 1918 he retired with the rank of major and appointed O.B.E., and returned to Cambridge, now as Professor of Engineering.

" Nevertheless he found time to maintain an active contact with his profession and to establish a distinguished reputation as a consultant, as shown, for example, by his work for the bridge stress committee of the Department of Scientific and Industrial Research, his appointment to the committee set up by the Secretary of State for Air to inquire into the loss of the airship R101, and more recently by his chairmanship of the Railway (London Plan) Committee, which reported to the Minister of War Transport in 1946 with a bold scheme for the development of the whole of the railway systems of London to fit the future needs of the metropolis. In 1944 he retired from the Chair of Engineering at Cambridge, though continuing to devote himself to consulting, and in the summer of 1945 he was awarded the honour of knighthood for his distinguished services to the country in war and peace. Lady Inglis, daughter of the late Lieutenant-Colonel Moffat, whom he married in 1901, died a few weeks ago.

"Such is a brief outline of the life of a man who was bound to achieve distinction in any career which he had chosen to adopt, since his gifts of personality, character, and intellect passed far beyond the limits of any specialist attainment. Of his contribution to science much will remain to be written by the many whom he served (he himself would have chosen the word) ; by the firms who came to him as a consultant and found an engineer with an intensely practical outlook as well as a depth of knowledge and, where required, a rare mathematical skill to bring to their aid ; by the London Midland and Scottish Railway, of whose research committee he was for many years an inspiring member ; by the Institute of Naval Architects and the Institutions of Mechanical, Structural, and Waterworks Engineers, on which councils he served, and of the latter of which he was elected president in the year 1935 ; by the Royal Society, into whose Fellowship he was admitted in 1930 ; and by the Institution of Civil Engineers, who first recognized the value of his work by their award of the Telford Medal in 1924, and into the presidency of which—perhaps the greatest honour which can be paid to an engineer—he was elected in 1941 after many years of service on their council.

"In a life of such width of activity it is not easy to single out a particular feature, but since technical and scientific achievements will come to be recorded in their lawful places it may be proper here to refer to two other aspects which must rank him as one of the great men of his generation. The first is as a teacher, whose influence in engineering education throughout the country was profound. It is the engineer's business to build first of all a solid foundation upon which the stability of whatever structure may later be required must rest, and it was upon this that Inglis based his creed—that the first essential of an engineer's education is a solid groundwork of scientific first principles upon which the specialized knowledge and technique required later can be firmly built. The other aspect is personal. What characterized Inglis above all can only be described as his joy in living ; his intense pride, but humility, in the profession which he had chosen, and an enthusiasm for the achievements of men in any sphere of human activity provided it was true and honest."

BOOK REVIEWS

THE GERMAN ARMY IN THE WEST

By GENERAL SIEGFRIED WESTPHAL

(Published by Cassell & Co. London. Price 17s. 6d.)

This book is the English translation of *Heer in Fesseln* or *An Army in Chains*, published by the Athenäum-Verlag, Bonn in 1950. Except for the significant omission from the preface of a six-line quotation from Thomas Carlyle and the addition of some excellent footnotes in the body of the work, the English version follows the original faithfully. The unnamed translator has, on the whole, done his work well, although "End-Game" for *End-Kampf* seems neither accurate nor elegant.

The quotation from Carlyle relates to the duty of soldiers and can be epitomized in Tennyson's words "Theirs not to reason why, theirs but to do or die"—Carlyle was himself one of the "strong arm" philosophers, who believed in rigid control at the top and utter subordination below. Such rules of conduct have always found favour with the Germans—indeed it is hardly an exaggeration to say that the root cause of the German tragedy was the unquestioning acceptance of the Hitler régime by the German people.

Later in the book, General Westphal suggests that the Allied demand for "unconditional surrender" was bad propaganda and prolonged the war. According to him the Allies should have said: "We are waging war against the Hitler régime, but not against the German people. We can clearly distinguish the one from the other." But in actual fact the German people were so wedded to Hitler and all his works, that they could not be distinguished from them. That was the chief trouble: it made the demand for unconditional surrender almost unavoidable.

As the momentous struggle between regimented nations and free nations is now in full career, it is of world-wide importance that the Germans realize to the full what frightful penalties they have had to pay for their blind belief in an evil and totalitarian system of government.

Apart from the failure to stress this vital point, General Westphal's book is one of the most valuable German contributions to the military history of the second World War that has so far appeared. He amply fulfills the promise made in the preface to write soberly and objectively about the wide range of facts which came to his notice at first hand.

His account of Rommel reveals the latter's tactical skill and daring but does not conceal his limitations as a High Commander. It is difficult, for instance, to imagine Montgomery taking over the German campaign in the desert without insisting on the capture of Malta as an essential preliminary.

Kesselring stands out as a Commander of uncommon ability. His handling of the hectic situation in Italy after the Italian collapse was masterly. He was, at that time, under a cloud at the Wehrmacht H.Q. and Rommel was already in the offing in northern Italy. But for once, Hitler had the gumption to see that Kesselring knew what he was about and posted Rommel to northern France.

The book is full of interest from first to last and rings true. No one who wishes to get an impression of Hitler's war from the German side should fail to read it.

B.T.W.

THE CAMPAIGN IN ITALY

By ERIC LINKLATER

(Published by H.M.S.O., Price 12s. 6d.)

This book is one of a series of short military histories of the second World War, based on official documents, and written for the general reader. It is a vivid account of the vicissitudes of the Eighth and Fifth Armies in nearly two years of bitter fighting, beginning with the attacks on the Mediterranean Islands of Pantellaria and Lampedusa in May and June of 1943, and ending with the German capitulation at Caserta in Italy on 2nd May, 1945.

Eric Linklater deals faithfully and in great detail with all the phases of the campaign. The story starts with the capture of Sicily, the landings in the Toe of Italy by the Eighth Army, and the rapid overrunning of southern Italy, including the capture of the strategic airfields at Foggia. The author then shifts to the Salerno Landings, followed by the capture of Naples, and the advance to the Gustav and Hitler Lines. The battles for Cassino are described in great detail, together with the winter regrouping, when the Eighth Army moved over from the Adriatic, preparatory to the launching of the spring offensive. Then follows the battles for the Gustav and Hitler Lines by the Fifth and Eighth Armies, culminating in the capture of Rome, unhappily submerged in the world's news by the successful landings in Normandy two days later. Kesselring's Armies then fled north in disorder, pausing to offer resistance at Lake Trasmiene and Florence in the late summer, and being slowly pushed back to the ramparts of the Gothic Line, designed to prevent the allied armies debauching into the Northern Plain of Italy. Throughout the winter of 1944/45 the allied armies kept up unrelenting pressure against the Gothic Line, though sadly mutilated by the withdrawal of the experienced French mountain troops, and several American divisions for the landings in the south of France. The weather, and their own lack of reinforcements, prevented a decisive victory, but they were able to engage large forces of the enemy, which might have been employed on other fronts. With the spring came dry weather and sadly needed reinforcements. The story continues with the hard battles to break the Gothic Line, the entry by both armies into the Northern Plain, the pursuit across the River Po, and the final round up and surrender of all the German forces in Italy.

Eric Linklater fought in Italy as a R.E. officer, and he is at pains to record the vital work done by the Royal Engineers throughout the campaign. He shows that without the unfailing work on road repair and bridging, there would have been no advance at all.

The book is rather too detailed for the general reader, and not detailed enough for the student of military history. At times, therefore, it tends to be a boring repetition of actions fought by various units and formations. There are, however, many passages of the finest prose, when individual exploits of great gallantry are described. The author's sense of fun and comedy keeps creeping in as well, as would be expected from the creator of Private Angelo. His description of the favourite pastime of the Army—"Swanning"—is instructive. "The Swan, that gracious bird, has the habit of taking short flights that create appreciable commotion but have no serious purpose."

The book is a handy reference manual of the Italian campaign, but is written from too low a level for serious study. However, one cannot but admire the author for his great research into official documents.

D.G.B.B.

OUR MEN IN KOREA

By Eric Linklater

(Published by H.M.S.O., 1952, Price 2s. 6d.)

The author of those delightful books *Don Juan in America* and *Private Angelo* is also a most competent military historian. In *Our Men in Korea* he dovetails the varied exploits of the Commonwealth forces very neatly into a general outline of the campaign. They were, of course, only a minority in a large international force to which the U.S.A. contributed by far the greatest strength. But their arrival was timely and significant.

The narrative, well written and illustrated with some splendid photographs, is eminently readable. The maps and sketches enable the reader to follow the course of the war easily, whilst a Commonwealth order of battle gives a seemingly complete list of the units of all three services which took part in the struggle up to 31st July, 1951.

The high spot of the story is the battle of the Imjin River, in which the 1st Gloucestershire Regiment once more became famous. The action is well portrayed, although not in any great detail. An excellent chapter describes the tactics of the Chinese; how at first they attacked like the crowd coming out from a League football match and how at other times "they sprang up like partridges in all directions." The book is worth reading for this chapter alone, not to mention the excellence of the rest of it.

But if there ever was a book about war which required a lively political preface, it is surely this one, published at half a crown for the information of ordinary men and women. Such a preface would help the general public to understand why Great Britain, the U.S.A. and the other members of the United Nations have been compelled to expend so many valuable lives and so much treasure in bitter fighting on the outer confines of Asia.

It would explain the recent political history of Korea in its relation to the political vacuum created there by the defeat of Japan and to the obvious intention of the U.S.S.R. to utilize the opportunity to gain access once more to the Yellow Sea. Above all it would emphasize that any policy of appeasement would have jeopardized the already complicated plans of the United Nations for the peaceful settlement of the Far East. The challenge of Communism just had to be accepted and so it was, most boldly, by "Our Men" as well as those of the U.S.A.

B.T.W.

EASTERN EPIC

By Compton Mackenzie

(Published by Chatto & Windus. Price 30s.)

In the December, 1951, *R.E. Journal* we published an advertisement about Compton Mackenzie's book *Eastern Epic*. The Publishers have asked us to issue the following notice:—

"In the light of further information which has since become available to the Author it appears that certain statements in Chapter 29, relating to the Commander of the 22nd (Indian) Infantry Brigade, were written under some misapprehension of the true facts and do not accurately represent what took place. The necessary corrections will be incorporated in any further edition of Volume I."

GUIDE TO ARMY OFFICERS' PAY, ALLOWANCES AND FINANCIAL AFFAIRS

By Captain W. B. Wilton, M.C.

(Published by Gale & Polden Ltd. Price 5s.)

Captain Wilton has written a most informative book and no officer will regret purchasing it. The author realizes that many officers are surprisingly hazy about their own pay and allowances and in the space of a little over a hundred well set out pages he has given enough information to enable the reader to see exactly what he is entitled to.

Allowances are comprehensively dealt with ; the rules under which those for travelling, detention, entertainment, and a host of others are issued are made very clear. Married officers will find the explanations of disturbance and removal grants particularly useful and perhaps profitable. The latest information about qualification pay and various other forms of additional pay is all given, as well as tables showing basic rates and increments.

The book also contains information on income tax, insurance, and banking. The author brings out some points that few officers can be aware of. For instance, in writing of income tax he states that if an officer spends on his uniform in one year more than the amount of the tax-free allowance, he is entitled to a rebate on the excess.

The newly commissioned officer will find sound advice and much knowledge ; officers more senior will be glad to have this varied information gathered into one book, and for those about to retire there is a summary both of the regulations under which they will be paid and of the rates they will receive.

It is an accurate book and the information in it is up to date (Jan. 52). References to official regulations have been given wherever necessary. The index is good and the cross referencing has been carefully done. As it will be used chiefly as a reference book it is a great pity it has not been provided with a stouter and more firmly attached cover.

J.N.E.

GEODESY

By Brigadier G. Bomford, O.B.E., M.A.

(Published by Clarendon Press, 1952. Price 50s.)

This is an important book and it is rightly described as " the first comprehensive treatise on the subject printed in England since Clarke's Geodesy of 1880." The headings of the chapters will serve to give an idea of the extent of the field covered : Triangulation (Field Work), Bases and Primary Traverse, Triangulation (Computation), Heights above Sea-Level, Geodetic Astronomy, Gravity and Geophysical Surveys, the Earth's Figure and Crustal Structure. To this we should add that there is a very useful Bibliography. The work pays special attention to geodetic practice in India and in the United States.

The author acknowledges his indebtedness to Dr. J. de Graaff Hunter, formerly of the Survey of India, and to Brigadier M. Hotine, and to others. The book deals not only with the well-established classical methods of geodesy, but also with new methods which are on trial, such as radar, with regard to which the author remarks that distances up to 500 miles can be measured by this system, but, at present, accuracy is not up to primary standards. Also, towards the end of the book, there is some account of modern geophysical methods, and a brief, but interesting sketch of the tasks in front of geodesists in the world at large.

In his preface the author states that "restrictions on space" have prevented his including matter which he, and we may add, most of us, would have liked to have seen in the book. The excluded matter would have greatly added to the value of the book. Thus, there is no history of geodesy or its methods, and the result is to de-humanize the subject to a remarkable degree. "No worked numerical examples have been given," so that the beginner will find himself in a maze of symbols, without any relief. And, thirdly, there are but few proofs of the formulae which are accepted or recommended, and perhaps this is the most unfortunate omission of the three, for the student, or even the accomplished geodesist, will feel that he must consult a perfect library of original authorities before he can satisfy himself as to the formulae which he uses. We should have liked much more space to be devoted to the Transverse Mercator. The book is so valuable that it is a pity that there should be these deliberate omissions.

Apart from these, the work is a mine of information and good practical advice on such matters as the use of invar tapes, the system of computation, the use of radar, estimation of errors, difficulties connected with atmospheric refraction, geodetic levelling, gravity surveys, the geoid, and so on. It is a learned book which is obviously the fruit of much knowledge and experience. Every British survey organization should possess a copy.

C.F.A-C.

ROCKETS, MISSILES AND SPACE TRAVEL

By Willy Ley

(Published by Chapman & Hall. Price 30s.)

This is a second edition of the book entitled *Rockets and Space Travel* published in 1948, and reviewed in the *R.E. Journal* in June, 1949. Additions have been made to bring it up to date.

The author of this excellent book combines a truly Teutonic thoroughness with a most unusual gift for stimulating and readable treatment of a very technical theme. This has not come without practice. His first popular book on Space Travel appeared in 1926, when he was "not quite 20 years old" and sold 6,000 copies. In the present book his, now encyclopaedic, knowledge of all things rocket driven has not dimmed his humour, and capacity for popular exposition. The result is a small masterpiece.

His first four chapters trace the development of rockets in theory, practice and prediction from their first mention at the siege of Kai-fung-fu in 1232, up to the end of the 1914–18 war, and contains much military history of great technical interest. As one accustomed to thinking of the 3.5-in. rocket as a recent weapon, it was good to discover that rockets of that calibre were first used operationally in a naval attack on Boulogne in 1805. These rockets, designed by Colonel William Congreve carried a 7-lb. incendiary warhead, had a range of 3,000 yds., and were a complete success. Even the principle of the hollow charge, from which the modern 3.5-in. rocket derives its armour piercing capacity, is no novel discovery; Professor Munroe described and explained it fully in America in 1887.

And this is to quote only one example of the way in which these chapters throw light upon the weapons of the present day.

The middle chapters of the book take on a more personal character as the tale is carried forward from the early struggles of the German rocket society (of which Willy Ley was a foundation member) to the development of the great German war rockets at Peenemunde, and their eventual transplantation to the proving ground of White Sands, New Mexico. Though the author himself left Germany for political reasons in 1934, when the Peenemunde Research Institute was in its infancy, he has pieced together almost the whole story (technical and political) of the V-weapons, and their even more fearsome successors which were never brought to operational use.

The final chapters deal with projects of the future—" The Rocket into Cosmic Space " tells its own story. They begin with the tale of the historic ascent in February, 1949, when a small rocket (The W.A.C. " Corporal ") was launched at an altitude of 20 miles from the nose of a V2 and rose clear of the atmosphere to about 250 miles above sea-level before gravity reclaimed it. The next step, said to be already attainable, is the creation of a permanent satellite to the earth by means of a rocket given sufficient horizontal velocity at a great altitude. A missile to the moon stands not much farther off. Beyond it comes the promise of a rocket with human pilot to navigate at large in open space.

This book does much to substantiate its own claim, that no science has such a record of living up to its own predictions as that of rocket research. It is good to have these achievements and these predictions clearly laid before us. But perhaps above all this book should be read for its wealth of anecdotes and explanations, its photographs and diagrams, and the first-class narrative which make its pages not only a profitable but a most absorbing study.

W.G.H.B.

UNIFIED SCREW THREAD STANDARDS

(Published by U.S. Department of Commerce. Price 20 cents.)

The National Bureau of Standards (U.S.A. Circular 479) gives a report of the Meeting of 18th November, 1948, at Washington at which the United Kingdom, Canada and the U.S.A. agreed on common standards for screw threads.

The report states that the United Kingdom was represented by members from the British Industry, the Ministry of Supply and the British Standards Institute. (Subsequent to this meeting the British Standards Institute produced B.S. 1580 of 1949 and this should be read in conjunction with the report in order to obtain a clear picture of what this agreement involves).

It is interesting to remember that the need for a common thread became apparent in the 1914–18 war, but it was not until 1926 that an attempt was made to unify the British Standard and the American Standard Threads. This attempt was unsuccessful. During the last war, when the enormous amount of Lease Lend equipment came to this country and to the Services, the need for a common thread became even more important, and discussions were resumed in 1943. It took five years of discussion to come to the signing of this very important agreement, and although it was given very little prominence at the time, there is no doubt that it will have an important effect in due course.

Briefly the signing of this agreement means that this country is now committed to use an entirely new form of thread on all bolts and nuts (the term bolts and nuts is used in a general sense and refers to all external and internal threads). This change from one standard thread to another is a difficult one to make, as the re-equipping of factories with new dies and thread testing instruments will be a long and expensive undertaking.

In the Services, where all forms of standardization with the U.S.A. are of vital importance, the sooner this is implemented the better and it is understood that already the Ministry of Supply are insisting that all equipment for the Army, with the possible exception for the time being of engines, will have bolts and nuts with this Unified Thread.

The report gives details of this new thread in the majority of sizes and classes but discussions are still going on with a Working Committee and a considerable amount of work has yet to be done before all sizes and classes of bolts and nuts are covered by this agreement.

The two most important changes in the British Standard screwed thread are first the angle of the thread is now 60 deg. instead of 55 deg., and secondly there are now three series of threads to cover all uses. The series are Fine, Coarse and Special designated as U.N.F., U.N.C. and U.N.S. respectively. Bolts will now be designated by the nominal size the pitch in threads per inch and the series.

In conclusion it can be said that this report gives a good introduction to the new Unified Screw Thread. It also gives an idea of some of the problems involved and a list of the various Committees who were responsible for making the signing of this agreement possible.

W.F.

1950 SUPPLEMENT TO SCREW THREAD STANDARDS FOR FEDERAL SERVICES 1944

(Published by U.S. Government Printing Office Washington D.C. Price 50 cents.)

This Supplement deals with the amendments necessary to the *National Bureau of Standards Handbook H28* (1944) (U.S.A.) following the agreement made between the United Kingdom Canada and the U.S.A. on common standards for screw threads. It is full of technical data and tables of tolerances and is of little interest or value except to those intimately connected with this highly technical subject.

W.F.

PRINTING REVIEW

(Published quarterly by Printing Review Ltd. Price 5s.)

In these days of restrictions and high costs it is very stimulating to see a really high-class magazine depicting some of the best work of the Printing trade.

The Winter 1951/52 issue is a special Cartographic number and contains a number of articles by retired Sapper officers dealing with the latest developments in map production, in addition to articles on other subjects.

C.C.P.

TECHNICAL NOTES

THE MILITARY ENGINEER

(Journal of the Society of American Military Engineers)

November–December, 1951

Lithium—Hydrogen Bomb-Source Material by Jack De Ment

The author, a distinguished chemist, who named and established the science called fluorochemistry, gives an interesting analysis of the chemistry and world distribution of lithium, its ores, spodumene, lepidolite, tryphylite, amblygonite and certain high-lithia content waters. This leads him to the conclusion that any attempt to control this raw material of the hydrogen bomb, owing to its wide, though sparse distribution in the earth's crust, would be a complicated if not impossible task. Fortunately the problem is not serious as without uranium or thorium, essential for the hydrogen bomb detonator, lithium alone is useless and thermonuclear weapon production is at present automatically controlled by the controls imposed on the raw materials of the old-fashioned atom bomb, a comforting thought for those readers who have already gone to considerable trouble to provide themselves with suitable protection against A-bombs.

To those not already completely familiar with the theory of the use of lithium in the production of H-bombs a reminder is given that when the nuclear reactor or atomic pile is fed with lithium instead of uranium a mixture of radio-active triple-weight hydrogen—called tritium—is produced, instead of the more conventional plutonium. The basic requirements of the hydrogen bomb are a light element fusion reaction with the liberation of energy, as is the case when tritium is a reactant; and a detonator to initiate the reaction by the production of enormous heat. So far the only practical way of triggering is by an atomic explosion, where temperatures approaching those of the interior of the sun are created.

Earlier designs of hydrogen bombs included lithium compounds of deuterium or tritium but later plans generally involve the double and triple-weight hydrogens, deuterium and tritium, respectively: Using heavy hydrogens alone three reactions are possible. One or all of these appear feasible thus giving rise to an entire class of thermonuclear explosives, not just one bomb.

To obtain maximum efficiency from the H-bomb, like the A-bomb, the reaction must be kept confined so that the device does not blow itself apart prematurely, or fizzle. The author points out, however, that the fizzle type of H-bomb, with a comparatively slow reaction and the emission of vast quantitites of gamma rays and neutrons, offers a weapon of low-order physical destruction which has many uses in warfare. We can, therefore, confidently anticipate a complete class of thermonuclear weapons starting with fizzle models and ranging upwards through types of various explosive qualities.

THE DESIGN OF NAILED STRUCTURES

(*Civil Engineering and Public Works Review*, dated January, 1952)

This is the first part of an article by Professor E. George Stern of the Virginia Polytechnic Institute in Virginia, U.S.A. He feels that the mass production of improved types of nails should bring nailed construction into its own once more, as at present nailed joints have, to a great extent, been replaced by a number of types of modern timber connector.

Both in the U.S.A. and in U.K. the design data for nailed structural joints is very inadequate. Recommended loads being restricted to headed wire nails without surface treatment driven perpendicularly into the wood without pre-boring. Very little other information is given, though in countries where nailed structures have been extensively used very full specifications are in being ; possibly this is because of their more extensive laboratory and field experience.

To assist in the design of nailed structures and to supplement the existing design data in the U.S.A., Professor Stern gives some recommended practices.

Regarding types of structure, nailed designs are not recommended for exposed permanent structures such as road and rail bridges which are heavily and repetitively dynamically loaded. Nailed trusses should have a camber of about $\frac{1}{200}$ span, part of which will disappear during the first year.

Several comments are made concerning the strength of wood and the load carrying capacity of nails. Amongst these it is interesting to note that member thickness may be neglected from the design viewpoint.

Driving wire nails without pre-boring does not weaken the wood cross-section as much as drilling of holes, because in the former case the wood fibres are only wedged apart. However, to be on the safe side the nail cross-section should be deducted from the timber section for designing.

THE CONSTRUCTION OF TANKS IN PRESTRESSED CONCRETE

(*Civil Engineering and Public Works Review*, dated January, 1952)

Five tanks just completed for the Ministry of Supply are claimed to be the first prestressed concrete tanks to be constructed in this country. These tanks, on which the Magnel-Blaton system of prestressing was employed, are connected with the process of manufacturing sea-water magnesia.

As this was the first time a job of this sort had been carried out in this country the tanks walls were made thicker than actually required, in order to permit the concrete to be properly placed and compacted. However, experience has since shown that thinner walls can be satisfactorily concreted, and thus higher concrete stresses may be used. The walls were prestressed both horizontally and vertically so that under all conditions of loading there remains a compressive stress at all points.

All the tanks were designed with a sliding joint between the walls and base, this joint being formed by constructing a groove in the base and then casting the wall in it. Owing to the number of large pipes passing into the tanks at floor level the base, the bottom 6 ft. of the wall and the channelled apron, which surrounds these tanks to collect overflow, were designed in normal reinforced concrete, thus overcoming the problem of having the continuity of the lowest rim of the prestressed shell interrupted by pipe holes. The tank floors were also designed in normal reinforced concrete.

The horizontal cables are composed of groups of four high tensile wires of 5 to 7 mm. diameter depending on the diameter and depth of the tank.

The vertical cables pass from a top anchorage around a bottom anchor bar and back to the top, each wire of the cable being 5 mm. dia., and is tensioned to 140,000 lb./sq. in.

Near the foot of the shell there is a manhole. The vertical prestressing cables are located to pass on either side of this opening. The horizontal prestressing force is carried across the opening by means of a structural steel frame to which the horizontal cables are anchored.

THE CONSTRUCTION OF A TIED-ARCH STEEL BRIDGE

(*Civil Engineering and Public Works Review*, dated February, 1952)

An article in this periodical describes the construction of the Vila Franca Bridge over the river Tagus for the Portuguese Government. The total length of the bridge including approach spans, is 4,015 ft. of which the river crossing is 1,700 ft. and is bridged by five spans of tied-arch steel construction. The interest lies in the methods of construction. The foundations had to receive their bearing from a gravel and sand layer, the surface of which lay up to 100 ft. below the river bed, the overlying layer being silt. Each pier was built as a caisson in a graving dock and floated into position, when it was sunk over a cluster of piles driven to the ballast. Seating for these caissons when sunk, were formed by excavating the river bed and laying a sand carpet in the excavation to the level required. The piles were then driven through this.

A temporary span formed the bed for the construction of these main spans and this temporary span was moved from gap to gap, by barges, as the work proceeded. The barges moved in to place the service span, or remove it, at slack water at low tide and considerable care was needed to carry out the task to prevent the service span being trapped under the completed bridge when it was being removed or the barges being trapped under the service span when in the process of landing it on the piers. The care taken in removing all rust and mill scale before painting the bridge is also worthy of note.

The work was carried out by Dorman Long and is an excellent example of several different types of civil engineering construction to solve a very difficult problem.

SOME FUEL AND POWER PROJECTS

The Proceedings of the Institution of Mechanical Engineers, 1951, Vol. 164, No. 4, contains a most interesting description of "Some Fuel and Power Projects" by Dr. Roxbee Cox, Chief Scientist, Ministry of Fuel and Power. Dr. Roxbee Cox describes the current research and development work of the Ministry of Fuel and Power.

This falls under the following main heads :—

1. *The Use of Solid Coal*

   The development of coal-burning gas turbines for industrial purposes and for locomotives.

2. *The Use of Available Gases from Coal*

   (*a*) The development of methane-burning gas turbines utilizing "firedamp" from coal mines.

   (*b*) The development of heat pumps such as that installed in the Royal Festival Hall. This uses town gas as its source of power.

3. *The Gasification of Coal*
   (*a*) Underground gasification. The production of a combustible gas below the surface which will be used on the site for generating electricity.
   (*b*) Total gasification, i.e., the conversion of coal into gas with such completeness that the only other product is ash.

4. *The Use of Peat*
   There are two programmes of peat utilization, one under the Ministry of Fuel and Power and the other under the Secretary of State for Scotland. Both of these include the development of peat-burning gas turbines.

5. *Compressors*
   Development of centrifugal air compressors for gas turbines.

6. *Wind Power*
   Wind power is a practical possibility and its economics are being explored by experiments in construction and operation. Two contracts have been placed for pilot-scale wind power generators of about 100 kw. each, one for the B.E.A. and one for the North of Scotland Hydro-Electric Board.

AIR CONDITIONING

There is an increasing demand both in the services and in civilian life for air conditioning and dehumidification. Refrigeration equipment does not meet all needs and it often happens that the installation of full scale air conditioning plant is unjustified. There has recently, therefore, been much military and civilian interest in adsorption methods which have hitherto been little used outside the U.S.A.

A. E. Pickles, in *The Heating and Ventilating Engineer* for February, 1952, gives a brief description of these methods under the title of "Low Humidity Air Conditioning." Briefly, adsorption dryers employ a solid granular, highly porous material which has the property of attracting to itself the molecules of water vapour from the surrounding atmosphere. Extremely low humidities can be produced and the system can be applied to large or small scale installations.

GAS TURBINES

The mid-February edition of *The Oil Engine* and the editions of 1st February and 15th February of *The Engineer* contain fairly detailed descriptions of Western Region's second gas turbine electric locomotive, No. 18,100. The locomotive was designed and constructed by Metropolitan Vickers and has a declared continuous rating of 3,000 h.p. The fuel used is gas oil and so this fact alone removes any opportunity of serious competition with diesel electric traction, since the G.T. loco's considerable weight advantage and anticipated lower maintenance costs cannot do more than partially offset its much inferior thermal efficiency. The traction power available at the wheels is about 15½ per cent of the heat value of the fuel consumed. With an all-up weight of 129½ tons, a rail h.p. of 2,450 and a 60,000-lb. tractive effort available at starting, the locomotive is easily the most powerful on British Railways.

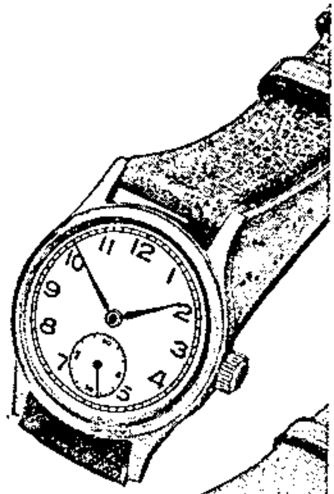
Watches for men

In the really good-quality watch where beauty is combined with purpose we find the most acceptable of gifts. We at '112' are proud to think that the selection of watches we are able to place before you embraces all that is best in the art of the watchmaker. In addition there is a 2-years' guarantee with every watch sold by us.

An illustrated catalogue is available and will be sent on request.

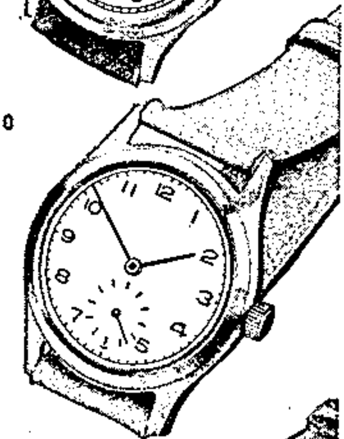
Fully jewelled Swiss lever movement compensated for changes in temperature stainless steel back to waterproof case.

£9 · 0 · 0



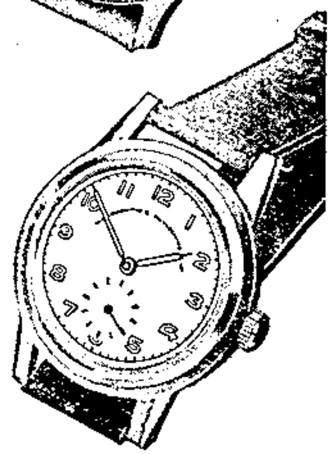
Fully jewelled French lever movement compensated for changes in temperature stainless steel waterproof case, shockproof.

£21 · 7 · 0



Fully jewelled Swiss lever movement compensated for changes in temperature stainless steel waterproof case, luminous dial.

£13 · 10 · 0



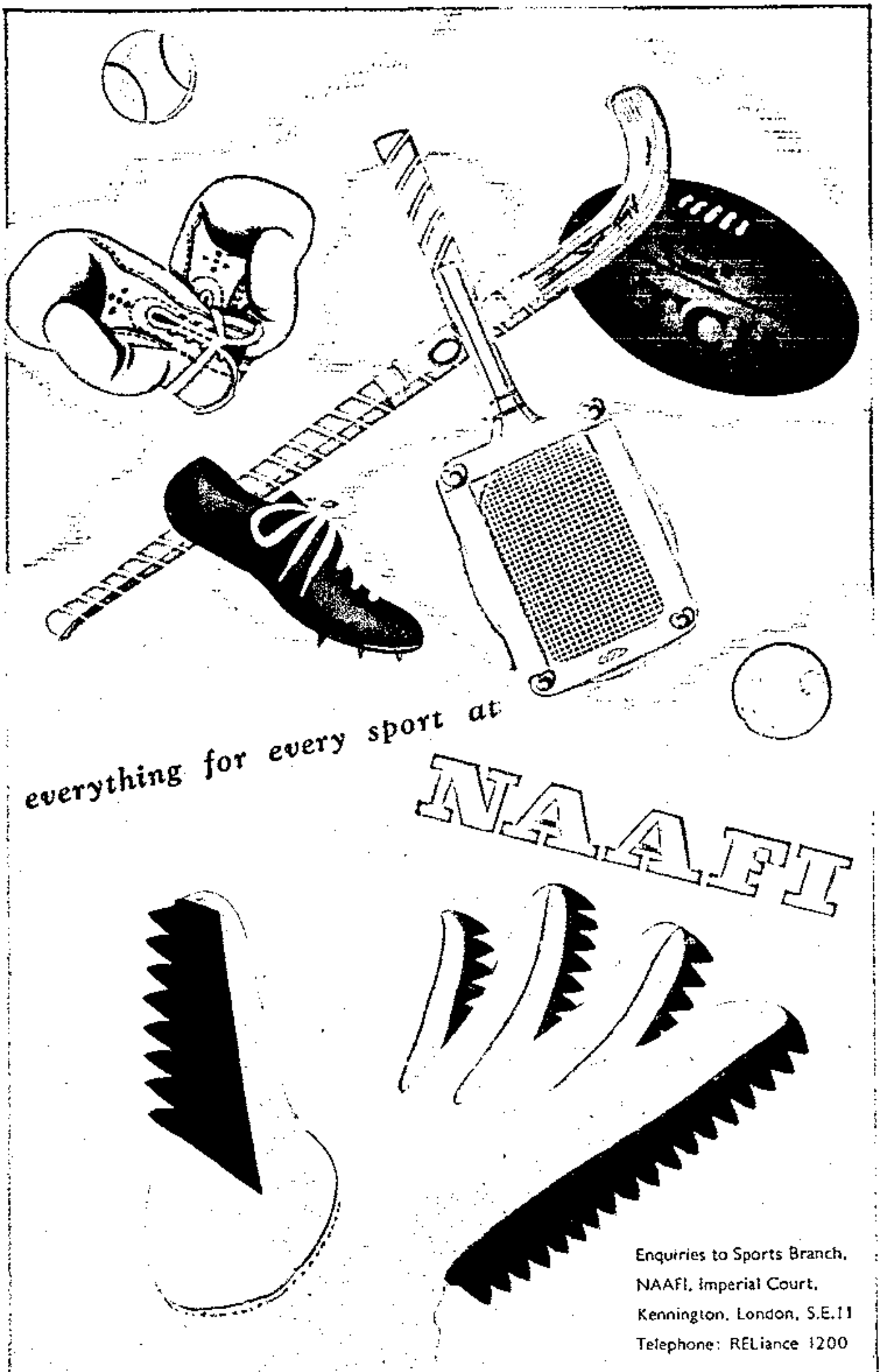
THE GOLDSMITHS & SILVERSMITHS COMPANY LTD

112 REGENT STREET · LONDON : W.1

Number **'112'** *is our only address. Telephone: REGent 3021*


why you should shop at
NAAFI
DEPENDABLE QUALITY
VARIETY OF GOODS
PERSONAL ATTENTION
MONEY'S WORTH
MORE
AT
NAAFI
. . . . and you get 10% discount
The official canteen organisation for H.M. Forces. Ruxley Towers, Esher, Surrey.


a complete sports service at your fingertips
The fitness of the athlete for the game must be matched by his equipment. Nowhere is this better understood than in the Services: for nowhere is sport more highly valued.
Only the best can be of Service standard: and only the best is to be found at NAAFI Sports Shops. In any one of them, the finest of all sports goods and equipment—by leading manufacturers — is ready for the game.
NAAFI
The official canteen organisation for H.M. Forces
RUXLEY TOWERS · ESHER · SURREY


everything for every sport at
NAAFI
Enquiries to Sports Branch,
NAAFI, Imperial Court,
Kennington, London, S.E.11
Telephone: RELiance 1200


PORT

16 YEARS' SERVICE

CONFIRMS 1934 TESTS

The illustration above shows part of the Men's Slipper Baths at Wimbledon, where Cementone No. 7 Gloss Finish was used for decorative work in 1936. This photograph was taken some 16 years later and shows how Cementone No. 7 has retained its superb high gloss finish after 16 years' exposure to the severe conditions experienced in public baths. In 1934 tests were carried out by the *Decorator* Journal on all types of surface, including new plaster, new cement and asbestos sheeting. These tests proved the claims made that Cementone No. 7 was suitable for application to almost any type of building surface, eliminating the need for using special paints for different surfaces. Our claim, first made in 1934, that the "one-shot" decorative material had arrived, has been confirmed by thousands of contracts in all parts of the world and tests carried out by independent bodies.

You would be well advised to use Cementone No. 7 Flat or Gloss Finish with Universal Primer on your next contract. A handbook, giving specifications and costs per yard, will be forwarded on request.

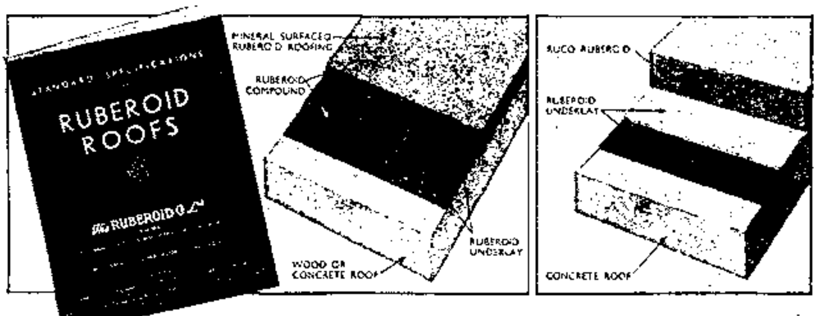
YOU CAN DEPEND ON

Cementone PRODUCTS

JOSEPH FREEMAN SONS & CO., LTD. — **CEMENTONE WORKS, LONDON, S.W.18**

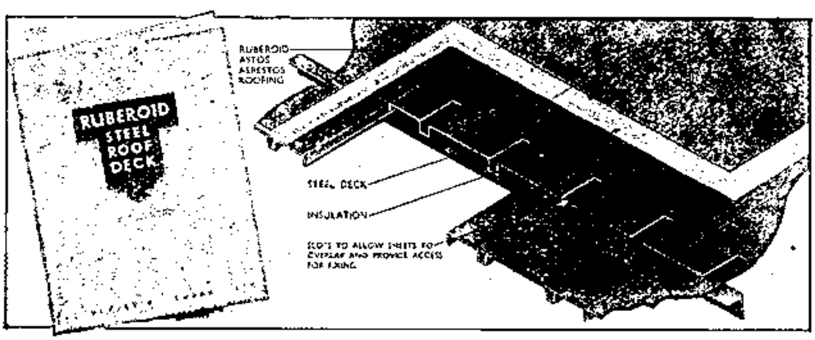
Telephone : VANdyke 2432 (5 lines) — *Telegrams : Cementone, Wesphone, London*

RUBEROID ROOFING SPECIFICATIONS



THE BUILT-UP RUBEROID ROOF

THE RUCO-RUBEROID ROOF



THE RUBEROID INSULATED STEEL ROOF

Experience gained during more than half a century has enabled The Ruberoid Co., Ltd., to provide standard roofing specifications which meet every requirement.

Single layer specifications for light structures ; Built-up Roof Specifications for permanent buildings ; and where wheel or foot traffic is encountered, the Ruco-Ruberoid Roof and the Ruberdal Roof—are all fully described and illustrated in " Standard Specifications for Ruberoid Roofs " (Brochure No. 326).

As a light and rigid form of roof, the Ruberoid Insulated Steel Roof has many advantages over other forms of structure. It is economical to erect and maintain and combines maximum strength with minimum dead load. Technical data and illustrated details of construction are contained in Brochure No. 343.

Estimates for the supply and fixing of Ruberoid Roofs on any scale, large or small, anywhere in the British Isles, will be sent free on receipt of particulars.

THE RUBEROID COMPANY LIMITED

177 COMMONWEALTH HOUSE, 1-19 NEW OXFORD STREET, LONDON, W.C.1

R. 40