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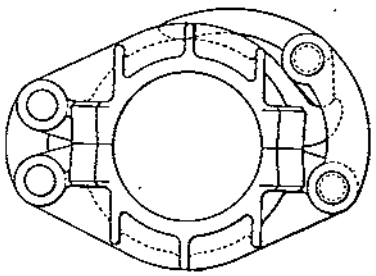

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THE UNIFORMS OF THE CORPS OF ROYAL ENGINEERS UP TO 1914.

By the late LIEUT.-COLONEL P. H. KEALY, R.E. (*retired*).

INTRODUCTION.

THE Corps of Royal Engineers owes a great debt of gratitude to Captain Thomas Connolly, one time a Quartermaster of the Royal Sappers and Miners, and later of the Royal Engineers. His *History of the Royal Sappers and Miners, from the formation of the Corps in March, 1772, to the date when its designation was changed to that of Royal Engineers, in October,* 1856, was published in 1855, a second edition appearing in 1857. This was the first history of the Corps in any form which had been written, and the timely researches of Connolly undoubtedly rescued a great deal of information about the men of the Corps from oblivion. Especially useful are the seventeen coloured plates showing the dress of the Royal Sappers and Miners at various periods: without these plates we should be almost entirely devoid of any definite information as to the uniform of the men up to 1857.

Thomas William John Connolly was born in Paris at the Champs Elysées in October, 1815. His father was probably serving with the Army of Occupation at the time, though in what capacity is unknown. His grandfather, John Connolly, was Adjutant of the 12th Light Dragoons, and his name appears in the Army Lists from 1800 to 1808. T. W. J. Connolly joined the R. Sappers and Miners at Woolwich on 1st October, 1829, from the Duke of York's School, Chelsea. He served for many years at Woolwich, then the H.Q. of the Corps, as Chief Clerk in the Brigade Major's office. As a serjeant in 1848 he received the Meritorious Service Medal with an annuity of £10. He was appointed Quartermaster on 26th June, 1855, and retired on 22nd August, 1865, being given the honorary rank of Captain. He died in London on 21st May, 1885.

Connolly married a daughter of William Collins, who served for 44 years in the R.A. Band at Woolwich. One of the six sons of Collins who joined the army was William Collins, for some time Bandmaster of the R.A. Band, and afterwards the first Bandmaster of the R.E. Band, Chatham. Of Connolly's four sons, the eldest served in the Engineer Department as Clerk and Draughtsman, whilst the second, Rowley, obtained a commission in the 72nd Regiment in December, 1863; he passed out of Sandhurst first out of a batch of 34 who were examined, and his regimental sword was purchased and

presented to him by the officers of the Royal Engineers, amongst the subscribers being Sir John Burgoyne, Sir Harry Jones, and General H. Sandham. This was a testimony to the high esteem in which Connolly was held by the Corps.

In his Preface to the first edition of his work Connolly explains how he came to write the history of the Royal Sappers and Miners. It started in 1836, when the Adjutant was directed by the Brigade-Major "to prepare a list of officers of the Royal Engineers who had commanded, from time to time, the different companies of the Corps." The officers at H.Q. frequently changed, and Connolly was a permanency, so that eventually the latter became interested in examining the old records, which were very incomplete, and in piecing together the history of the Corps, originally for immediate use and eventually for purely historical purposes. It was Major H. Sandham who, as Brigade-Major in 1847, practically ordered Connolly to prepare a history for publication.

In the history no mention is made of the Royal Engineers, except when such mention is unavoidable. This course was insisted on, it is believed, by Sir Charles Pasley. When he had finished his *History of the Royal Sappers and Miners,* Connolly continued his researches, and went on collecting till the day of his death materials for a history of the Royal Engineers. His papers were eventually bought by the R.E. Institute in 1888, and they are now kept in the Secretary's office at Chatham. Connolly's industry was amazing; he collected information about the Corps from stations all over the world, he ransacked the Ordnance papers and returns, and spent many hours amongst the records in the British Museum; no detail about an Engineer was too trivial for him to record. *The Connolly Papers* now consist of 17 foolscap-size books of about 80 pages each, every square inch of paper and the inside of the covers being crammed with information in Connolly's minute writing. The information in these books was abstracted by him on to separate sheets, one for each officer. These records formed the basis for the *Roll of Officers of the Corps of Royal Engineers, from* 1660 *to* 1898, edited by Captain R. F. Edwards, R.E., and published by the R.E. Institute in 1898. In addition there are the beginnings of the writing of a history of the Corps, which, judging from the scale on which the story up to 1744 only had been completed, would have run into several volumes. Some of Connolly's diaries also are in the R.E. Museum.

Major-General Whitworth Porter, in the Preface to his *History of the Corps of Royal Engineers,* dated 1889, pays the following tribute to Connolly's researches:—"In the compilation of this work I have received very valuable assistance from my brother officers and others. Chief amongst these in importance must be named the late Captain Connolly, many years of whose life were spent in the accumulation of a vast mass of varied information on the subject

of the Corps. It is only within the last few months that I have been able to obtain access to these valuable papers as a consequence of their purchase by the Royal Engineers' Institute. Had I been permitted to peruse them earlier I might have been saved much labour expended in going over ground already explored by him. . . . He intended writing a history of the Corps himself, and was engaged in the earlier portion of the work at the time of his death."

Recently, during a structural upheaval in the Secretary's office, the opportunity was taken to ransack a large map chest. Amongst the contents was a file containing original papers got together by Connolly. The story of the file is unknown, but it contains many papers of interest, including three General Orders of the Corps of the years 1824, 1830, and 1845, all of which deal with dress. These Orders fill up a gap in our knowledge of this subject, and for the first time we are able to compile a reasonably complete account of the uniform of the Corps; for this we are once more indebted to Captain Connolly.

The writer of this article gratefully acknowledges the assistance he has received from Major H. Fitz M. Stacke, M.C., and Mr. P. W. Reynolds.

THE UNIFORM OF THE OFFICERS UP TO 1914.

PART I.

The earliest regulation that deals with the dress of the Engineers of which we have any knowledge is dated 1782. For information before that time we are dependent almost entirely upon portraits, but a certain amount may be deduced from Macdonald's *The History of the Dress of the Royal Regiment of Artillery*. That history commences with the reign of Charles I., when armour was beginning to go out of fashion. There was little uniformity in soldiers' dress at that time, but officers generally wore in the field "a richly laced coat, encircled by a broad scarf tied in an enormous bow." A cuirass was often worn over the coat. The earliest drawing depicting an artilleryman appears in a book dated 1642; it is a woodcut, coloured at some subsequent date unknown, and shows a man in a blue coat with scarlet facings and yellow lace.

Until the formation of the Artillery into a separate body in 1716, the Engineers and Artillery were always shown in the estimates of the Board of Ordnance on a single list, and on service both categories were members of the Ordnance Train. The peace establishment authorized in 1683, on the reorganization of the Board of Ordnance, was as follows:—*Under Ministers.*—Principal Engineer @ £300; Second Engineer @ £250; Third Engineer @ £150; Two Ordinary Engineers, each @ £100; The Master Gunner of England @ £190; His three Mates, each @ £45 10s.; Sixty Gunners, each @ 1/- per

Captain TWJ Connolly

An officer of the train 1660-1702

diem; Fire Master @ £150; His Mate @ £80; Four Fireworkers or Petardiers, each @ £40; Two Proof Masters, each @ £20; Wagon Master @ £100; Clerk of the Cheque @ £60; Surveyor @ £40; Messenger @ £60; Labourers, 44, each @ £26.

On service the Train, containing both Engineers and Artillery, was generally commanded by the Chief Engineer. Colonel Holcroft Blood, an Engineer, commanded the Artillery personally at the battle of Blenheim. The probabilities, therefore, are that all the officers of the Board of Ordnance were dressed alike, and that there was no distinction at that time between the uniforms of the Engineer and Artillery officers. Macdonald remarks that blue had always been the colour of an Artilleryman's coat. The same would apply to the Engineers at that time.

An officer of the Train for the period 1660-1702 is depicted here following Macdonald's plate (Plate 1). Silk armour was also worn at this period; it was made of "quilted silk, so closely stitched and of such thickness as to be proof against bullet or steel; while a thick bonnet of the same materials, with ear-flaps attached to it, protected the head." On 30th October, 1685, the following Ordnance issue was made:—"To Jacob Richards [an Engineer] for his own use in the Train of Artillery, by order of the Board, silk armour—one suit." On 1st November, 1688, a similar issue was made to the Chief Engineer; and again on 1st December "To Sir Martin Beckman [Chief Engineer], lent him for his own use, by order of the Board, silk armour—one suit." (Macdonald.)

The portrait of Captain John Romer, an Engineer, *circa* 1710, is given in Porter, Vol. I.

In general, the pattern of dress worn in the Army as a whole underwent no essential modifications from the period of King James II. till about 1730-35. Its main features were a long single-breasted coat reaching nearly to the knees, with very full skirts and heavy cuffs, a long sleeved waistcoat—practically the same length as an officer's service-dress jacket of the present day—breeches of coloured cloth or plush, long stockings pulled up over the breeches at the knee, top-boots or buckled shoes, and a black felt hat. The latter, at first worn with the brim down all round (and hence termed a "round hat"), had its brim turned up, or "cocked," on three sides about the year 1700, thus becoming the "cocked hat" characteristic of the eighteenth century. About the same time long gaiters, termed "spatterdashes," buttoned down the outside of the leg, were adopted to protect the stockings from rain and mud.

The heavy perukes, characteristic of officers' dress in the period of Queen Anne, went out when powdered hair came into fashion about 1720-30. This custom lasted till the end of the eighteenth century, and, although usually omitted on active service, must greatly have complicated the preparations for all ceremonial parades during that period.

About the years 1730-35 uniform coats were more frequently made double-breasted, with lapels which could be buttoned back to show the colour of the facings, on the model of the Prussian Army, then for the first time becoming a pattern to others. At about the same time it became customary to loop back the heavy skirts of the soldiers' coats for convenience in marching or riding; officers, however, did not normally loop back the skirts of their coats till the middle of that century.

In 1716 the Royal Artillery became a definite regiment with an establishment of two companies, and the officers were given King's Commissions. The Engineers continued as they were before, serving on warrants issued to them by the Master General of the Ordnance, until 1757, when they too were given Commissions by the King. During this period, 1716-1757, the position of the Engineer was a difficult one; as an engineer he had no military rank, but most Engineers held Commissions in line regiments or in some cases in the Royal Artillery. Whether there was any regular uniform for the Engineer as such is not certain; he probably wore a blue coat as formerly, or else the uniform of his regiment. No portraits of this period are known, except those of Michael Richards and John Armstrong, who are depicted conventionally in armour.

The year 1757 was a landmark in the history of the Engineer, as after a great deal of agitation, and in spite of the opposition of the Board of Ordnance, he was granted a Commission by the King. The first Commissions were dated 14th May, 1757, and about 1760 those Engineers who held Commissions in other Corps as well were called upon to relinquish one or other of their Commissions.

The Engineers were not yet apparently known as a Corps, the wording of the Commission running :—" We do by these Presents constitute and appoint you to be one of the (Practitioner) Engineers, upon the Establishment of our office of Ordnance, and to take your Rank as (Ensign) in Our Army." But from this time the dress that appears in portraits of various Engineers of this period is of the same general pattern : five of these portraits are known, the earliest being that of Ensign Gother Mann (1763), which appears in Porter, Vol. I. Photographs of the others are in the R.E. Museum. The coat is red with dark blue lapels and facings, and gold-laced buttonholes (the Artillery coat with the colours reversed), the waistcoat and breeches white. The general design is clear from the portraits, but it was not till the nineteenth century that there were any sealed patterns, so that there was a good deal of latitude over details and cut.

After the Seven Years' War, about 1768, there was a general modification of the dress of our Army, following the changes made about that period in the principal armies abroad. The coats were made much lighter, and were cut away from the front into a shape some-

thing like that of the present day civilian "morning coat"; the cuffs were made smaller and lighter; white breeches were introduced for most of the Army, including the Artillery and so, presumably, the Engineers; and the officers' crimson sash, which previously had been worn outside the coat over the shoulder, was now worn round the waist over the waistcoat, but showing in front under the cut-away coat.

We now come to the year 1782, and the first order on the subject of Engineer dress so far discovered. This order is given in Porter, Vol. I, page 226, and the following is a specimen (from the R.E. Museum) of the letter issued:—

Office of Ordnance
December 24th, 1782.

Sir,

His Majesty having been pleased to direct that the Uniform in future to be worn by the Corps of Engineers, shall be a Blue Coat faced with Black Velvet, lined with White, with White Waistcoat and Breeches.

I have received his Grace the Master General's Commands to signify the same to the Corps, and that a Pattern Suit may be seen at his Grace's House.

You will therefore be pleased to accept this Notice thereof yourself, and communicate the same to the Engineers under your Command.

I am
Sir
Your most obedient
Humble Servant
James Bramham.

Colonel Dixon Commanding Engineer at Plymouth.

From this time onward the forward corner of the cocked hat was gradually stiffened up until it became nearly vertical, and was then of so little use as a protection from the sun that for hot climates a new "round hat" was introduced about 1790-91, as the following quotations bear witness:—

Gibraltar Orders relative to dress.

24 Feb. 1790. The Officers [of the two companies of R.M. Artificers] to appear in boots, plain cocked hats with black buttons and loops, and black stocks—sashed and with regimental swords.

25 April. 1791. Colonel Morse directs that the several Engineers do appear on the Great Parade the 1st of May next in round Hats with feathers such as are worn by the other officers of the garrison and upon all parades from that time till further orders.

These "round hats" were virtually the version of "top hat"

worn then in civilian life, with a very curly brim and the sides of the "top" sloping inward.

The outbreak of the war with Revolutionary France in 1793 found the uniforms of the British Army very stiff and unpractical; and after the severe hardships of the Flanders campaign of 1793-5 various reforms were made. Powdering of hair was going out of fashion in civil life, and orders were issued to discontinue the custom, which soon took effect, although a few conservative regiments and individuals continued to powder their hair up to the beginning of the Peninsular War in 1808. Various other changes in dress were introduced during 1796-99. The heavy lapelled coat of the rank-and-file was replaced by a short single-breasted jacket with short turned back skirts, while the officer's coat was differently cut, becoming a double-breasted coat, cut square along the waistline in front, but falling over the hips into two long tails—the form which may be seen in any picture of the Regency period, and from which has evolved the civilian evening-dress coat of the present day. With this "coatee"* the sash was worn outside the coat, round the waist.

An Order of 15th November, 1796, gives further details:—"A crimson and gold cord round the hat, with crimson and gold rosettes or tufts brought to the edge of the brims. The sword to have a brass guard, pommel, and shell, gilt with gold, with the gripe of silver twisted wire. The blade to be straight and made to cut and thrust, one inch broad at the shoulder and 32 inches in length, according to former orders. The sword knot to be crimson and gold in stripes as required by H.M.'s present regulations. The sword to be worn in a cross-belt (white) with an oval plate gilt, having the King's cypher with the crown over it, engraved on the middle. To be seen at Kimbley's, Cutler, Charing Cross." The portraits of this period are those of Captain William Fyers (reproduced here—Plate 2) and Major William Nicholas, both given in Porter, Vol. I (unfortunately the Nicholas portrait has been incorrectly coloured).

The following is an extract from Welch and Stalker's book, in the possession of the Reverend P. Sumner, who has kindly given permission for its publication:—

"Royal Engineers. Coat as made for Mr. George Cardew, December, 1798.

Blue superfine cloth coat, black Genoa velvet lapels, cuffs, and stand-up collar lined with the same velvet, and a coat button on each end of the collar, to run with the lapel. Nine twist holes in the lapel a little longer than to admit the button. Three-pointed flap with four holes. Four buttons on cuff, no holes, and open under-

* The actual term "coatee" did not come into general use until well on in the nineteenth century, about 1820. In the R.E. regulations not until 1830.

Captain William Fyers 1790

Plate 3 1832

neath with covered button. Soldier's back and side, with two holes of a side, and 2 buttons in middle of the side-edges. Artillery buttons. Lapell short of the waist. N.B.—Mr. Cardew's coat had white cassimere turnbacks, stitched down, with a breast button for skirt ornament." This agrees closely with the Fyers' portrait.

By this time the forward corner of the cocked hat had become quite vertical, so that the hat was now really "two-cornered" "athwartships"—the shape traditionally associated with the Emperor Napoleon. But this form was so unpractical and inconvenient that from about 1800 it became customary when on active service to wear the hat "fore-and-aft" instead of "athwartships" —*i.e.*, with the brim fastened up on each side instead of at back and front * This fashion, at first frowned on as being contrary to regulations, was eventually accepted officially, and from the time of the Peninsular War onwards this manner of wearing the cocked hat became officially recognized.† In the Infantry (including the Foot Guards) and the Heavy Cavalry cocked hats were worn for Levee Dress until about 1830, but were then superseded by the other head-dresses of those respective arms; but the Royal Engineers remained faithful to the cocked hat for another hundred years; and it was not until 1932 that the old head-dress disappeared altogether from the uniform of the Corps.

Other changes also occurred at the beginning of the nineteenth century; notably the introduction of trousers, at first as "overalls" to cover the breeches, afterwards to replace them. The fashion became general during the Peninsular War, apparently from its earliest campaigns, although only authorized in 1811. At first these trousers or overalls were made of grey cloth, sometimes with buttons to fasten up the outer seam of the legs.

The next change in the dress of the officer took place in 1812. The diaries of Landmann (*Recollections*, II, p. 105), Boothby (*Under England's Flag*, entry for 20th September, 1808), J. T. Jones (*Autobiography*), and Rice Jones (*The R.E. Journal*, July, 1912, entry for 5th April, 1809), all refer to the wearing of a blue coat. In the proposals for a Corps of Sappers and Miners put forward by Sir Richard Fletcher on 29th January, 1812, appears the sentence, "The other officers of the Corps of Royal Engineers to wear a blue uniform as at present" (*The R.E. Journal*, 1930, p. 595).

The authority for the date of the change back to red is a letter written by Captain W. Nicholas, R.E., on 2nd April, 1812, from before Badajoz (*R.M. Chronicle*, Feb., 1813, p. 271). In this letter he wrote,

* The change was effected by turning the fan or back of the hat to the left side, and the front to the right side.

† Until 1812–13 Infantry officers mostly wore the hat, although their men had the cylindrical chaco. Cavalry officers also frequently wore the cocked hat off duty.

"Our uniform is changed to scarlet with a gold-laced dress-coat. I dislike the change on account of the colour and the expense; but I shall order nothing till I know whether I am to have the brevet rank, as it makes a difference in the epaulettes." Nicholas died of wounds received at the assault of Badajoz on 6th April, and never lived to wear the scarlet coat and to enjoy the brevet rank which he was given posthumously: yet in the portrait given in *Porter* he is shown as wearing a red coat.

The change from blue to red was presumably brought about by a General Order of the Corps, but no copy has so far come to light. We know that a General Order on the subject of dress was issued in 1817, which on the return of peace probably elaborated the previous orders. There is a coat of this period in the R.E. Museum, which is of the same pattern as that shown in the portrait of Burgoyne, which appears in Vol. I of his *Life and Letters* by Wrottesley; when, worn as he has it with the lapels buttoned back, the coat was fastened with hooks and eyes and the velvet facings and gold-embroidered buttonholes were displayed; but it could also be worn with the lapels unbuttoned and folded right across. The gold embroidery on the buttonholes appeared also on the back of the lapels. It will be noticed that the orders of 1817 introduced a separate undress coat without embroidery, instead of making the one coat serve the two purposes. We know the contents of the 1817 General Order from the first printed Standing Orders for the R.E. Establishment at Chatham, issued in 1818, and the relevant extracts from these orders will now be given.

Orders chiefly relating to The General Discipline of the Establishment, by Lieutenant-Colonel C. W. Pasley, R.E.

DRESS OF OFFICERS.

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1. Officers of the Royal Engineers are to conform strictly to the general orders of the corps, of the 26th of March, 1817, relating to dress, an abstract of which is as follows:—

"The dress uniform is intended to be worn at dress reviews, birthdays, and on other particular occasions (which, of course, so far as relates to the duties of this establishment will always be specified in orders)."

"The full dress, when officers attend the drawing room, or levee, and on occasions of a similar nature."

"The undress is to be adopted for general use, and is to be worn on all occasions not specified above."

Dress. .

"*Coat* . . Scarlet, with garter blue velvet facings, and embroidered button-holes; lappels buttoned back. 2. *Epaulette* . . Plain gold, with the distinctions for the ranks of field officers and colonels. 3. *Hat* . . Cocked, without ribbons at the side. 4. *Loop* . . Plain gold lace. 5. *Feather* . . Plain white, four inches long. 6. *Cravat* . . Black silk. 7. *Pantaloons* . . White, with hessian boots. 8. *Sword* . . The army regulation. 9. *Scabbard* . . When doing mounted duty —steel; on all other occasions, black leather. 10. *Sword belt* . . White leather waist, one inch and a half broad (*With an Engineer's regulation plate, on which the badges, "Egypt," "Peninsula," etc. may be worn by those officers who are entitled to them*). 11. *Sword knot* . . Crimson and gold striped. 12. *Sash* . . Crimson silk. 13. *Gloves* . . White leather. 14. *Great coat* . . Blue or grey."

Full Dress.

"*Coat — Epaulette — Hat — Loop — Feather — Cravat — Sword* — and *Sword Knot* — as before described. *Scabbard* to be black leather. *Sword belt*" (*which is usually narrow and of white silk without a plate*) " to be worn under the coat.—*White kerseymere breeches*, with *silk stockings*, and *shoes*, and *gilt knee and shoe buckles*, to be worn, but no *sash*."

Undress.

"*Coat* . . The same as the dress, but without embroidery—Lappels buttoned over.—*Hat — Loop — Feather — Cravat — Sword — Knot — Scabbard — Belt — Sash — Gloves*, the same as the dress. *Great Coat* . . Blue or grey.—*Overalls* . . Blue or grey. Officers attached to Royal Sappers and Miners, to wear grey."

Horse Furniture.

"*Housing or saddle cloth*—Dark blue, of the usual shape and size with an edging of gold lace. *Bridle* . . With brass cheeks embossed, the forehead band and rosettes of garter blue.—*Collar* . . White. —*Holsters* . . To be covered with black bear skin."

2. When the detachment parades under arms, officers are never to wear great coats, unless the men are ordered so to do. Blue overalls are not to be worn, because all officers attending this establishment are to consider themselves attached to the Sappers and Miners. The assistant director and adjutant only, are to wear steel scabbards. — The adjutant is to wear a strap on his left shoulder.

3. When employed in the field duties, or on fatigues, or within the barrack square, officers may wear round hats, or foraging caps, and great coats, if they think proper; and sashes etc. are dispensed with. But on all other occasions they are to wear cocked hats, and sashes, and their uniform coat, unless in bad weather, when a great coat may be worn. Swords may be dispensed with, excepting when officers are employed on military duties, unless the commandant of

the garrison for the time being, should be pleased to direct to the contrary. Officers not for parade duties may wear white trowsers in summer.

4. At balls and assemblies or other public places, where it is usual for the company to assemble full dressed, no officer is to appear in black or coloured pantaloons or small-clothes, nor in black silk stockings. The senior officer present on such occasions is to enforce the execution of this order, by directing those officers who do not conform to it, to go and change their dress.

5. Gentlemen of the Honourable East India Company's Engineers, doing duty at this establishment, with temporary rank in the army, are to wear an undress uniform, and all appointments precisely similar to those of the Royal Engineers, excepting that on their buttons and sword belt, they will have the Lion and Crown, or badge of the Company's service, with the words "Bengal Engineers," "Bombay Engineers," etc., as may be proper, instead of the badge and inscription in the king's service. At balls, assemblies, etc., they may wear the full dress uniform of their own service.

Remarks.

Epaulettes. At this time Subalterns and Captains wore one epaulette only, on the right shoulder. Field officers and Colonels wore an epaulette on each shoulder. The ranks for field officers were distinguished by a crown for a Lieut.-Colonel and by a star for a Major; a Colonel wore a crown and star.

2. *Sword belt plate.* No description of the regulation pattern has been found so far, but the Corps device is believed to have persisted practically unchanged for nearly 150 years, and during that time to have been substantially the same as that now worn on the full dress sword belt plate and as the cap badge. The device worn on the plate of 1782 was "The King's cypher with the crown over it." At some later time the cypher was surrounded by the garter, on which was placed first "Corps of Royal Engineers," and later simply "Royal Engineers." It is not known when the laurel wreaths were added, but it was very probably after Waterloo when honourable awards were made to all regiments which took part in the battle, including the Royal Engineers. How the personal honours referred to in Pasley's orders were shown on the Engineer's plate is not known, possibly on separate scrolls below the Corps device.

3. We see here first laid down alternative dress according to whether the officer was doing duty with the men or not. Regulations of this sort finally disappeared in 1932 with the abolition in the Corps of the cocked hat.

4. *Hat.* It is interesting to note that Pasley countenanced the wearing of non-regulation "round hats."

We now come to the first of the dress regulations recently discovered, those of March, 1824.

GENERAL ORDERS.

CORPS OF ROYAL ENGINEERS.

84 Pall Mall, 16th March, 1824.

The Master General having directed that the Uniform of the Officers of the Corps should be assimilated (excepting as to colour) with that of the Artillery, so as to have only one uniform coat instead of two as at present, and that such officers as are attached to the Companies of Royal Sappers and Miners should wear caps; the following description of the Uniform and Appointments, shewing the alterations, is published for the information of the Corps; and General Mann desires that it may be strictly adhered to in every particular. Commanding officers are held responsible that not the least deviation from the established patterns, as approved by the Master General, be permitted in the Dress and Appointments of the Officers under their command.

The alterations are to take place immediately, but officers will be allowed six months to wear the Uniform Coats of the old pattern, with which they may be already provided.

The full dress uniform is to be worn when officers attend the Drawing Room or Levee, and on occasions of a similar nature.

The Dress Uniform at Dress Reviews, Birth Days, and on other particular occasions when the Troops are assembled.

The Undress is for general use, and to be worn on all occasions not specified above.

Full Dress.

Coat. Scarlet, single breasted. Cuff and collar of Garter Blue Velvet; Collar, Prussian, full 3 inches deep, laced round, with a loop 4½ inches long and a small button at the end. Cuffs 3½ inches deep, laced round, and 4 loops and large buttons of the present pattern on each—2 short loops on the back skirts with cross flaps and 4 loops and large buttons on each. White Kerseymere turnbacks—skirt ornament and embroidered grenade. The button holes on the breast not to be less than 2 inches asunder.

Epaulette.—Gold lace strap 2½ inches wide, double bullion crescent, 2 rows of bright bullions, 3 inches long. Field Officers to wear on their epaulettes the established distinction for their rank.

Hat. Cocked, with bullion tassels.

Loop. Gilt — Scale.

Feather. White Hackle, 9 inches long.

Breeches. White Kerseymere, uniform buttons and gilt buckles.

Stockings. White silk.

Shoes. With Gilt Buckles.

Sword. The new sabre for Infantry, as described in the Army Regulations.

Scabbard. Black Leather with Gilt Mountings.

Sword-knot. Crimson and Gold Strap with Bullion Tassels.

Sword Waist Belt. White Buffalo leather, 2 inches wide, clasping in front with the Corps Plate, and 2 gilt rings for the sword slings. Worn under the Coat.

Cravatt. Black silk.

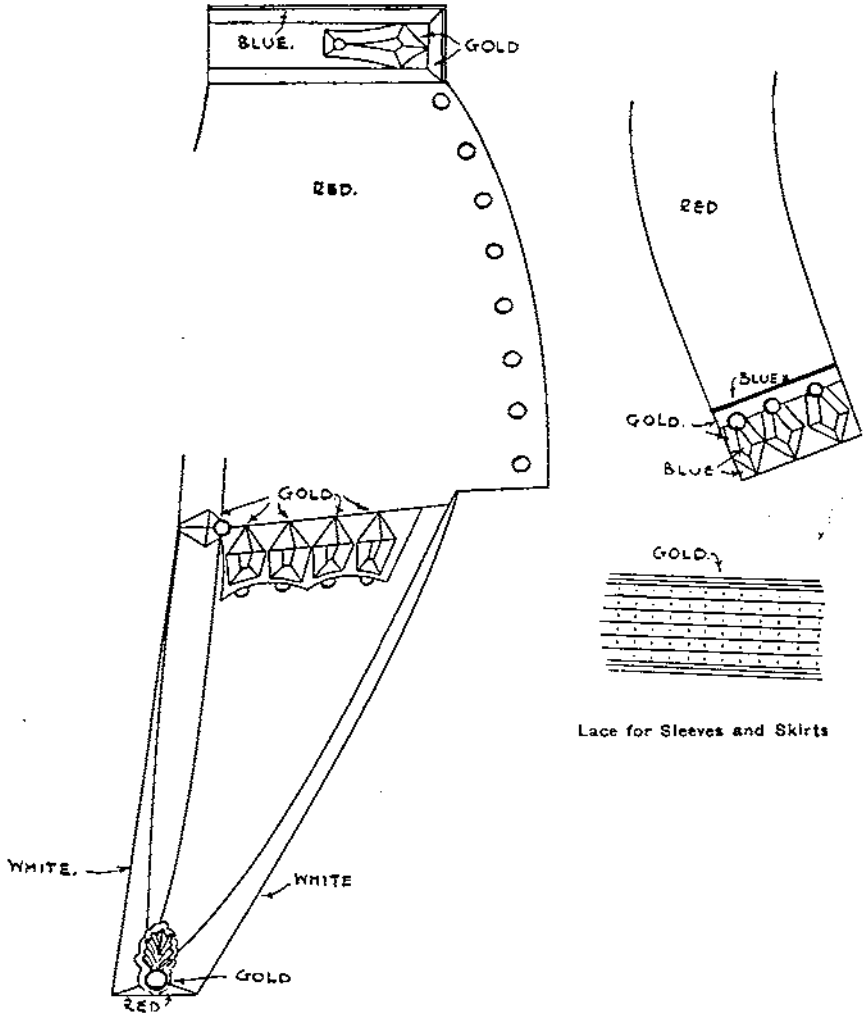
Gloves. White leather.

Dress.

Coat, Epaulette, Hat and Feather, Sword and Belt, Sword Knot, Cravatt, Gloves, as in Full Dress.

Scabbard. As in Full Dress; but when mounted, Steel.

Belt. As in Full Dress, only worn over the Coat.



Coat, 1824.

Sash. Crimson Silk patent net, to go twice round and tied.

White Trowsers. According to the existing Regulations of the Army, with Ankle Boots.

Cap. Bell Shape, lackered top with Device, Scales and Mohair Plume, similar to those of the Artillery; to be constantly worn by such Officers as are attached to Companies of Royal Sappers and Miners.

Undress.

Coat and other Appointments as in Dress.

Trowsers. Blue Grey. The Officers attached to the Royal Sappers and Miners to wear a red stripe, 2 inches wide, down each outer seam.

Great Coat. Blue Cloth, single breasted quite plain ; with Prussian Collar and Uniform Buttons.

Cloak. Blue lined with Scarlet Shalloon, gilt clasp ornaments at bottom of collar, and ball buttons.

Forage Cap. Blue Cloth, laced round — with black leather Peak, the same as the Artillery.

The patterns of the Coats, Epaulettes etc may be seen at Mr Thomson's, 12 Frith Street, Soho.

The pattern of the Hat and Cap at Mr Oliphant's, Cockspur Street, and that of the sword and belt at Messrs Hawkes and Co, Piccadilly.

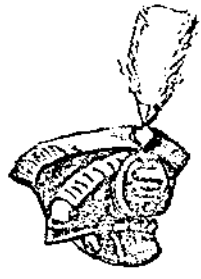
The annexed sketch descriptive of the Coat and Lace is for the guidance of those Officers who may not be able to obtain a view of the patterns.

The General Order dated Pall Mall 26 March, 1817, so far as relates to the dress of the Corps of Royal Engineers is now cancelled.

By order of General Mann,
C. G. Ellicombe
Brigade Major.

Remarks.

1. The dress is becoming more elaborate. The grenade now appears as the skirt ornament for the coat. The feather of the cocked hat has grown from four inches to nine inches long, and the epaulette is more heavily bullioned. The Hessian boots, however, have gone and ankle boots take their place with white trousers.



1824 Cap or Chako.

2. There is no mention of the sash in the Full Dress.

3. There are two points of special interest :—(*a*) The introduction of a cap, really the chako, to be worn instead of the cocked hat by officers attached to the Sappers and Miners. The chako being of the same pattern as that worn by the Artillery would be that shown in Macdonald, plate 14, a sketch of which is reproduced herewith.

(*b*) This is the first appearance of the red stripe on the seams of the blue-grey trousers; it is confined to those officers attached to the Sappers and Miners.

4. The *forage cap* appears officially for the first time; it was round with a flat top 12 inches in diameter, with a peak.

GENERAL ORDERS.

CORPS OF ROYAL ENGINEERS.

84 Pall Mall, 6th November, 1830.

The Master General having directed that the Uniform Coattee of the Officers of the Corps should be assimilated in shape with that of the Artillery and other alterations to be adopted in the Dress and Appointments agreeably to the following description, the Inspector General of Fortifications in publishing the same for the information of the Corps directs that the Dress and Appointments as now approved may be strictly adhered to in every particular. Commanding Engineers are held responsible that not the smallest deviation is adopted by the Officers under their command, and they are directed to transmit to the Inspector General of Fortifications Returns on the 1st of January and 1st of July in each year, shewing whether the Regulations are strictly complied with.

Coattee. Scarlet, double breasted, without lappels, the Buttons on the breast to be placed at equal distances, not less than two inches asunder; the width between the rows of buttons being 3 inches at top and 2½ inches at bottom. Collar and Cuffs of Garter Blue Velvet. The Collar, Cuffs, and back Skirts laced (as shewn by the annexed sketch, on which is also shewn the exact width of the Lace). Turnbacks of White Kerseymere with Skirt ornaments embroidered upon Blue Velvet.

Epaulettes. Gold, of the same pattern as the Infantry, two being worn by every Officer, and the distinction of Ranks to be in the progressive size of the Bullion and in the Devices. The stripe upon the strap of the Epaulettes of Captains and Subalterns to be of Garter Blue. The strap of the Epaulettes of Field Officers to be without stripes, but with the distinction of Devices as established for each Rank.

Hat. Cocked, with Bullion Tassels and gilt Scales.

Feather. White Hackle.

Cap. Bell shaped and lackered top, with Scales, Tassels and Plume of the Artillery pattern. To be worn instead of the Cocked Hat by all Officers attached to the Corps of Royal Sappers and Miners.

Sword. The Regulation Sabre for Infantry.

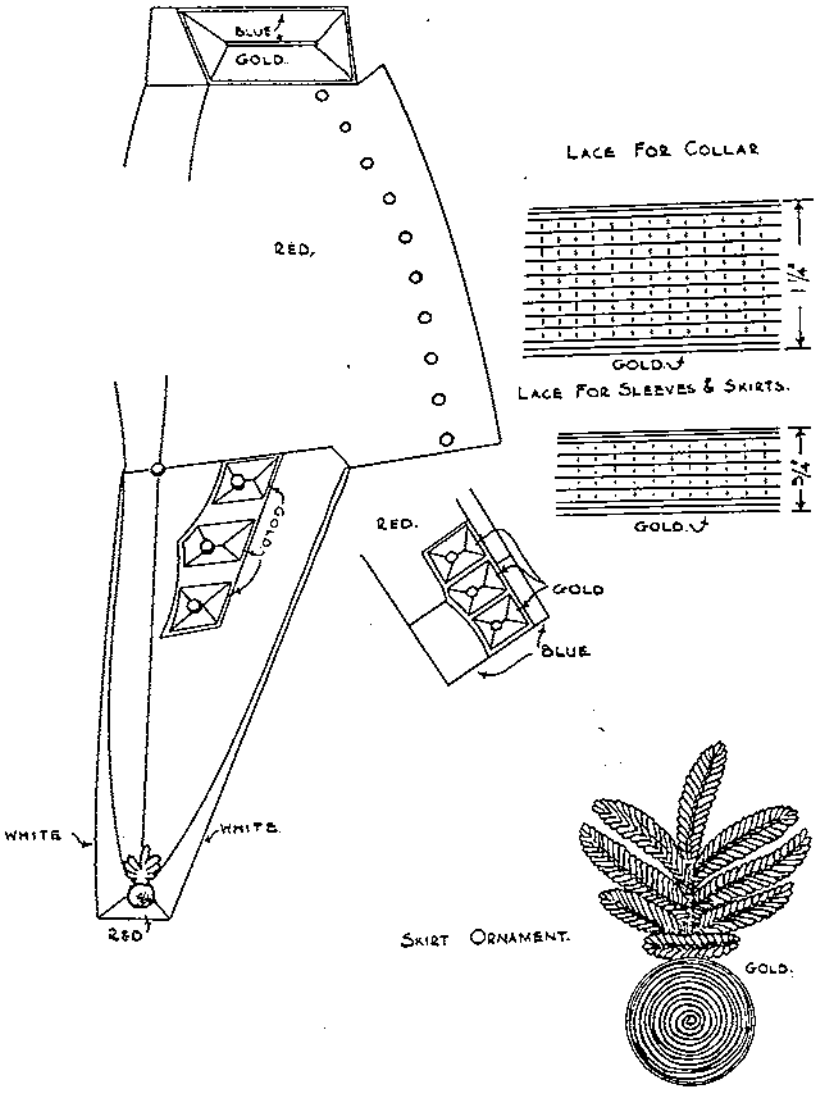
Scabbard. Black leather, with gilt mountings. When on mounted duty, Steel.

Sword Knot. Crimson and Gold strap with Bullion tassels.

Sword Waist Belt. White buffalo leather 2 inches wide, with the Corps Plate and Gilt rings for the slings. Black patent leather of the

same width, and Corps Plate, with slings, to be worn *over* the Blue Great (*i.e.*, Frock, see note below) Coat on and off duty, and *under* the Red Coattee off duty.

Sash. Crimson silk patent net.



Coattee, 1830.

Cravat. Black Silk.

Gloves. White leather.

Trowsers. *White Linen* or Duck for Reviews and Dress Parades or duties. *Dark grey cloth*, or Oxford mixture, with a red stripe 2 inches wide down each outer seam.

Great Coat. Blue cloth, single breasted, quite plain, with Prussian collar and Uniform Buttons.

Cloak. Blue cloth, lined with scarlet shalloon, gilt clasps and buttons.

Forage Cap. Blue cloth, laced round, with black leather peak.

The Blue Great Coat is to be worn upon the following duties viz. Drills, Working Parties, Inspections of Barracks, Regimental Courts Martial and Courts of Enquiry, and Committees, Orderly Duty, and in times of Peace upon the March. Upon these occasions the Sash will invariably be worn. When the Officer is not engaged in any Duty, the Great Coat must be worn with the black Waist Belt over it, and the sword, but without the sash.

The Red Coattee is to be worn on all Parades under arms, at Divine Service, on Guards and Pickets, Public Field Days, General Inspections, Funeral Parties, General, District and Garrison Courts Martial and Courts of Enquiry. Upon these occasions the *White* Sword Belt and Sash to be always worn.

The Red Coattee and Black Sword Belt *under* it to be worn invariably at the Mess and in the evening, without Sash.

Upon no occasion is an Officer to appear, whether in the Blue Great Coat or the Red Coattee, without his Sword.

These alterations are to take place immediately, allowing Officers who have recently provided themselves with a Uniform Coattee of the old pattern to wear the same for a period not exceeding six months from the date of the receipt of this order, but the other alterations are to take place forthwith.

Patterns of the Coattee may be seen at the office of the Inspector General of Fortifications, 84 Pall Mall, and will also be shewn to any person on producing a written application from an Officer of the Corps. The pattern Coattee may also be seen at Mr Thompson's, 12 Frith Street, Soho. The pattern Hat and Cap at Messrs Oliphant's Cockspur Street, and that of the Sword and Belt at Messrs. Hawkes and Co, Piccadilly.

By order of Major General Sir Alexander Bryce,
C. G. Ellicombe
Brigade Major.

Remarks.

1. *Coatee.* This is now double-breasted.

2. *Epaulettes.* These throughout the whole army are now worn on both shoulders by all officers, though the General Order for the Army was not issued till 18.5.1831. The royal cypher is added to the devices worn by the Colonels.

3. *Hat and Feather.* These have now reached their greatest height (see Plate 3, facing p. 193).

4. *Cap.* This was a most preposterous affair, as shown in the sketch. The device was the three guns from the Ordnance arms, worn on a star-shaped plate. In 1832, the R.A. and R.E. were granted

as their badge the royal arms and supporters, with a gun and the mottoes "*Ubique*" and "*Quo fas et gloria ducunt.*" This device then took the place of the three guns on the cap plate for the Royal Artillery, and presumably for the Royal Engineers also.

1830 Cap.

5. *Sword Waist Belt.* The black patent leather belt is new.

6. *Trousers.* All officers now wear the red stripes.

7. *Great Coat.* The instructions as to the wearing of the "Great Coat" are at first sight rather startling, but this coat is evidently the "Frock Coat" introduced into the infantry in 1831.

8. These orders contain the first reference to a dress to be worn "at the Mess."

Revised General Orders relative to the Uniform of the Corps of Royal Engineers dated 6th April, 1832, noting the alterations that have taken place to the present time, including those which have been ordered for the Officers of the Corps attached to the Royal Sappers and Miners.

84 Pall Mall,
18 May, 1835.

The Master General having approved of certain alterations in the Uniform and Horse Furniture established for the Corps of Royal Engineers, agreeably to the following description, the same is communicated for the information and guidance of the Corps.

Coattee. [The same as before.]

Epaulettes. The same as before, with the addition " and upon the straps of the Epaulettes of each Rank, a silver Grenade, the same as worn by the Artillery."

Hat. No change.

Feather. White swan, 8 inches from stock to stem, extreme length 13 inches from stock to end of feather.

Chaco. Bell shaped and lackered top, with scales; feather, white upright hackle, 10 inches long, with a gilt socket. To be worn instead of the cocked hat by all officers attached to the Corps of Rl Sappers and Miners: the Second Lieutenants on first joining will provide themselves with the Chaco and Feather.

Sword. The regulation sabre for Infantry.

Scabbard. For Field Officers, Brass; for all other ranks black leather with gilt mountings; when on mounted duty, steel.

Sword Knot. [No change.]

Sword Waist Belt. Russia leather, 1½ inch wide, with two stripes of gold embroidery. Carriages embroidered on one side only, with the Corps plate and gilt rings for slings.

Sash. Crimson silk patent net, to go twice round the waist, and to be tied on the left hip (mounted officers on the right hip), the pendent part to be uniformly one foot in length from the tie.

Cravat. Black silk.

Gloves. White leather.

Trowsers. *White Linen* or Duck for Reviews and Dress Parades or duties, from the 1st of May to the 14th of October. *Dark Grey Cloth* or Oxford Mixture, with a red stripe 2 inches wide down each outer seam from the 15th of October to the 30th of April.

Frock Coat. Blue cloth, single breasted, quite plain, with Prussian collar, and eight uniform buttons down the front and two small ones for the cuff.

Shoulder Strap. Blue Cloth with gilt crescent; regimental lace edged with scarlet cloth, solid silver grenade, gold lace binder, and brass tongue.

Cloak. Blue cloth, walking length, lined with crimson shalloon, gilt clasps and regimental buttons.

Spurs. For Field and Staff Officers yellow metal, with necks 2½ inches long including rowels.

Shell Jacket. Scarlet, with collar and round cuffs of garter blue velvet, without lace, and an edging down the front and round the bottom seams of garter blue velvet, a row of small regimental buttons (14 in number) down the front. Gold platted cord double twisted shoulder straps. This jacket is to be worn by Officers serving at the undermentioned stations. viz:—Ceylon, Mauritius, Cape of Good Hope, Gibraltar, Mediterranean, West Indies, Canada.

Dress for Levees, Drawing Rooms, and Evening.

Coattee, buttoned; Cocked Hat and Feather; if attached to the Rl Sappers and Miners, Chaco. Trowsers white from the 1st of May

to 14th October; Oxford Mixture with red stripes from the 15th October to the 30th April. Sash and sword waist belt over the coattee. Regulation sword and black leather scabbard with gilt mountings.

Horse Furniture for Mounted Officers.

Saddle Cloth. Dark blue of 2 feet 10 inches in length, and each flap one foot 10 inches in depth, with one row of gold lace five eighths of an inch wide, and scarlet cloth edging.

Bridle. Of black leather, bent branch bit with gilt bosses, and a cypher " W.R. " in the centre, and " Royal Engineers " round the W.R.; the front and roses of garter blue.

Collar. White.

Holsters. Covered with black bear skin, except in tropical climates, when they are to be covered with black leather.

Forage Cap. Blue cloth, the same pattern as ordered in November last for Officers attached to Rl Sappers and Miners.

The Blue Frock Coat made according to Regulation is to be worn with the sash and sword upon the following duties, viz.:—Drills, Working Parties, Inspections of Barracks, Regimental Courts Martial, and Courts of Enquiry, and Committees, Orderly Duty, and, in times of Peace, upon the March.

The Red Coattee is to be worn with the sash and sword on all general parades, Under Arms, at Divine Service, Public Field Days, General Inspections, Funeral Parties, General, District, and Garrison, Courts Martial.

Upon no occasion is an Officer to appear, whether in the Blue Frock Coat or the Red Coattee, without his sash and sword.

Patterns may be seen etc.....

By order of Major-General Sir F. W. Mulcaster.

C. G. Ellicombe,

Brigade Major.

Remarks.

Epaulettes. The grenade has now been placed on the epaulettes as well as on the skirts of the coatee. This happened in the R.A. in 1828 (Macdonald, page 77).

Scabbard. The brass scabbard for Field Officers had been introduced into the R.A. and infantry in 1833 and 1834 respectively.

Sword Waist Belt. This was the first appearance of the present pattern of full-dress belt for the Corps.

Frock Coat. The description of this coat, previously called the Great Coat, is now more detailed, and follows that of the general army pattern.

Spurs. These agree with the scabbard in colour.

Shell Jacket. This had been introduced into the army generally. It will be noted that it was to be worn on foreign service only.

REVISED GENERAL ORDERS.

Relative to the Uniform of the Corps of Royal Engineers, approved by the Master General, 27th September, 1845.

Coatee. [The same, except for the spelling, as in the orders of 1830; the collar, however, to be "*all round* of garter blue velvet."]

Epaulettes. [The same as before, with the addition: "and upon the straps of the Epaulettes of each Rank, an embroidered silver grenade."]

Hat. Cocked; staff pattern.

Feather. White swan, 4 inches from stock to stem; mushroom shaped.

Sword. The new Regulation pattern for Infantry.

Scabbard. For Field Officers, Brass; for all other Ranks, black leather, with gilt mountings; when on mounted duty, steel.

Sword Knot. Crimson, and gold strap, with bullion tassels.

Sword Waist Belt. Russia leather, 1½ inch wide, with two stripes of gold embroidery, 1/3 of an inch wide. Carriages embroidered on one side only. Gilt plate, with Corps device in silver, and gilt rings for slings.

Sash. Crimson silk, patent net, with cord ends and tassels, to go once round the body, and to be tied at the middle of the back, and to pass on the right side.

Stock. Black silk.

Gloves. White leather.

Trowsers. Dark cloth Oxford mixture, with a red stripe, 2 inches wide, down each outer seam for undress; and with stripe of gold lace, staff pattern, 1¾ inch wide, for dress. White Linen or Russia Drill Trowsers to be worn only in the Mediterranean or Tropical climates.

Frock Coat. Blue cloth, single-breasted, quite plain, with Prussian Collar, and eight uniform buttons down the front, and two small ones for the Cuff.

Shoulder Strap. Blue cloth, with gilt crescent, regimental lace, edged with scarlet cloth, solid silver grenade, gold lace binder, and brass tongue.

Forage Cap. Blue cloth, with scarlet piping round the crown, and with band of black lace, oak leaf pattern, 2¼ inches wide, with leather peak in front, and the Corps device, with gold grenade above it, in embroidery, in front. To be worn with oil-skin cover from 15th October to the 30th April.

Cloak. Blue cloth, walking length, lined with crimson shalloon, gilt clasps, and regimental buttons; Collar lined with red silk velvet.

Spurs. For Field and Staff Officers, yellow metal, with necks, 2½ long, including Rowels.

Shell Jacket. Blue. (Sir C. Smith's pattern.) Braid and Tags ¾ inch wide. To be worn in undress in the Colonies.

Dress for Levees, Drawing Rooms, and Evening.

Coatee, buttoned.
Cocked Hat and Feather.
Trowsers, Oxford mixture, with gold lace.
Sash and Sword Waist Belt, over the Coatee.
Regulation Sword and black leather Scabbard, with gilt mountings.

Horse Furniture, for Mounted Officers.

Saddle Cloth. Dark blue, of 2 feet 10 inches in length, and each flap 1 foot 10 inches in depth, with one row of gold lace, §ths of an inch wide, and scarlet cloth edging.

Bridle. Of black leather, bent branch bit, with gilt bosses, and a cypher V.R. in the centre, and " Royal Engineers " round the V.R. The front band and roses of garter blue.

Collar. White.

Holsters. Covered with black bear skin, except in Tropical climates, where they are to be covered with black leather.

The blue Frock Coat, made according to regulation, is to be worn with the Sash and Sword upon the following duties, viz.—Drills, Working Parties, Inspections of Barracks, Regimental Courts Martial, and Courts of Enquiry and Committees, Orderly Duty, and, in time of peace, on the March.

The Red Coatee is to be worn with the Sash and Sword on all General Parades, under Arms, at Divine Service, Public Field Days, General Inspections, Funeral Parties, General, District, and Garrison Courts Martial, and at Mess.

Upon no occasion is an Officer to appear, whether in the Blue Frock Coat, or the Red Coatee, without his Sash and Sword.

.....

By order of the Inspector General of Fortifications,
E. Matson,
Brigade Major.

Remarks.

1. *Feather.* This is now of the modern pattern, " mushroom shaped."

2. The cap or chako has disappeared, and officers paraded with the men in full dress wearing the cocked hat.

3. *Trousers.* The gold lace stripes are now mentioned for the first time; they had been ordered with blue cloth trousers for the R.A. Battalions for evening dress in 1827 (Macdonald, page 77).

4. *Frock Coat.* This is still very plain, but by 1851 had become frogged. This date is fixed by the following letter:—

" Horse Guards,
17 April, 1851.

Sir,

I have the honour by the direction of the Commander-in-Chief to acknowledge the receipt of your letter of the 15th instant (with its

enclosures) relative to the Frock Coat worn in undress by the officers of the Royal Engineers doing duty in the garrison at Chatham, which is stated to be similar to that worn by officers of the Foot Guards, and to intimate to you in reply that, although it is certainly unusual thus to adopt the dress of other Corps, yet, as the innovation has been made with the sanction of the Master General of the Ordnance, it is not His Grace's intention to interfere with, or to issue any orders on the subject.

I have etc.,

G. Brown,

A.G.

The Commandant
at Chatham. (P.R.O. W.O.3/315, page 85.)"

5. *Shell Jacket.* This is now blue. Later the jacket was frogged and became the "Burgoyne Mess Jacket," a specimen of which is in the R.E. Museum.

6. These orders lay down the dress which was worn by the officers of the Corps in the Crimean War of 1854-56.

(To be continued.)

COLONIAL SURVEYS AND THE CORPS.

A Lecture delivered at the School of Military Engineering, Chatham, on 13th October, 1932, by BRIGADIER H. ST. J. L. WINTERBOTHAM, C.M.G., D.S.O.

I AM going to describe to you a way of life rather than to point a moral or attempt to impart disguised instruction. It will be as well, however, to point out why I am going to describe this way of life and to give its bearing upon the general duties in peace and in war of the Corps to which we belong.

It is difficult in these specialized days to remember how extraordinarily diverse are the problems with which we, as Royal Engineers, are so frequently confronted. Throughout our history we have been for ever inventing some new thing. As a Corps, in fact, we propagate ourselves in the way of those primitive organisms which break into independent bodies, each animated with its own life. There still remains, however, an enormous field for the average R.E. officer to cover, and in this matter we are, of course, essentially different from our civil brothers who, in general, can call in this or that expert to provide specialized knowledge.

Now survey is one of those matters which in the course of time has lost importance in ordinary civil engineering. England is so well mapped as to call for little original work. The instruction given at many, if not all, of our Universities concerns that style of chain, vernier-theodolite and dumpy level survey, which was prosecuted with such vigour by our grandfathers. That sort of attitude will not, of course, do for the Corps. At a moment's notice the Royal Engineer officer may have to survey or level (sometimes with much precision) as the first item in preparing for his subsequent construction. Colonel By, who made the canal from the Great Lakes to the Ottawa River, no doubt had to make the survey and run the levels for it. The Engineers who built the Government House and Cathedral at Singapore no doubt surveyed the sites as a preliminary. The Sappers who made the desert railway in Egypt ; or constructed the line from Baro to Kano ; or made the roads of the Gold Coast, did their own survey. The officers of a fortress company surveyed (astronomically) the boundary between British Columbia and the U.S.A. Of recent years, however, there has been a tendency even in the Corps to suggest that these necessary engineering surveys are the province of specialists, and it is not so very long ago since we had

to send out specialized surveyors to a foreign station for work which should have been perfectly simple to any one of us. Consider the position if the O.C. of a Field Company could not survey, in war, the roads, railways, or deviations he had to construct.

Now I need hardly remind you that many of the most distinguished members of the Corps have at one time or another done a spell of pure survey work. Lord Kitchener, for example, mapped Cyprus. Many an R.E. officer has been offered, and accepted with joy, the post of a Boundary Commissioner, or the command of a topographical survey without ever having done more than an initial course at Chatham. You will see, I hope, from the above, I am talking to you about something with which you may be actually confronted either in peace or war, and it may, therefore, be of interest to see the conditions which you may meet with, the people whom you may have to employ, and the sort of tasks which are implied.

There is, as you know, a further stage. There are developments of survey which the general engineer can hardly be expected to master. When we begin to play with such words as geodesy, isostasy, gravitation, density and so on, all those words, in fact, which we employ to add a fictitious importance to our knowledge, we begin to recognize the work of the specialist. Now some specialists we must have in the Corps. No body of engineering experience is complete without a few such, and the justification for those specialists lies, of course, in our war tasks. A word about them.

In the times of the Crimea the Army was not supposed to require any particular study of the country. Reconnaissance was a personal matter. Instead of directing fire upon a target thirty or forty miles out of sight, one fired at the eyeball. It came, then, just before the Crimean War, as a severe shock to the authorities to be offered a good map of the Crimea by an R.E. officer who had happened to get hold of copies of the Russian Staff map. He was informed that if any officer of the British Army desired such a thing he would no doubt purchase it, but that it was impossible to consider the issue of such maps at the Government expense. The officer in question accepted the challenge, had his maps reproduced, and sold them. The maps were, of course, indispensable, and had to be purchased, and the officer in question afterwards became Chief of the Geographical Section of the General Staff.

In India the Frontier affairs of the last 50 years have been very ably illustrated and helped by that admirable institution the Survey of India, but we at home were not at the same pitch, and when it came to the South African War most of us used a map at the scale of 1/5M, or thereabouts, called "Boer or Briton," and printed by an enterprising daily journal. This, however, was not all we were given, for "Intelligence" reproduced a multitude of sketches of individual farms where fighting was likely. On those farm sketches

some surveyors had shown contours at about 10-feet intervals, others had shown vague form lines at, perhaps, 100-feet intervals, and others none at all. The result was pure fantasy, and when, as generally occurred, a " dust devil " carried them off we were uncommon pleased to be lightened of so valueless a burden. The situation was soon amended, however, when Close, Casgrain and others were put on to survey work. After the South African War staff rides and courses were without number, and the British Army really settled down to work. The topographical instruction at Woolwich and Sandhurst was admirable and far more detailed than it is to-day. Generally speaking the Old Contemptible was a thoroughly good map reader with a well-trained eye for country. Adequate preparation was made before mobilization by copying all the relevant maps for France and Belgium, and the expeditionary force left with each man carrying a bundle of the appropriate maps. No Survey Units were sent out at first, but as soon as conditions stabilized we started to survey, and presently our maps were, if not ideal, at any rate the best that could be made in the time.

Now for years past the Ordnance Survey had been in the habit of surveying the sites of coast defence batteries and giving the co-ordinates of gun and datum points. We were simply continuing that principle in the introduction of what are now called " Survey methods of gunnery." The survey of the gun is comparatively easy, of course. The survey of the target—a trench, an enemy gun, or a cross-road—followed from air photographs, from flash spotting and sound ranging. We developed from four field surveyors to more than as many thousands. As we got more and more entangled in matters which lie at the root of accurate gunnery, so did it become more and more obvious that those surveys which can be thought of as domestic to the Regiment must pass into their hands. We have, at all events temporarily, washed our hands of the survey of guns, our own or the enemies'. We retain the foundations of them, however, in the triangulation and mapping upon which all domestic artillery surveys must rest. The tactical importance of this subject is immense. It has been the theme of countless exercises. It is one of the decisive factors as to who gets in the first blow. We have to find, then, on service, directorates and field survey units and we must have, for them, surveyors of experience. Where is that experience gained? In the boundary commissions and topographical surveys of the Empire. The War Office gets, in fact, the best of training at the expense of civil departments. The Ordnance Survey, the Survey of India, the Boundary Commission and the Colonial Topographical Survey have all in the past been paid for by others. Will Boundary Commissions and Colonial Topographical Surveys continue to be at our disposal? It seems doubtful, but some opportunities there certainly will be, and I will now

describe some of the circumstances characteristic of such work in the past.

Let us try and picture what will probably pass through the mind of the lucky individual who has gladly accepted his appointment as a Boundary Commissioner, and let us follow him rapidly as he makes his preparations, travels to the scene of his labours and makes a start on the job. The senior Commissioner will probably be the first to receive his appointment, and the first thing he should consider is the composition of his party. If conditions permit he should be allowed to have some say in the choice of his subordinates. A small party which is going to work together, probably in a tropical climate and at times under somewhat trying conditions, should be a well-balanced happy family from the start. It must, therefore, be tactfully selected with a view not only to technical ability but bearing in mind also the importance of personality, cheerfulness and the ability to make good under all conditions and with all sorts of people.

It is more than probable that the boundary to be demarcated will be one between a British Colony and a Colonial possession of one or other of the European powers. In that case the senior Commissioner would, of course, pay a visit to the Colonial Office and make his bow to the responsible officer who deals with the Colony in question, and with whom he will have much subsequent dealing. The establishment of a personal and friendly atmosphere with him and also with the financial department of the Colonial Office will save a lot of subsequent bother and possible misunderstanding.

It may be that the Boundary Commission does not concern one of our own Colonies but is international in character, in which case it would probably come under the Foreign Office, but the same necessity arises for the establishment of personal touch between the Commissioner and the officials in Whitehall.

The Geographical Section of the War Office would almost certainly draw up technical and administrative instructions for the guidance of the Commissioner,* and one of the first points that will arise is the question of pay and conditions of service for the various grades of officers and N.C.O's appointed to the Commission. It is essential that all points of possible doubt in this respect should be settled and thoroughly understood by all ranks before leaving England, as it is sometimes difficult to establish what you consider to be righteous claims when you are sweating in a tent near the Zambesi and the official who receives your growl is comfortably seated in Whitehall.

Another and more important personal touch remains to be considered, namely, to make the acquaintance of your opposite number,

* He should study first of all an article and bibliography on "The Demarkation of International Boundaries," to be found in *Empire Conference of Survey Officers*, 1928, Report of Proceedings, H.M.S.O., Col. No. 41.

if possible before embarking for the theatre of operations. This will probably entail a visit to one or other of the European capitals, where you will find that the hospitality offered to you will come up to all your expectations. When you meet again on the boundary you are certain to find many occasions on which you will have different points of view, and a friendly *entente* is the first essential to a satisfactory solution to your differences.

The time allowed to you for making your preparations may be a few weeks or possibly only a few days, and you will find that there is a great deal to be done. If you have never before taken part in colonial survey work you must seek experienced advice as to what clothing to take and details regarding camp equipment, sporting guns and rifles, food supplies and many other important subjects.

Much valuable experience has by now been stored up at M.I.4, War Office, by officers who have been employed on similar work in the past, and a study of their various reports will give you much valuable knowledge. In addition you will find the officials at the Colonial Office and at the Crown Agents only too willing to give you full details as to the conditions of living, climate, health, sport, etc., in the country in which you will have to work.

Basing your requirements on the technical instructions drawn up by the Geographical Section, you will have to make complete arrangements for the collection of instruments and stores which you will want for survey work, and possibly also food supplies, if you are going to a locality where you will not be able to purchase locally.

As soon as the approximate date of your departure has been laid down, you will then complete your arrangements for steamer passages and it will be necessary to get into touch with the administration of the colony to which you are going and inform them of the date of your arrival. They will then be able to do many things which will make your lot easier when you disembark.

One thing not to be overlooked is to ask for a concession in respect of customs duties for your stores and provisions.

In all probability you will require an escort, which will be provided by the local native troops or police, and it would normally be part of the duty of the officer in charge of this escort as soon as he knows where you propose to commence work to go there and prepare a camp site, so that on arrival you may commence work without delay. The provision of local labour, *e.g.*, carriers, native servants, etc., is also a matter which must be arranged for beforehand with the local administration, so that all can be ready when you arrive.

We will imagine, then, that you have safely transported your personnel, instruments and stores and disembarked at some convenient port. The port authorities, who have been warned beforehand, will have made things easy for you, and you find yourselves settling down perhaps for one, two or more days' train journey up

country. At some suitable point on the railway you will detrain, check up your possessions in men and stores, and then proceed either by motor transport, camels or on foot to the point on the boundary where, by previous arrangement with your opposite number, you have agreed to meet and commence work on a certain date.

Here comes an interlude. On the way up you will detrain somewhere and make your bow to His Excellency the Governor, the Colonial Secretary, the Treasurer, and last, but not least, the Director of Surveys. With all these you will have much to do, and if Corps experience is a criterion you will find them as charming and helpful as a man could wish.

While the junior officers and N.C.O's are busy unpacking stores, testing and adjusting instruments and getting everything ready to commence work, the senior Commissioners will probably confer together and draw up a detailed plan of campaign, based on the general plan which they should have discussed previous to leaving Europe.

There is no time here to discuss in detail the various technical operations which may have to be carried out, but in all Boundary Commissions the four following essentials will hold good :—

(1) To mark the boundary clearly on the ground by a series of boundary pillars.

(2) To determine and fix the positions of these pillars by survey methods in such a manner that they can be replaced at any subsequent date if they are destroyed or removed.

(3) To prepare a topographical map or cadastral plans or both, to illustrate the results of such a survey ; and

(4) To draw up the various agreements, reports and detailed survey results for signature by the Commissioners of both parties and for subsequent ratification by the interested Governments.

In any survey operation the first essential will be the establishment of a trig. control. If the colony already possesses a trig. framework within reasonable distance of the boundary and of sufficient reliability, the boundary triangulation would normally commence from one of the sides of such a framework. If no such framework exists then it will be necessary to measure a base (and this must be good and precise these days), take astronomical observations for latitude and longitude and azimuth, and a chain of triangles will then be run from this base and carried along the boundary.

It is usual for boundary pillars to be classified under two heads, namely, main pillars, which may be anything up to five miles apart,

and intermediate pillars at intervals of 500 to 1,000 yards, filling up the gaps between the main pillars.

You will probably then break down your triangulation in order to tie the main boundary pillars into the framework, thus fixing their positions in terms of geographical co-ordinates. You would then probably run a traverse all along the boundary from main pillar to main pillar, thus fixing the positions of the intermediate pillars with reference to the main pillar. It is customary to arrange for topographical detail to be surveyed to a limited depth on either side of the boundary-line. This will probably be done by plane-tabling, or possibly, if conditions are favourable, by air survey methods. If the latter is to be adopted then arrangements would, of course, have been made beforehand for an R.A.F. unit to be attached to the Commission for photographic duties.

Such, briefly, is a *résumé* of what you may expect to happen on a typical boundary commission such as that between two African Colonies. Every day will bring its own problems, and it is one of the chief joys of this class of work to surmount the difficulties as they arise and to make bricks without straw.

It is safe to say that it would be hard to find any officer who has taken part in such work who would not jump at the opportunity of repeating it if the opportunity arose. It is work which takes one to the out-of-the-way corners of the earth where your mind is broadened; where you escape from the horrible ties of over-civilization, and where you experience a freedom and opportunities for sport which many rich men pay thousands of pounds to taste.

Boundary Commissions are, perhaps, the most spectacular of our Colonial Survey tasks, but they are by no means the only ones. Of equal importance, perhaps, are those occasional geodetic surveys in which the Corps has taken so active a part. There is a case of that sort at the present moment. The 30th Meridional Arc of Triangulation is perhaps the most important possible arc in the world. It stretches from Hammerfest to Cape Town, or will do so when it is complete, and that considerable part of it which lies south of the equator is the longest continuous arc in the Southern Hemisphere which we shall be able to measure. All sorts of interesting scientific subjects are connected with the measurement of a very long length like this upon the earth's surface, and all sorts of valuable economic advantages result from its measurement. When it is done it will be the backbone, the controlling measure of all the surveys of south-east and north-east Africa. Its southern extremity in the Union of South Africa was conceived by Sir David Gill, a man of very great foresight and energy, but the practical work connected with it fell to the lot of the Corps. A little fragment, unconnected as yet to the main part, was measured in Uganda by Brigadier (then Captain) Jack, and at the present time the South African portion and Brigadier

Jack's portion are being connected by Captain Hotine and Lieutenant Urquhart. The northern portion of this arc, *i.e.*, that portion which is supplied by the triangulation of Egypt, was organized by another Sapper, now Sir Henry Lyons. Work of this very precise character may be regarded as the work of an expert rather than a general practitioner engineer, and yet the subaltern now engaged in this party had no previous acquaintance with survey matters, and is, as a matter of fact, doing uncommonly well.

Now we come to another large class of survey, namely, the topographical survey, which makes the first map of one or another portion of that immense Empire of ours. The preliminary stages of a topographical survey are stages of arrangement at home and abroad, and are very similar to those of a Boundary Commission. One must arrange one's staff, and buy one's instruments. One must make the acquaintance of the Colonial Office officials concerned, and on arrival in the country one must make one's bow to the Governor, the Colonial Secretary, and the Director of Surveys, who may, or may not, have the final direction of the work.

From that time on the life is a perfect joy. Instructions from home come so rarely as to be almost welcome instead of a nuisance. The problems are wholly connected with the work, and the staff required for that work. There is triangulation to do on which the map will rest, and there is the direction of the plane tabling, or other survey method, which fills in the detail. The final objective may be a 1/20,000 survey like that in Johore, a one-inch map as recently prepared in Sierra Leone, or half-inch map as was the case in the Orange Free State, town surveys at a large scale as have recently been done in the Gold Coast, or triangulation and traversing such as we have taken considerable part in recently in both Nigeria and the Gold Coast.

All the surveys I have described may seem to lead the young Sapper a long way from his real task of military engineering, yet it is not so. If, technically, he has for the moment been mastering a special branch, he will find that special branch immensely useful to him in any of the work that he subsequently does. Above and beyond all that he will have had that valuable lesson, so difficult to come by in the Service, of managing his own finance without much let or hindrance from others, and of learning how to employ a definite sum in order to achieve a definite end. He has, in order to effect the utmost, to gamble on his own judgment and to prove his own capacity.

TEMPORARY ROADS DEPARTMENT—IV.

ESTIMATING; DRAFTING AND LETTING OF CONTRACTS; MAINTENANCE.

By "ROADSURVEY."

WHATEVER work a Sapper may be doing, he will inevitably find himself sooner or later surrounded by Tables of Time, Men and Tools, Schedules of Prices, etc., as he struggles to produce an estimate for the work in hand. Furthermore, although an estimate is, by definition, "a valuing in the mind" or "a rough calculation," he will very soon find that his estimates are expected to be extremely accurate.

When the T.R.D. was first required to produce estimates for the construction of the roads which they had surveyed, several specimen estimates were handed over as guides. Although some of these were good, others were definitely a "valuing in the mind," the body containing the "mind" having apparently done its "valuing" at some considerable distance from the site of the work!

It was obvious from the outset that no really accurate estimate could be produced before the completion of the survey. But it was equally obvious that no government was prepared to spend possibly £5,000 on a survey, only to find that the cost of the road was beyond their means. Furthermore, there was generally a long delay between the beginning of the survey and the submission of the estimate, as many of the surveys took a year or more to complete.

To overcome these difficulties, the T.R.D. undertook to produce two forms of estimate:—

(i) The Preliminary Estimate, prior to the survey, with an accuracy within about 15%.
(ii) The Calculated Estimate, subsequent to the survey, with a maximum error of 5%.

It would be as well at this point to warn those readers of *The R.E. Journal* who find it difficult to tolerate or understand those tricky little everyday Sapper problems dealing with twice-times-twice-times-filleted-and-fried @ 1¼d., that they would be well advised to have nothing to do with the following spate of facts, figures and fiction.

THE PRELIMINARY ESTIMATE.

By the time that the first Preliminary Estimate was required, the T.R.D. had sufficient experience to be able to assess the value of such topographical maps as were available. Hilly formations or " blocked in " portions of the maps were often shown in the outline of " dying ducks " or " elephants rampant," but we had now ceased to expect that we should find formations of this description on the ground. It was, therefore, decided that the Preliminary Estimate must be based on a study of the map, checked by a reconnaissance on the ground, and that the wretched subaltern blundering about in the bush doing the reconnaissance should be made responsible for this portion of the work.

It was found easiest to divide the estimate up under two broad headings, (i) Bridges and Ferries, and (ii) Earthworks.

For ferries a flat rate of £1,000 each was accurate enough, since the pontoons, anchorages, hauling equipment and approaches were roughly standard for all sizes of rivers, and the ultimate cost varied only according to the distance that the stores had to be transported from railhead. Ferries were easy!

Bridges were not quite so easy. A tentative suggestion for the span was made from a study of the catchment area as shown on the map, making due allowance for any of the aforementioned " dying ducks " and " elephants rampant " which might appear on the topo. sheet. To assist in this decision a table was made showing the approximate catchment areas for various spans. This table was of great use, and is given in Appendix I. Discretion is advised in using it, since it is applicable only to country similar to the bush country of the Gold Coast, where, although the annual rainfall is 50–90 inches, the soak-away and evaporation are very high. A light-hearted attempt to apply this table to the open country of the Northern Territories had regrettable results on a treble 20-ft. span masonry bridge.

The span of bridge selected from the table had to be checked by reconnaissance of the actual river in flood, but once the span had been decided, the actual cost could be computed from the table of yardages and costs given in Appendix I.

It is important to note that the " cost of work " figures do not include transport, which must be allowed for, especially if the site is far from railhead. For instance, a 400-lb. drum of cement cost 12s. 6d. at the Port of Takoradi, but when delivered at the site 500 miles up-country cost 70s. A trifle like this is apt to upset any estimate for bridges.

These two tables, together with extracts from another, later referred to as a " Cut-and-Fill " Table, are the only ones that will be given. This problem of estimating produced an absolute flood of

tables, some of which were considered " good things," whilst others, although they had their good points, were not used in connection with roads or their survey or construction. One in particular, about a yard square, known in the department as the " baby's bottle," on account of the peculiar shape of the columns of figures, purported to show at a glance the economic cut in all sidelong slopes, together with the yardage of cut-and-fill required. Its use never became general because few officers, beyond its author, who took six months to produce it, understood its simple working. It was, however, on account of its canvas backing, much used for facing targets on the rifle range which we later constructed for our own use at Tarkwa, and so entered the category of " good things."

Earthworks. Under this heading was included all the work other than bridges and ferries. This part depended almost entirely on experience, which was unfortunate but inevitable. The officer making the survey reconnaissance made notes of the country traversed and the estimate was arrived at by taking a figure of so much per mile based on previous construction figures for similar country. This sounds a very rough-and-ready method, but it produced results the accuracy of which often surprised even the officer responsible for the estimate.

Two items were liable to cause a hiatus in this part of the estimate —rock or laterite. (For the benefit of the simple, laterite is an " argillaceous sandstone of a reddish or brick colour ! ") Rock was usually shown in the form of outcrops and could be allowed for, but laterite was not so easy to detect, and when time allowed, test holes were sunk for about six feet in depth at intervals along the route where its presence was suspected.

The Calculated Estimate.

This estimate, with its 5% maximum allowable error, was a sterner problem, but fortunately the information on the plans and profiles was very accurate. This type of estimate is put forward in all its gruesome details because it is considered that when all the nations have paid their debts and sacked their armies, Sappers may again be employed on the survey and construction of roads in the Colonies.

The estimate was divided into the following sub-heads :—

(*a*) Earthworks.
(*b*) Grubbing and side-drains.
(*c*) Bush clearing and tree felling.
(*d*) Gravelling.
(*e*) Concrete.
(*f*) Cement.
(*g*) Transport.

The figuring of the computations under each head was tabulated in an *Estimate Book*, a specimen page of which is shown on page 221. The following are the details of the various columns :—

Column I. Shows the number of the Chain Peg.

Column II. Shows the ground level at that Chain Peg, and is obtained from the *Location Level Book* or profile.

Column III. Shows the level of the grade line, taken from the profile.

Columns IV and V. Show the cut or fill required, which is taken either from the profile or by subtraction from Columns II and III.

Columns VI and VII. Show the yardage of cut or fill required over the preceding chain (*e.g.*, the figure opposite 1426 shows the yardage of work, in this case cut, required between chains 1425 and 1426).

Column VIII. Shows the cost of grubbing the road and digging side-drains over the previous chain.

Column IX. Shows the cost of bush clearing and tree felling required over previous chain.

Column X. Shows the cost of gravelling over the previous chain.

Columns I to V need no further explanation. Columns VI and VII are arrived at by the aid of the " Cut-and-Fill " Tables, extracts from which are shown in Appendix II.

The amount of work to be done on a road was always taken from dimensions along the centre line. " Cut-and-fill " tables were designed to give the yardage of work required (at every 0·1 feet difference in level) for all heights of fill and depth of cut normally used. Provided that the ruling dimensions of the road are the same as those of the T.R.D., such tables would be a great boon to an officer faced with the task of working out the yardage of, say, 40 to 100 miles of road. They can be used anywhere, since a cubic yard in Malay or elsewhere is probably much the same thing as a cubic yard on the Gold Coast !

The use of these tables involves some very elementary mathematics and is best explained by concrete examples taken from the specimen page of the *Estimate Book*.

Example I. To find the amount of banking required between chains 1439–1440 on specimen estimate page.

Fill per chain of 2·1′ banking from Fill Table = 211 c.y.
Fill per chain of 3·0′ banking from Fill Table = 316 c.y.

Total .. 527 c.y.

The actual banking chain 1439–1440 = $\frac{1}{2}$ × 527 c.y.
= 264 c.y.

SPECIMEN PAGE OF ESTIMATE BOOK.

From Wiawso to Krokosua. Section Chain 1421 to Chain 1630.

Chainage Chain. I.	*Level Ground.* II.	*Formation.* III.	*Feet.* Cut. IV.	*Feet.* Fill. V.	*Cu. Yds.* Cut. VI.	*Cu. Yds.* Fill. VII.	*G.R. and S. Drains* £ s. d. VIII.	*Bush Clear Tree flg.* M. S. £. IX.	*Gravelling.* X.
1421	687·8	—	—	—	—	—	1 7 6	Chains 1421–1435 at 15s. per chain, *i.e.*, 15 chains at 15s. = £11 5s.	Chains 1421–1435 at 30s. per chain, *i.e.*, 15 chains at 30s. = £22 10s.
1422	92·5	—	—	—	—	—	1 7 6		
1423	97·7	—	—	—	—	—	1 7 6		
1424	703·4	—	—	—	—	—	1 7 6		
1425	11·6	710·0	1·6	—	75	—	0 15 0		
1426	20·4	17·0	3·4	—	234	—	0 15 0		
1427	28·9	22·0	6·9	—	487	—	0 15 0		
1428	35·5	25·0	10·5	—	835	—	0 15 0		
1429	38·5	26·0	12·5	—	1114	—	0 15 0		
1430	29·5	27·0	2·5	—	725	—	0 15 0		
1431	22·6	28·0	—	4·5	42+	164+	0 7 6		
1432	26·3	29·0	—	2·7	—	396+			
1433	29·1	30·0	—	0·9	—	182+			
1434	29·1	33·0	—	3·3	—	219			
1435	38·1	—	—	—	—	177			
1436	40·9	—	—	—	—	—	1 7 6	Chains 1436–1450 at 25s. per chain, *i.e.*, 15 chains at 25s. = £18 15s.	Chains 1436–1450 at 35s. per chain, *i.e.*, 15 chains at 35s. = £26 5s.
1437	40·5	—	—	—	—	—	1 7 6		
1438	38·5	39·0	—	0·5	—	23			
1439	34·9	37·0	—	2·1	—	128			
1440	32·3	35·3	—	3·0	—	264			
1441	37·6	33·5	4·1	—	111+	67	0 7 6		
1442	34·1	32·0	2·1	—	291+	—	0 15 0		
1443	27·1	30·0	—	2·9	42+	87	0 7 6		
1444	23·6	28·0	—	4·4	—	401			
1445	27·7	26·5	1·2	—	12+	196	0 7 6		
1446	28·0	25·0	3·0	—	196+	—	0 15 0		
1447	24·6	23·0	1·6	—	215+	—	0 15 0		
1448	22·7	21·0	1·7	—	154+	—	0 15 0		
1449	18·3	—	—	—	79	—	0 15 0		
1450	13·6	—	—	—	—	—	1 7 6		
	Totals—Cut 3549. C. to F. 1805. Fill 1562.						£19 7 6	£30 0 0	£48 15 0

This may be accepted with credulity or not, but in either case the figure 264 should be entered in Column VII opposite 1440.

Example II. To find the cut between chains 1428–1429.

Excavation per 100 f.r. of 10·5′ cut	From Cut Table	= 1013
Excavation per 100 f.r. of 12·5′ cut	From Cut Table	= 1215
	Total	= 2228

As before, the actual yardage of work over this chain = $\frac{1}{2} \times 2228$ = 1114 c.y., and this figure should be entered in Column VI opposite 1429.

Example III. This takes into account the slightly more involved case where the work inside one chain is partly cut and partly fill, as in the case of chain 1430–1431.

Excavation per 100 f.r. of 2·5′ cut From Cut Table = 234

The actual excavation required

$$= \frac{2{\cdot}5}{2{\cdot}5+4{\cdot}5} \times \tfrac{1}{2} \times 234 = 42 \text{ c.y.}$$

Fill required per 100 f.r. of 4·5′ bank From Fill Table = 512 c.y.
Actual fill required

$$= \frac{4{\cdot}5}{2{\cdot}5 + 4{\cdot}5} \times \tfrac{1}{2} \times 512 \text{ c.y.} = 164 \text{ c.y.}$$

These figures may strain the credulity even further, but still, nevertheless, the figure 42 should be entered in Column VI and 164 in Column VII opposite 1431.

Where there is a change from fill to cut on a line, the contractor will always use the spoil from the cut to make his bank, and so save himself time and money. This form of work is known as "Cut to Fill," and is estimated at less cost than either cut or fill. How far a contractor will carry his cut to fill varies with conditions, but in estimating, a maximum carry may be taken as three chains. Thus the cut of 37 c.y. at chain 1431 can be used to form part of the bank of 219 c.y. at chain 1434. Similarly, parts of the cuts at chains 1428, 1429 and 1430 will go to form the fills at chains 1431, 1432 and 1433. The drill, therefore, is to "star" chains 1431, 1432 and 1433 to denote "cut to fill," or "fill from cut."

The figures in Columns VI and VII are then added up, with the exception of the items "starred" as "cut to fill," which are totalled separately. The rates paid on the Gold Coast were 1s. 3d. per c.y. of either cut or fill and 3d. per c.y. for "cut to fill." These yardage figures are then abstracted to an abstract page shown later.

The cost of grubbing and side-drains is given in Column VIII. Grubbing consists of removing all roots, etc., from the surface of the

ground when the road is in formation (*i.e.*, no cut—no fill) or on banking less than 12 inches high. Reference to Column V, therefore, decides whether grubbing (at 12s. 6d. per chain) should be allowed for.

It is most important that this grubbing of roots and tree-trunks should be properly carried out, for otherwise the trunks will gradually rot away and large holes will appear in the road. This rooting of trees not infrequently involved digging and cutting a hole six feet deep and 12 feet across—a tedious and expensive business in bush country. Several contractors showed signs of being desirous of " economizing " on this item. In one instance, an officer inspecting some construction work was pleased to see how thoroughly the grubbing and rooting was being carried out. There was the usual hideous mess of holes indicating the places from which the roots had been removed, and beside each hole was the pile of spoil taken from it. He complimented the contractor on his work—the sun shone—life was good—and the officer, in an excess of *joie de vivre*, playfully kicked the nearest pile of spoil. With a yell of agony he commenced to hop round on one foot. All the largest roots had been left intact and covered over with earth dug from the hole beside them !

The best people always construct drains where the road is in cut or in formation ; in the case of sidelong slopes drains are necessary on the uphill side only. Column IV, in conjunction with the plan, decides whether drains should be estimated for or not (cost 15s. per chain).

Bush clearing and tree felling is costed in Column IX, and it was ultimately found that for this purpose bush should be classified and paid at so much per chain.

The classifications were :—

A—Cocoa Farms.
B—Light Bush.
C—Medium Bush.
D—Thick Bush.

This information can be found in the *Location Chain Book*. This was booked by the head chain man, with frequent checks from the Surveyor, because a native chainman's flights of fancy in this respect are phenomenal.

Gravelling in Column X was estimated at 30s. per chain where gravel was available within four chains of the location, but when the survey disclosed that gravel was not available close to the line the price rose, in proportion to the carry required, to as much as 80s. per chain.

Columns VI–X are all totalled and abstracted to another page as shown on p. 234. This abstract page is largely self-explanatory.

is obvious that the price of culverts of the same span varies according to the foundations and more still according to their length, which, in turn, is governed by the height of the banking over them. Average prices were, therefore, tabulated with bridge costs, and are given in Appendix I, as further "good things" to assist in estimating.

The final estimate is arrived at by the summation of this mess of figures together with an addition of 10% for unforeseen troubles.

The unforeseen trouble usually takes the form of rock or laterite in cuts, and bad bridge foundations.

Estimating in this form is a very dreary job, but it was found possible to leave the worst portion, that is, the cut-and-fill columns, to be done by specially-trained natives who are quite capable of functioning with the "cut-and-fill" tables. The remainder was always done by an officer.

DRAFTING OF CONTRACTS AND SPECIFICATIONS.

When the estimate had been approved by the Government, the T.R.D. were confronted with the problem of how to draft some form of contract which would enable the department to get the construction work done. Enquiries were made of other departments as to how they drafted contracts. They were rather vague as to how they drafted them, but were quite ready to show us copies! Unfortunately these copies were mostly inapplicable to our work, although they showed us that a contract was definitely a legal document, and should consist of two parts—(1) The Contract, and (2) the Specification. This was something learnt.

The party, therefore, began to take stock of its knowledge of law, and it was a severe shock to discover that this was limited to (a) The Powers of a C.O., and (b) How to deal with Private Bugle on the occasion of his first, second, third, fourth, and all subsequent "drunks."

It appeared to be very difficult to decide what items should be included in the Contract and what items should be put into the Specification. After considerable discussion it was decided that the main object of the Contract should be to *ensure the completion of the work*, and that the Specification should *fix the standard to be attained, and give necessary details of the work to be done.* (As the Specification must differ for each particular job, and as it is not considered desirable or necessary to give here further details of the actual methods of construction, we shall confine ourselves to a few remarks on the drawing-up of the Contract.)

THE CONTRACT.

After the above momentous decision had been arrived at, it was unanimously decided that the first item to be inserted in the contract

should be the names and description (not physical) of the contracting parties, and the date of signature.

In natural sequence to this it seemed vital to put down what the parties were contracting about, so the liabilities of each party were next stated. In the case of the contractor this described in *general terms* the work to be done, including all large items meriting special mention, such as bridges and ferries. The contractor was also made liable for the production of all labour and stores and for their transport and efficient storage.

The liabilities of the Government were not usually very involved, and consisted mainly of paying the agreed sum, and producing certain special stores.

At this point it seemed that colossal progress had been made, until someone pointed out that we had not really ensured the completion of the work at all, as the contractor was still at liberty to take fifty years over the work if he wished.

A time limit was, therefore, hastily included, with additional dark threats as to what action would be taken if the work was not completed to time. This may seem an unfriendly act, but one has only to read through a legal document to realize what blackguards one's fellow-beings are. The dark threat usually took the form of deductions from the amount to be paid for the work. Incidentally, it was discovered that these threats should never be termed " penalties," as the law deems that it alone is allowed to impose penalties. People " in the know " call these penalties " liquidated damages " !

A great obstacle to the quick completion of a contract is the eternal state of financial crisis in which even the best contractors find themselves. To overcome this it was decided to include a clause showing that a contractor could expect payments on account as the work proceeded to enable him to pay his labour, purchase stores, and to convince him that the Government really meant well by him. Experience later made it necessary to include sometimes a clause enabling the Government to hand over to the Police or Political Officers money due to a contractor to cover such items as wages due to labourers.

There was a noticeable tendency on the part of the contractors, having got a contract, to get other contractors to do whole or part of the work for them. To keep control of the work it was necessary to state in the contract that the sub-letting could only be done with the approval of the department.

Having bound the contractor and the Government hand and foot, and working on the principle that " one puts in the whisky to make it strong, and then the water to make it weak," it was now decided to insert a clause to give the contractor or the department the right to appeal to an outside authority in case of dispute. The question was to decide who should be this disinterested outside person. Worthy people like Political Officers, policemen, customs officials,

were ruled out because of their probable inability to decide the point at issue, and it was decided to elect the Director of Public Works for the post. By some oversight the Director of Public Works was not informed of the high honour that had been bestowed upon him, and, when, six years later, it was necessary to enlist his services in a dispute, he was naturally overcome with confusion at not "having notice of the question."

Finally, to increase our standing as lawyers and to allow for all the frightfulness on the part of the contractors which we had not already foreseen, a clause was inserted to state that the plans, profiles, and specification were to be considered as referring to the contract, and that the Government reserved the right to alter any of the work (with necessary financial adjustment); to terminate the contract in the event of unsatisfactory work, and, if necessary, to make good any faulty work at the contractor's expense.

This appeared to clinch the matter, but in order to allow the supervising officer plenty of time to ensure that the work had been completed to his entire satisfaction, it was decided to withhold a retention of 15% of the contractor's money for three months after he had finished his work. He was informed of this decision in yet another final clause in the contract.

It was found quite easy to express all these points in language which could be understood not only by the contractor, but also by the officer signing the contract. All the legal "hereinasmuch's" and "whereforeasif-hereafter's" may lend tone to the document, but they do not tie the parties any more securely, so they were left out.

LETTING OF CONTRACTS.

The procedure adopted for the letting of contracts was to invite tenders for the work and accept the *most suitable* one. In England the most suitable tender is usually the lowest one, but in the Colonies it was found that this was very far from being the case.

Tenders were called for by means of notices sent to contractors whose addresses and ability were known, and also by posting tender notices up in public places. These notices contained the following information:—

(i) Brief general description of the work to be done.
(ii) The place where, and time when, the plans, profiles, contract forms, etc., could be inspected.
(iii) To whom the tender should be sent and how it should be addressed.
(iv) The latest date and time of acceptance of tenders.
(v) A clause to state that the Government did not bind itself to accept the lowest or any tender. This last was necessary because it sometimes happened that no suitable tender at all was received.

The responsibility for accepting tenders varied according to the amount of the contract. It was carefully laid down in a *Financial Regulations* which was subject to even more amendments than *K.R.* and which was much more tricky to use, because no one ever considered it worth their while to supply copies of the amendments to the T.R.D.

Actually the O.C., T.R.D., could accept tenders up to £1,500 on his own responsibility. Above this figure and up to £3,500 a tender board was necessary, and over £3,500 the proceedings of this board had to be confirmed by the Secretariat.

The usual form of tender board consisted of a senior Political Officer, a Treasury Official and a Sapper Officer. The last-named was actually the responsible official on these boards, because he was the only one who knew anything about the details of the work to be done, and was quite often the only one who knew the contractors by name or reputation. The other two were there to " see fair play " and to sign on the dotted line when the time came.

It was, therefore, very necessary for the Sapper to use great care and judgment in his selection. *At all times his guiding star was the office estimate.* In England, of course, the first tender to be considered is the lowest one, but in the Colonies the lowest tender is usually not worth considering.

It is usually put in by an optimistic native contractor, from whom it was a common occurrence to receive a £600 tender for a £6,000 job. The average native contractor was usually a simple fellow using simple methods. If, by any chance, he could get his tender accepted, he proceeded with the maximum amount of delay and " palavers " to get about £200 worth of work done, draw £170 in cash, and promptly " go for bush," leaving his labour unpaid and the work unfinished. One bright lad reappeared four years later to demand the remaining £30. He got it, too, because at the time of his " flitting " there was no clause in our contract authorizing us to hand his £30 credit over to the police, and when he popped up again, no one could find any of the labourers to whom he owed wages. So much for the simple native contractor, whom the T.R.D. very early on refused to employ for any large work.

It was found that, to be of any use, a tender must be within 15% of the office estimate. It boiled itself down, therefore, to a choice of one of those conforming to this figure.

At the beginning there was little to guide one, and the lowest suitable tender (*i.e.*, within 15% of the office estimate) usually won the day. Later on, when many of the contractors were known, it was found to be more economical in the long run to accept the tender of a known contractor than to gamble with an unknown one. " Better the devil you know than the devil you don't ! "

This practice of giving work to known contractors in preference

to the unknown sounds akin to "heresy" and "conduct to the prejudice" in England, but in England it should be remembered that only "specially selected" contractors are invited to tender, whereas on the Gold Coast tenders were open to the world. Further, of those who did tender, probably at least 75% could be classed as "specially not selected."

One advantage of giving work to known contractors was that it quickly tended to build up an *esprit de corps* amongst those who were working for the department. They soon realized that, provided their work was good, they did hold an advantage over the outsider, an advantage that they were loath to throw away by high tenders or bad work.

There are, of course, obvious limitations to this practice, but care was taken never to give too much work to one man, and to keep the number of contractors employed as large as possible, so that the element of competition was always present. The occasional introduction of new blood also had a very salutary effect, and nothing in the nature of a "ring" was ever formed. An unsatisfactory contractor was never re-employed, a good rule *pour encourager les autres*.

It would be pleasant to record that British contractors received precedence over others, but unfortunately the T.R.D. experience in this respect was a very sorry one. The tenders of British contractors were usually far in excess of the others, and only three were employed in six years. Of these three, only one finished his work, and he shipped for England without paying his labour! Actually, the best English contractors would never tender for "bush work," as they preferred to compete only for construction work in town areas where there were some of the amenities of civilization.

Of the contractors actually employed 75% were Italians, and they were undoubtedly the best, possibly because they are by nature best suited to withstand the West Coast climate. They were mostly first-class workmen with good powers of organization, and the best of them took a real pride in their work, which they were thoroughly entitled to do.

MAINTENANCE.

"The eye of the master maketh a fat horse."

The officer who produced the above quotation has stated, with much pride, that it is an Arab proverb. He may be right! But he certainly has some justification for considering it an appropriate heading to a few words on road maintenance, for the whole secret of success in such work is careful and continuous supervision.

It is essential to remember the type of road with which we are dealing. It is not an English arterial highway or even a rural lane. It is a road which consists merely of four to six inches of gravel laid on the top of pure "dirty," or soil. The only reason that it is able

to stand up to mechanical transport, even during the rainy season, is that the tropical sun bakes the clayey particles of soil mixed with the gravel, and the whole forms a crust of brick-like hardness which gives the road an almost waterproof surface.

One would expect that the heavy downpours must very soon soften the sun-baked surface, and that once this has occurred, the roads would very quickly become impassable. This will happen to a certain extent, but it must not be forgotten that a well-drained surface will very soon dry under the action of the sun, which is rarely obscured for more than a few hours together, and that a well-baked surface of the correct material will often withstand considerable rains before it begins to soften.

Bearing this in mind, the T.R.D. decided that the first essentials for efficient and easy maintenance were obviously good drainage and the careful clearing of the trees and bush which would otherwise shade the surface. One boy in each gang was, therefore, permanently employed on clearing the drains in his section. These soon became blocked with grass and soil, and even if the water did not flow over the road, it soaked into the "dirty" foundation and did a lot of damage. Furthermore one boy soon learnt to cut the sides of the drain straight. Nothing on a road looks worse than zig-zagging side-drains.

Under the terms of his contract, a good deal of the clearing work was done by the contractor in the course of construction, but certain places always required considerably more clearing and this had to be done by the maintenance gangs. It was found essential to stipulate very definitely where this extra clearing was to be done, and the gangs were forbidden to do any clearing elsewhere, since they preferred it to any other maintenance work. It was easy to do; they were working in the shade, or at least out of sight, and if they could not be found during an inspection it was always a case of "work for bush hard past all, massa."

For reasons of economy, the only method of consolidating the surface was by running traffic over it. It was inevitable that each vehicle should follow in the tracks of the preceding one along the crown of the road. "Tramlines" were, therefore, very soon formed down the centre of the road, and the camber destroyed, so that the water proceeded to run along the road instead of into the side drains. It was essential that these tracks should be removed as early as possible, and the most satisfactory method of doing so was by picking the surface, adding fresh clean gravel and ramming with a hand rammer or rolling with a petrol roller. Small petrol rollers were worth their weight in gold when they were available, and would function, but it was found to be an almost superhuman job to keep them in running order, probably because those in use were considerably over-age and their drivers distinctly under-trained. Even those who should have known better were somewhat shaky on their

maintenance, one officer attaining fame throughout the Gold Coast by dispatching an urgent order to the Public Works Department for a new magneto for steam roller No. X ! !

With their natural cunning, maintenance gangs were apt to repair the tramlines by using gravel from the crown of the road or from any other part of the road which they considered could spare it. This had to be stopped at once. We also found that in some cases, where these tramlines showed signs of becoming a real menace to the road, it was necessary to force the traffic to use the sides by driving in stakes along the centre line.

"Dirty" was never used for repair work for obvious reasons, and during wet weather only clean washed gravel was used, as in practice it was found that sufficient binding material would be squeezed up under the pressure of the traffic. Pot-holes were repaired in the same way as the tramlines.

In the tropics, grass and weeds grow very quickly and soon become a foot or more high if they are not "kept under." It is true, as some experts point out, that they tend to bind the surface together, but unfortunately they also hold the water and are the cause of endless trouble if not cleared away. They also hide any defects and increase the tendency of the traffic to drive along the crown of the road. Thus the sides are never consolidated and accidents are much more frequent. No driver, not even an African Jehu, likes to drive into grass a foot deep which may hide stones, branches of trees, or even the lazier members of the maintenance gangs.

Except in very special circumstances, bush sticks (so-called corduroy) were never used to repair a road. Corduroy not only smashes cars and lorries to pieces, but it also ruins the road. The water lies underneath the logs and quickly soaks into the "dirty." Worse still, it is practically impossible to prevent the gangs leaving the corduroy permanently on the road and making a new surface on top of it. The wood quickly rots, the surface sinks and becomes badly corrugated, and will always get into the same condition, however often it is repaired, because the foundations are wavy.

To the tidy-minded, the sight of grass growing on the sides of a cutting may be very offensive. Such people may be deeply gratified to find that such a spectacle is equally distressing to the maintenance boys. But it is quite wrong to remove this grass and the reason for the latter's distress is not so praiseworthy as one might think. The boys like the job of removing this grass, second only to bush clearing, because they can loll against the side of the cutting in the partially prone position, scratching their backs and chewing a kola nut until they hear a lorry approaching. If there is then any chance of its containing the Superintending Engineer, they can idly swing a cutlass at the nearest blade of grass without the trouble of changing their position.

hoto 1—100-ft. steel span erected over R. Mansi at Bopa, Western Province River at dry season level.

Photo 2—End view of R. Mansi bridge.

Photo 3—Ferry site across R. Taiama prior to the construction of the ferry. The view of the bush gives some idea of the difficulties of survey.

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Photo 4.—Triple 28-ft. reinforced-concrete span over R. Disue at Enchi (W.P.)

Photo 5.—Concreting the beams and deck of D 28-ft. reinforced-concrete bridge across R. Sui. (Showing shuttering in position).

Photo 6.—Another view of R. Sui bridge, showing stirrup reinforcement in position and concreting in progress.

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The sides of cuttings and embankments were the only places that grass and weeds, such as lemon grass, were encouraged. Here they were most useful in preventing new cuttings and banks being washed away during very heavy downpours.

We found that bridges and culverts required little attention beyond the periodical clearing of the waterways and keeping the weep-holes of parapets and abutments in a lachrymose condition. A wary eye was also kept open for bumps appearing at bridges or culverts. Not only did such bumps cause great distress to road users, but every time a vehicle hit the bump it induced much distress in the culvert, which, unlike the human body, was not designed to withstand it. Their presence also indicated that the banking had sunk and that floods might reach the road.

The T.R.D. maintenance was invariably carried out on new roads which required more attention during the first year than at any other time. The strengths of maintenance gangs varied according to the conditions, but on the average a gang of six boys under a headman, who was a working member of the party and not an onlooker, were sufficient to maintain a stretch of three miles of road during the first year, this distance being increased to four miles during the second and following years. An overseer was appointed to look after each stretch of roughly twenty miles of road, and was responsible for the condition of his section. He worked in partnership with a time-keeper, who, being able to read and write, was responsible for the correct keeping of the time sheets. These two had to be able to ride bicycles, provided by themselves, for which they drew an upkeep allowance, as it was soon apparent that without this means of transport it was extremely long odds, if not a dead certainty, against them trekking miles in the heat of the day to see that the boys were carrying out the orders of a crazy engineer!

Although we were able to prove to many pessimists that it was possible to keep the Gold Coast gravel roads in very fair condition during even the wettest seasons of the year, we could never absolutely guarantee a trouble-free journey. However efficient the maintenance clearing might be, it was impossible to cut down all the trees that might be blown down across the road during a tornado, and on our many journeys we not infrequently found a road blocked in this way. We, therefore, made it a practice to take at least one felling axe with us. In spite of this precaution, it was sometimes found impossible to clear the road when travelling at night after the maintenance gangs had gone home. There was then no alternative except to return to the nearest Rest House, if any, or to pitch camp in the dark and spend the night in bush. But that is life, if one *will* go in for this Empire-building business!

(To be continued).

APPENDIX I.

AVERAGE SIZES FOR CATCHMENT AREAS FOR STANDARD PLANS.

15 ft. span (9 ft. clearance)	...	...	6 square miles.
20 ft. span (11 ft. clearance)	...	...	10 ,, ,,
Double 20 ft. span (11 ft. clearance)	...	20	,, ,,
Treble 20 ft. span (11 ft. clearance)	...	30	,, ,,

In very hilly country, these catchment areas will be considerably reduced.

CULVERT AND BRIDGE DATA.

Span.	*C.Y. of concrete.*	*No. of drums of cement (400-lb. drums).*	*Cost of Work.*	
			£	
1 ft. Tube...	1·5	2	9	
2 ft. Tube...	6	7	14	
2 ft. Culvert	9·5	11	19	
3 ft. 6 in. Culvert ...	12	14	26	
5 ft. 6 in. Culvert ...	22	26	47	for 7 ft. clearance add 33%
Double 5 ft. 6 in. Culvert	42	50	85	
Treble 5 ft. 6 in. Culvert	60	72	135	
15 ft. span Bridge ...	120	144	290	
20 ft. span Bridge ...	160	192	450	
Double 20 ft. span Bridge	250	300	750	
Treble 20 ft. span Bridge	320	384	1000	

Note.—These data are averages taken from 50 constructed culverts and 10 constructed bridges. "Cost of Work" includes mixing and placing concrete, foundation excavation, and minor stream bed deviations.

Average cost of mass concrete was 40s. per cu. yd.
Average cost of reinforced concrete was 50s. per cu. yd.
The estimated cost of any culvert or bridge should include :—

(*a*) Cost of work.
(*b*) No. of drums of cement x 13s. = cost of cement.
(*c*) Transport of stores. Cost at 1s. per ton mile.

APPENDIX II.

Cut-and-Fill Tables.

(For the purposes of economy in publication these tables have been reduced to skeleton form so that the only quantities shown are those mentioned in the text. The actual tables give all the quantities for differences 0·1 ft. height of bank and depth of cut from 0–20 ft.)

Cut Table.

Cubic yards of work for 100 ft. run of cut 25 ft. wide at base with sides sloping 10/1.

Depth of cut in feet.	*Cubic yards.*
0·0	0·0
1·0	93
1·1	102
1·2	112
1·6	149
1·7	158
2·1	196
2·5	234
3·0	281
3·4	319
4·1	386
6·9	656
10·5	1013
12·5	1215
15·0	1474
17·0	1680
20·0	2000

Fill Table.

Cubic yards of work per 100 ft. run of bank 24 ft. wide at top. Slope of sides 1 to 1·5.

Height of fill in feet.	*Cubic yards.*
0·0	0·0
0·5	46
0·9	84
2·1	211
2·7	280
2·9	304
3·0	316
3·3	354
4·4	498
4·5	512
10·0	1443
20·0	3996

Note.—For anyone unlucky enough to have lost his "cut-and-fill" tables, and also what little mathematical knowledge he may have had, we give below the necessary formulæ for making out some new tables :—

The "Cut" Table.

$\frac{50h}{27}\left(\frac{h}{5}+50\right)$ cu. yds.

For every 100 ft. run of cutting depth h. 25 ft. wide at base, with sides sloping 10/1.

The "Fill" Table.

$\frac{50h}{9}(h+16)$ cu. yds.

For every 100 ft. run of bank height h. 24 ft. wide at top, slope of side 1 to 1·5 or 2/3.

SPECIMEN ABSTRACT.

From WIAWSO to KROKOSUA.
Chain 1241—1630

Page of Estimate Book.	*Cut.*	*C. to F.*	*Fill.*	*Gr. and S. Drains.* £	s.	d.	*Bush clearing and Tree Felling.* £	s.	d.	*Gravelling.* £	s.	d.
60	384	401	479	18	12	6	20	0	0	45	0	0
61	823	475	718	13	5	0	25	0	0	45	0	0
62	2385	1230	565	14	10	0	25	0	0	45	0	0
63	2994	2041	190	13	7	6	25	0	0	45	0	0
64	1689	652	340	19	5	0	30	0	0	48	15	0
65	735	484	1426	15	0	0	30	0	0	45	0	0
66	3549	1902	1562	19	7	6	30	0	0	48	15	0
67	1514	783	1034	13	5	0	35	0	0	48	15	0
68	1577	960	1770	16	7	6	35	0	0	48	15	0
69	1188	180	493	22	10	0	25	0	0	52	10	0
70	874	420	87	24	12	6	25	0	0	52	10	0
71	348	34	402	22	17	6	30	0	0	48	15	0
72	945	263	492	19	15	0	30	0	0	48	15	0
Totals	18705	9825	10557	232	15	0	365	0	0	622	10	0

CONCRETE ESTIMATE.

Culverts.	*Size.*					
	1′	2′ Tube.	2′ Culvert.	3′ 6″	5′ 6″	Double 5′ 6″
Chainage of Culvert	1241	1274	1333	1538	1504	
	1257	1303	1347		1550	
	1297	1323				
	1431	1417				
	1466	1451				
	1581	1476				
		1617				
Total chainage	8273	9859	2680	1538	3054	
No. of culverts	6	7	2	1	2	
Average chainage from Chain 0 ...	1379	1408	1340	1538	1527	
Average miles from Chain 0	26	26·5	25·5	28	28	
(Chain 0 is 60 miles from railhead.)						
Average miles from railhead ...	86	86·5	85·5	88	88	

SPECIMEN ABSTRACT—*continued.*

Size.	*No.*	*Cost of construction.*	*Barrels required.*	*Average miles.*	*Barrel miles.*
		£			
1 ft. Tube	6	54	12	86	1032
2 ft. Tube	7	98	49	86·5	4250
2 ft. Culvert	2	38	22	85·5	1881
3 ft. 6 in. Culvert ...	1	26	14	88	1232
5 ft. 6 in. Culvert ...	2	94	52	88	4602
Total		£310	149	—	12997

TOTAL ESTIMATE—Chain 1241—1630 (7·4 miles).

	£	s.	d.
Earthworks—18705 cu. yds. Cut at 1s. 3d. ...	1169	1	3
10557 „ „ Fill at 1s. 3d. ...	659	16	3
9825 „ „ Cut to Fill at 3d. ...	122	16	3
Grubbing and Side-drains (see page 234)	232	15	0
Tree felling and rooting (see page 234)	365	0	0
Gravelling (see page 234)	622	10	0
Concrete construction (see above)	310	0	0
Cement, 149 barrels at 19s. 3d. (at railhead) ...	143	8	3
Transport of cement—12,997 barrel miles at 3d. ...	162	9	3
	3787	16	3
Add 10% for extras	380	0	0
	£4167	16	3

Total—£4,168, or £565 per mile.

KHEDIVE ISMAIL'S DISPATCHES TO MAJOR-GENERAL CHARLES GORDON.

By LIEUT.-COLONEL F. W. MOFFITT, D.S.O., *p.s.c.* (*retired*).

RECENTLY, when examining certain unpublished papers connected with General Charles Gordon, which have been in my possession for many years, I came across a number of Khedive Ismail's dispatches, which not only affect Gordon's actions on the Equator, but throw a sidelight on Ismail's character. Dr. Bernard Allen, in his book *Gordon and the Soudan*, tells of the meeting between Gordon and Nubar, the Egyptian Foreign Minister, at Constantinople prior to the former being appointed Governor of the Equatorial Province. A year afterwards (September, 1873) Gordon received a telegram, offering him the appointment, which he provisionally accepted. In Nubar's subsequent dispatch (September 17th, 1873) he expresses the Khedive's pleasure at Gordon's acceptance, and then in answer to points raised by Gordon, says the Khedive agrees with the latter that publicity is not desirable, but that " with a name like Gordon's it is unavoidable." The Khedive does not agree that the appointment shall be termed a " Topographical Mission," as it would not be understood by the uncivilized tribesmen, nor would it confer on Gordon the necessary power and prestige. He adds " This does not imply that you are the successor of Sir Samuel Baker. The difference will appear quite naturally sometime later in a more obvious manner." It appears that Sir Samuel Baker's rule had failed to bring about good relations with the natives, and Gordon, inspired by the example of Livingstone, who had just died, wished to try methods of peaceful penetration. Nubar finishes his dispatch as follows :—" I do not speak of emoluments. I address a gentleman, and it is you yourself who shall fix them. I even doubt if it is right to mention the matter ; in any case, excuse me."

Khedive Ismail was certainly a spendthrift, but allowing this, the insolvent condition of the country was mainly due to the rapacity of his Ministers. He has been accused of not being whole-hearted about the suppression of the slave trade and of merely appointing Gordon to hoodwink public opinion. His dispatches on the subject ring true, and certainly Gordon believed in him.

A dispatch dated 30th August, 1874, signed by Ismail, contains the following :—" I now arrive at the all-important question. It concerns the application of very severe measures against the slave-

traders. In spite of very precise orders given to the local authorities and their energetic action several caravans of slaves have been stopped on the frontier. This disgraceful traffic though on a reduced scale continues. We must redouble our blows to annihilate it." He then lays down that when a caravan is captured, the slaves are to be liberated, the ivory, etc., is to be confiscated and those responsible severely punished. There is something naïve about the end of the dispatch. The Khedive encloses a letter for delivery to King Amtissi (M'tesa ?) adding, " you can send some gifts as coming from me, with the letter. I leave you to choose what will please him most " (and presumably pay for them). His next dispatch, dated November, 1874, states: " I have read with interest all you say about the slave trade and it must definitely stop. There is only one way and that is, to suppress the depots of the traders and for the Government to monopolize the whole trade of the country." He adds he has given these orders to the Governors of Bahr el Gazel and Darfur and asks Gordon to adopt them. Then he pays a high tribute to Gordon's work and promotes him to General de Division and confers on him the Order of —— 2nd class. Unfortunately the name of the Order is left blank.

A dispatch of February, 1875, begins, " I note with great interest your letters of 10th August and 5th September, also the two reports by Gessi. The details narrated in these letters and reports regarding the activities of the slavers and their soldiers surpass anything one can imagine. I have been acutely afflicted and I wish by every possible means an end could be put to them."

He goes on to say that the Government officials who are implicated, will be given exemplary punishments and he wishes for positive information about the routes taken by the caravans. He then points out to Gordon, who had suggested that the liberated slaves, who did not wish to be sent to their homes, should be transferred to Upper Egypt to work on the land, that he, the Khedive, and his nephew are the largest cultivators of sugar-cane in that part, and that his enemies would accuse him of waging war on the slave-traders to get the slaves for himself. He wishes the slaves to be enrolled and sent to Egypt for military training and then employed on agricultural and public works.

The next dispatch, dated 17th September, 1875, is of considerable interest. Though Dr. Bernard Allen mentions it in his book as having been written by the Khedive's own hand and consigned to the Mudir of Fashoda to deliver to Gordon, he had not seen it until I showed it to him. The Mudir was killed in a revolt, and the letter was placed in an ordinary mailbag and overlooked by Gordon on arrival. Gordon, not having had any replies to his letters for months from the Khedive, was on the point of resigning, when fortunately the letter was discovered and Gordon changed his mind.

Long before, Gordon had decided that the only way to open up the Equatorial Provinces was by making a route from Lake Victoria to the west of the Indian Ocean. The route to Cairo was 2,000 miles long, and beset with difficulties and would never make a satisfactory line of communication. The route suggested by Gordon had never been explored, and it is of interest to note that the French map used by Gordon, which is among his papers, shows Lake Rudolf as an extension of Lake Victoria, reaching to within 80 miles of Mount Kenya. In the dispatch the Khedive hopes to hear shortly that Gordon has launched his steamers on Lake Albert, and congratulates him on having broken the slave trade. He continues, "I cannot conceal from you, my dear Pasha, that your insistence for a year on my entertaining the idea of a route to the coast and opening it for commerce has filled me with surprise. Your mission was to establish security and put down the slave trade, thus opening these vast lands to European trade. My first impression was that commerce would take the line of the Nile as being the most natural and easy."

The dispatch continues that if Gordon insists, it must be that being on the spot he knows best; the Khedive will not oppose the plan, his goal and duty as sovereign of these countries is to "attract and help them by all possible means and give them secure communications. So, my dear Gordon, I adopt your idea and charge you to do for all our territory between the lakes and the coast, what you have done for the region of the lakes."

He sees no difficulty and has perfect confidence in Gordon. As regards choice of ports, he notes Gordon's preference for Formosa Bay, only 280 miles distant from the Lakes.

(In reality, it is approximately 450 miles, so presumably his map was also incorrect.) The alternative ports of Jubba and Drimforo, he knows, are only suggested because Gordon thinks the Sultan of Zanzibar may have claims on Formosa. "You appreciate the political difficulties and with the practical good sense which is characteristic in you, you will admit that these difficulties do not originate in the governments, but through agents who first involve their governments and then gradually lead them into sharing their narrow views, or into supporting the latter without sharing them." The dispatch goes on to say the Khedive does not hold Gordon's view, but he has hesitated in adopting Gordon's proposal owing to "apprehensions if not identical at least analogous," and that if there were no alternative he would occupy Formosa Bay. He does not fear the Powers, as they are too well informed not to applaud his sacrifices in blood and money, in opening up huge areas to their commerce and putting down the slave trade by all possible means. The English Government keeps a cruiser at Zanzibar for the purpose, but it is aware the slave trade must be attacked at its source by a government with force and tenacity of purpose, and is it

not clear that he, the Khedive, possesses the will and power? The Khedive's view differs from Gordon's in that it is repugnant to him to occupy territory over which the Sultan has never exercised any rights, but regarding which he may have plans rather than pretensions. The alternative route ending at the mouth of the Jubba has decided him, as there is no question of interference with a friendly neighbour. Though longer, there will be no trammels and scruples, on the contrary there will be approbation on the part of commercial states and men of science.

"I leave you free to regulate relations with the different tribes as you think best. I am certain you will draw them to you by gentleness and justice—the means you have so successfully employed with the chiefs and populations whom the rigorous rule of your predecessor had antagonized."

Nubar encloses a dispatch in the same strain, emphasizing the point that the "sole object of the mission is commerce."

A later dispatch from Nubar states that the Khedive has discussed the plan with the Prince of Wales (King Edward) and Sir Bartle Frere in Cairo, and both are in agreement, adding, there is no hurry as the lake districts must be occupied first. He wishes Gordon to enrol 2,000 men who will learn discipline in the Egyptian army and be taught work, so that they can spread their knowledge among their fellow tribesmen when they return from Egypt. He has heard Gordon has ivory, so will he send it "as the treasury cannot disburse unless it receives." Meanwhile everybody, including Gordon, must be self-supporting.

This was hardly a happy augury for beginning a difficult expedition. Moreover, Gordon's tenure of office was drawing to a close and his difficulties with M'Tesa were considerable. No wonder the scheme was shelved. The last of Ismail's dispatches to Gordon in the Equatorial Province congratulates him on having achieved his mission, *i.e.*, the exploration of Lake Albert. Three years later, Ismail was forced to abdicate. Among other Gordon papers is a letter written to him by General Stone, but whether it is based on rumour or is authentic, I cannot say. It relates that the French Consul-General boasted he would have Ismail off his throne before nightfall, and that he and the British Consul-General visited Ismail at his palace. The Frenchman demanded abdication, whilst the Englishman stood by in silence. Ismail ignored the want of courtesy and quietly pointed out that the Sultan of Turkey was his suzerain and that he alone could grant him permission to abdicate. He then dismissed the ministers. It did not save him, as the Sultan gave in to the demand of the Powers, but it shows the acuteness of Ismail's mind. With more reliable ministers, he might have been a great monarch.

THE LOCHABER WATER POWER UNDERTAKINGS, INVERNESS-SHIRE, SCOTLAND.

Exemplifying the part of the Electrical and Mechanical Engineer in Large Hydro-Electric Power Schemes at Home.

By LIEUTENANT F. H. MACLENNAN, *Royal Engineers.*

PREFACE.

As is implied by the title, the writer's knowledge, such as it is, of his subject has been acquired almost exclusively from a short study of one large hydro-electric scheme, and in consequence can hardly claim to be in any way exhaustive.

The reader's indulgence is craved for the somewhat turgid chronology of a good deal of the text; it is not easy, for instance, to know what tense to use in describing an operation which, though in embryo two years ago, may now be a *fait accompli*.

The project may be divided into three parts, namely :—

(*a*) The Treig–Fort William scheme, which, when the writer arrived in Lochaber in the summer of 1932, had been in successful operation for some two and a half years.

(*b*) The Laggan–Treig scheme, which was then well advanced, all preliminary work being long since finished; and

(*c*) The full development of the power house, factory and subsidiary catchments.

Any description, therefore, of parts of the first scheme, and of the greater part of the second with the exception of routine maintenance details, is of necessity based on hearsay evidence rather than direct observation.

GENERAL DESCRIPTION.

PURPOSE OF THE UNDERTAKING.

The scheme was floated by the North British Aluminium Company, a subsidiary of the British Aluminium Company, to provide their factory at Fort William with power for one of the processes in the manufacture of aluminium.

THE SOURCE OF POWER.

The source of power at full development is water which is to be collected from an area of approximately 300 square miles, lying to the east and north-east of Fort William, and draining, as will be seen from the map, into the following rivers and lochs (from east to west) :—

The headwaters of the *River Spey* and one of its tributaries.
Loch Laggan with its tributaries.
The tributaries of the *River Spean* below the outlet of Loch Laggan, and above Laggan Dam, at present under construction.
Loch Treig and its tributaries.

In addition to these, eleven side streams which flowed into the River Spean below the site of Laggan Dam have been dammed and led into the (now completed) Treig–Fort William tunnel.

The computed average daily yield of this trapped area is 800,000,000 gallons. Naturally the daily flow fluctuates, making a considerable storage volume necessary, fortunately supplied by Loch Laggan and Loch Treig.

Loch Laggan is a sheet of water about seven miles long and a quarter to five-eighths of a mile wide. Loch Treig, situated some seven miles from its lower end, is five miles long and has a maximum width of five-eighths mile. Both are deep ; the depth of Loch Treig is actually 436 feet.

At its lowest point, in times of scanty rainfall, the top water-level of Loch Laggan is 818 feet O.D., which is to be lowered by dredging to 804 feet O.D. After heavy rain it rises to 820 feet O.D., at which level it is proposed to keep it normally by forming the Laggan Dam, some 4½ miles down the River Spean from its normal discharge end.

The effect of building this dam, which is to be 700 feet long and 130 feet high, will be to form an additional reservoir whose waters will link up with those of Loch Laggan. There will therefore be available for power purposes a depth of 16 feet of water covering an area of 2,440 acres, which equals, approximately, 1,480 million cubic feet of storage capacity.

Loch Treig has a normal level of 783 feet O.D. This is to be raised by a horse-shoe shaped dam, 400 feet long, at the discharge end of the loch, to 819 O.D.—one foot below the top level of the Laggan Reservoir, to which it is to be joined by a tunnel, 2¾ miles long and sixteen feet in diameter, so that the waters of the Laggan Reservoir shall find their way into Loch Treig. From here the combined waters are to reach the power station at Fort William by the now completed main tunnel, which is 15 miles long and 15 feet in diameter—incidentally the largest tunnel, computed on a cubic basis, in the world.

As Loch Treig may be drawn down to 695 feet O.D., the level of the main tunnel roof at its intake, the total depth available will be 124 feet, giving a storage capacity of 7,838 million cubic feet.

In addition to these two main reservoirs it is proposed to build a weir 900 feet long and 30 feet high across the River Spey, two miles to the west of Laggan Bridge, in Inverness-shire. The waters trapped by it will be conveyed by a conduit three miles long to join the River Pattack, near the point where that river turns westward to discharge into Loch Laggan.

As was mentioned earlier on, other minor streams are to be linked up with the main system so that every possible drop of water shall reach the Loch Treig Reservoir.

Such is the fully-developed enterprise. As was stated in the Preface, the work is being carried out in three stages as detailed below :—

STAGE I.—COMPLETED.

(*a*) Construction of a power house for approximately 50,000 h.p. and of a factory, both at Fort William.

(*b*) The driving of the main (Treig–Fort William) Tunnel with its gates, valves, etc., and intakes from the side streams of the River Spean which cross it.

(*c*) The construction of a pipe line and surge shaft to join the tunnel and the power house.

STAGE II.—UNDER CONSTRUCTION.

(*d*) The completion of the power house to its full development of 120,000 h.p. (in abeyance owing to the present trade depression).

(*e*) The construction of Laggan Dam.

(*f*) The dredging of the outfall of Loch Laggan to 804 feet O.D.

(*g*) Diversion of the main Kingussie–Fort William Road for a distance of 1½ miles, the existing road being below the level of the Laggan Reservoir when completed.

(*h*) Construction of the Laggan–Treig Tunnel.

(*j*) Construction of Treig Dam.

(*k*) A diversion of the L.N.E. Railway by the side of Loch Treig for a distance of nearly 1½ miles, the existing line being below 820 feet O.D. at that locality.

STAGE III.—FUTURE DEVELOPMENT.

Construction of the Spey Reservoir.

Construction of an intake dam on the Mashie Burn.

Construction of a conduit from the Spey Reservoir to the River Pattack.

Construction of a conduit from the Mashie Burn Dam to the Spey Conduit.

In order that the reader may be able to form a tolerably clear picture of the problems to be solved by the Electrical and Mechanical Engineer in this undertaking, the following description of the design and construction methods, although in some part outside the scope of this article, is thought worthy of inclusion :—

Stage I.

(A) The power house at Fort William.

This is situated 3,000 feet from the outfall of the tail race (a concrete conduit) into the River Lochy, at 21 feet O.D., the nozzles of the Pelton wheels being at 19 ft. O.D., which with Loch Treig full, gives a maximum static head of 800 feet. At its present stage of development its main dimensions are: 270 feet by 63 feet. The plant comprises five main units, each consisting of a single runner Pelton wheel with two jets, developing up to 10,000 h.p. and driving two D.C. generators, by the English Electric Company, at 250 r.p.m. The generating voltage is 300, and the turbines and both generators are mounted on the same bedplate. A 30-ton electric overhead crane traverses the power house from end to end. The current from the generators is conveyed without switching through aluminium conductors to electric furnaces in the adjoining factory.

There are also two auxiliary turbo-alternators of 1,250 kw., 3-phase, 50-cycle, wound for 400/440 volts at 600 r.p.m., for power, lighting, and traction purposes.

Excavation of the power house site, which was done without mechanical excavators, was almost entirely in rock.

The foundations of the machines are of 6 to 1 concrete, and the turbine pits have floors of dressed granite blocks ten inches thick, while the pit walls are armoured with steel plates.

Control of the turbines is either automatic, by an oil relay-actuated throttle valve, or manual; but the latter is resorted to as seldom as possible because, being achieved by deflecting the jets into the pit, it is highly destructive owing to the very high jet velocity of approximately 220 feet per second.

(B) Construction of the main tunnel.

At a point roughly 120 yards from its entrance in Loch Treig the concrete-lined tunnel bifurcates to allow the installation of two Ransome and Rapier sluice gates operating in vertical shafts. These gates are controlled by electrically-driven winches at the top of the shafts. The two tunnels then reunite to form the single main tunnel which winds its way for 15 miles under the lower slopes of the Ben Nevis group to the surge chamber, the hydraulic safety valve of the system. This is a concrete-lined circular shaft, 240 feet deep and

30 feet in diameter, with a static water-level of 212 feet. It was excavated upwards, access being gained to it from the side of Ben Nevis through the excavated tunnel line from the portal—a distance of 250 feet. Concreting of the surge chamber was carried out by erecting a steel tower the full height of the shaft, and in it was installed a lift for materials. A circular steel shutter, 30 feet in diameter and four feet deep, was supported from the tower, which also carried the working platform. The bolts for the sluice gate and screen guides were grouted before the main mass of concrete was poured. In addition to the sluice gate and screens the surge chamber has at its base a sump.

Here the tunnel bifurcates into two twelve-feet diameter concrete-lined tunnels, only one of which is, so far, in use ; the other trifurcates 250 feet farther on, the water now entering three 70½-inch steel pipes, half an inch in thickness, with lap-welded joints. These pipes, just before emerging from the hillside, are provided with welded-on anchor rings. The flanged outer ends are connected to stop valves 54 inches in diameter, which are operated hydraulically, and normally will remain fully open, being for emergency only. Immediately beyond the stop valves are automatic butterfly throttle valves 69½ inches in diameter, designed to cut off the supply water should its velocity rise beyond 15 feet per second. From here the water flows down the hillside to the power house in mild steel pipes of a tensile strength of 24 to 28 tons per square inch, which vary in diameter from 70½ inches to 65 inches and in thickness from ½ inch to 1⅛ inches. They are in 30-foot lengths and were lap-welded under hydraulic pressure—being made of two or three plates according to the diameter of the pipe ; the plates after bending being assembled and secured by bolts through the lapped portion. After welding, the pipes were annealed and rolled, and after a second annealing the ends for jointing were formed in a machine, the joints being of the straight spigot and socket type, giving metal to metal contact. All the pipes were assembled, without welding, of course, in the works of the makers, the South Durham Steel and Iron Co., to check fit and alignment, and tested hydraulically to the test pressure—50% in excess of that at which they would have to operate in service, after deduction of a 1/16-inch allowance for corrosion. After being tested, the pipes were given a coating of Briggs' " Tenax " solution.

(c) LAYING THE PIPE LINE.

The pipes are anchored in six mass-concrete blocks, and below each anchorage is an expansion joint, with a possible range of travel of approximately six inches, made up of a cast-steel body, with a mild steel machined slider, the latter having a nickel deposit on the machined surface to resist corrosion. The packing is of three layers

of square graphited hemp. The expansion joints are double flanged to permit their removal for the purpose of inserting blank flanges during the testing of the pipes *in situ*. The pipes in the anchor bends are of lap-welded mild steel, the circumferential joints being welded by the water gas system. All bends have anchor rings welded on electrically.

Setting the Anchor Pipes.

The following is a short description of the procedure adopted in laying the anchor pipes :—

The site was excavated for the foundation, and concrete was poured in up to within two feet of the gradient-level, boxes being put in to take the holding-down straps by which the pipe was to be clamped into position. Three pedestals were then built to within one inch of the required level, and the pipe, which had previously been drawn on a bogie up the inclined railway at the side of the pipe-line site by a winch, was rolled across these into approximately the correct position. The pipe was then placed exactly by theodolite for (*a*) correct position, (*b*) correct alignment, and (*c*) correct level, being moved as was required by jacks and wedges, and packed up with iron packings.

At every 30 feet of its length each pipe line is supported on a concrete pedestal hollowed out to the correct curvature of the pipe and provided with a mild steel saddle, the sliding surfaces being kept greased by means of a Stauffer grease cup and pipe.

Welding the Joints.

All the joints throughout the two pipe lines were welded *in situ*, a method which has never before been attempted in this country. The welding was done by the quasi-arc process. For light work two Dorman portable petrol-driven generator sets, each capable of operating two welding arcs, were used. For the heavier work lower down the line where thick pipes occur, two Crompton Parkinson motor-driven electric welding sets were used, the supply being 440-volt, 3-phase A.C. Each set supplied two welding points.

After anchor block No. 6, the pipes split up into the distribution system, each main set being fed by a 42-inch flanged steel pipe.

Testing the Pipe Lines on Site.

The pipe lines were tested separately when in position, each pipe being tested in three sections, and each section being subjected to such a pressure that, at its lowest point, the test pressure was 25% above the maximum static pressure at that point. In order to minimise the " up-the-slope " thrust on the central anchor block of each of the two lower sections, the section above the one on test was filled and given a static head of 50% of its working head. In

the case of the lowest section a maximum test pressure of 432 lb. per square inch was applied at the bottom of the line adjoining the turbine inlet valves. No leakage of any sort showed itself on test.

STAGE II.

(D) THE COMPLETION OF THE POWER HOUSE.

As was stated earlier in this article, this part of the project is at present in abeyance. The excavation has, however, been completed, again by hand labour, since it has been found cheaper than mechanical excavators for this particular job.

(E) THE CONSTRUCTION OF LAGGAN DAM.

This is a mass-concrete structure which is being built in six blocks with a vertical expansion joint between each. For its construction a mono-tower bridge, which is described in Stage Three of this article, has been erected.

The first two blocks of concrete are on either side of the River Spean, their foundations being keyed to the solid rock. Block No. 2, being well above water-level, has offered no difficulty. In the case of Block No. 6, however, the foundation-level is well below the level of the river bed, and a sheet piling cofferdam was therefore constructed before excavation of its site could be started. This block, as will be seen from Fig. 1, was pierced by a rectangular channel of sufficient area to take the total estimated flow of the river at its maximum flood volume—7,000 cusecs. A small temporary concrete dam, running diagonally across the river, diverted it through this opening so that the central blocks (Nos. 3, 4 and 5) could be started. When the remainder of the dam has reached completion steel gates will be lowered down ways formed on the upstream side of this opening, the void behind being subsequently filled with concrete.

(F) THE DREDGING OF THE OUTFALL OF LOCH LAGGAN.

To 804 feet O.D.

This is a straightforward job, and merits no detailed description here. The bed is partly clay and partly sand, and the latter brings the only serious problem—that of preserving the new banks from erosion and consequent silting. It is thought that a sufficiently wide channel, and therefore a low water velocity, should offer the solution.

(G) DIVERSION OF THE KINGUSSIE–FORT WILLIAM ROAD.

This operation was in the embryonic state during the writer's visit.

(II) CONSTRUCTION OF THE LAGGAN–TREIG TUNNEL.

This tunnel, between its intake just above the Laggan Dam and its outfall at the lower end of Loch Treig, is 2¾ miles long. There are two adits and one vertical shaft, which, with the intake and outfall, gave eight working faces. Shafts were also sunk at two other points for side-stream intakes. A typical cross-section will be found in Fig. 2.

The tunnel passes for practically its entire length through hard grey granite; some schist was met with, but for the most part it was sound. For some 300 feet from the outfall into Loch Treig, however, the tunnel passes through sand, which necessitated entirely different methods of driving and lining from those employed in the rock. The method of driving in the rock, which had been found by experience in the Treig–Fort William tunnel to be the best, was to use a short top heading and a bench, the heading being 10 to 15 feet in advance of the bench.

The number and depth of holes drilled varied with the rock, but there were usually about 23 in the heading and 6 in the bench, 8 to 10 feet deep. The average "pull" per round was about 6 feet.

Electrically-fired gelignite cartridges were used exclusively, the firing current being provided by an "exploder."

Spoil was removed from the face thus:—

A Sullivan or Holman scraper was brought by the tunnel electric locomotive to within some forty feet of the face on the 2-foot gauge track, to which it was then clamped for working. A snatch-block was anchored to the face of the tunnel heading, the scraper then removing the spoil and tipping it into skips which were driven in under its stern.

Five or six hundred feet to the rear of the face came the trimming gang. Its function was to remove any rock which obstructed the free passage of the trimmed section template which was the measure of the minimum size of unlined tunnel. The apparatus of the trimming gang consisted of a trimming gantry, running on wide-gauge rails which had been accurately set in relation to the tunnel centre line, jack drills and the necessary blasting equipment.

The tunnel was then ready for concreting, which was carried out in this order:—

The haunches on both sides were poured, position and shape being controlled by a gantry, running on the broad-gauge rails mentioned above. When the haunches had set, the walls were concreted, a steel gantry with adjustable steel shuttering, which was greased before use, being used for the purpose. Concrete was fed in by labourers, working on ground-level, through openings in the shuttering till it reached their level, when doors were bolted on and the remaining section was poured from the upper floor of the gantry.

Continuous ramming has resulted in good close concrete with a fine smooth finish. After this concrete had set, the shuttering was pulled away from the walls by the adjusting screws, and the gantry taken to the next section. The roof was concreted by means of a similar gantry, though, owing to the fact that the filling doors were of necessity on the centre line of the roof, the job was more awkward and involved much greater waste of concrete. The invert was concreted last of all, progress being from the inside of the tunnel outwards to the adits and ends. The concreting gantries were provided with electrically-driven hoists for raising the concrete skips to the shovelling platforms, while mixing was done in electrically-driven mixers situated outside the tunnel, in batches of 10 cubic feet. All concrete for the haunches, walls, and roof was of 4 to 1 Portland cement concrete, the aggregate being excavated granite which had been crushed at the adit works, and sand obtained from a sandpit near Fersit Camp. The mixture for the invert was a 6 to 1 Ciment Fondu, which was used because of its greater resistance to the corrosive action of the acids in the waters of Lochaber. Expense prohibited its use for the walls and roof.

As was previously mentioned, the last few hundred feet of the tunnel lie in sand, which called for different methods from those employed elsewhere. The excavation itself was fairly straightforward, timber frames and matchboarding being used for the temporary support and lining of the tunnel. The permanent walls are of malleable iron plates similar to those used in the London underground railways, lined to the standard tunnel section with concrete. A good deal of trouble was experienced in lining up and adjusting the iron rings owing to their lack of uniformity.

(J) THE CONSTRUCTION OF TREIG DAM.

This is of selected rubble with a reinforced concrete corewall, the excavation for which has, of course, been taken down to solid watertight rock. The spillway will be faced with selected granite blocks.

For the work of excavation for the corewall, which was kept as narrow as possible, timber shoring was used in dry ground; steel piling being used in addition where considerable quantities of water were met. Electrically-driven pumps are used for drainage.

(K) THE DIVERSION OF THE L.N.E. RAILWAY AT THE SIDE OF LOCH TREIG.

This involved the driving of a short tunnel, and the construction of several cuttings and embankments, all of which are outside the scope of this article.

Fig 1.—Laggan Dam, showing mono-tower footing, Block 2, with temporary flume, and cofferdam.

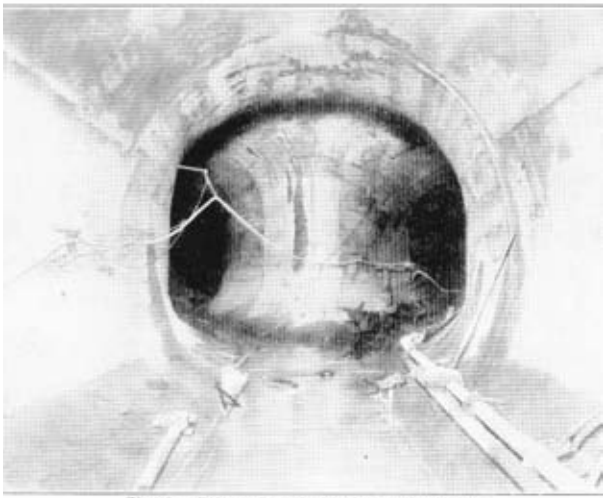


Fig 2.—Bifurcation of tunnel at valve-shafts.

The Lochaber water power undertakings 1-2

Fig. 3.—Laggan dam site from up-stream, showing mono-tower bridge.

The Lochaber water power undertakings 3

Fig. 4.—Tunnel wall concreting gantry.

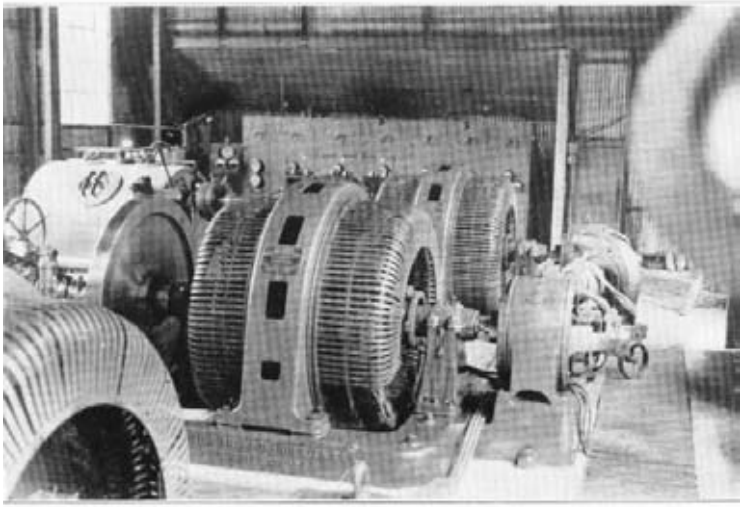


Fig. 5.—Interior of temporary power station.

The Lochaber water power undertakings 4-5

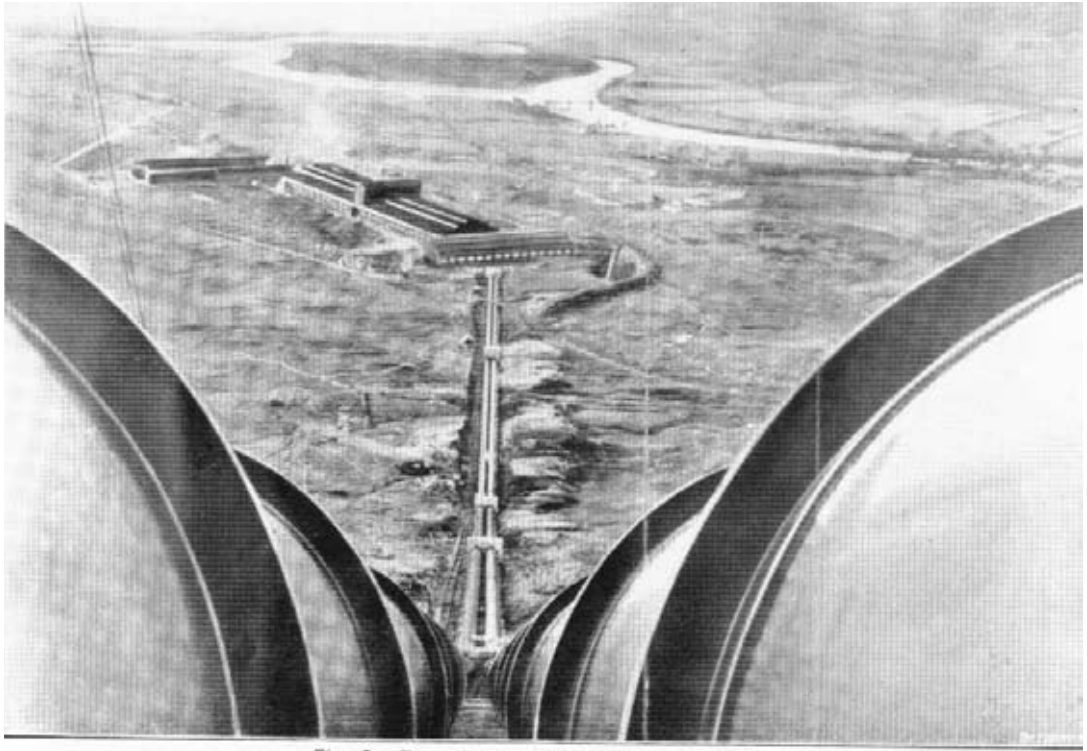


Fig 6.—Power house and factory from pipe-line portal.

The Lochaber water power undertakings 6

Stage III.

As far as the writer is aware, no designs for the final development have yet been prepared.

The Part of the Electrical and Mechanical Engineer on the Site.

For carrying out this undertaking a construction project had to be prepared, as follows :—

(*a*) Accommodation for the construction staff.

(*b*) The provision of tracks, railways, haulages, and shafthead gear.

(*c*) The installation of a temporary power house and an electric distribution system for the works.

(*d*) The installation of a telephone system.

(*e*) The provision of the usual erection plant, consisting of the following :—

Mechanical excavators, compressors, water supply and pumping systems, rolling stock, battery-charging plant, smithies, stone crushers and screens, concrete mixers, a repair shop, railway siding, etc., etc., and the organization of permanent staffs for their operation.

(*f*) The special equipment for driving the tunnel.

(*g*) The special equipment for building the two dams.

(*h*) The special equipment for dredging the outfall of Loch Laggan.

(*j*) The organization of a permanent rigging gang for the removal and erection of construction plant throughout the works.

(A) Accommodation for the construction staff.

Little need be said on this subject. The building of the huts was let to an outside contractor. The Electrical and Mechanical Engineer was concerned mainly with the supply of electric light, and water. For the camp at Fersit electric power at 11,000 volts A.C. was stepped down to 440 volts, giving a phase to neutral voltage for lighting of 250.

The water of an Dugh Lochan—a small loch some 1,000 feet from the camp—was found to be suitable and adequate for all uses in the camp. It is pumped by an electrically-driven pump, installed at the water's edge, through three-inch iron piping to a storage tank above the camp. From the tank the supply is distributed by pipes varying between two inches and ¾-inch.

(B) THE PROVISION OF TRACKS, RAILWAYS, HAULAGES, AND SHAFT-HEAD GEAR.

(i) It will be realized from a study of the map that the task of linking up the various works in the undertaking called for considerable thought and foresight. For Part I of the scheme the access railway had to run from Fort William to the tunnel intake at Loch Treig, this line being linked up later with the new one for Part II—the Laggan–Treig works—the layout of which was governed by experience gained during the operation of the former system. For the latter, therefore, the following limits were set :—

Maximum gradient—Heavy traffic, 1 in 50.
Light traffic (*i.e.*, cement, concrete, etc.), 1 in 35.
Minimum radius—110 feet, and on steep gradients 125 feet.
45-lb. rails, laid on larch sleepers, are used on the three-feet gauge system which is used for outside work. Ballast is the peaty sand of the district. For the tunnel lines two-feet gauge Decauville track is used. Permanent gangs were organized for track maintenance.

The bulk of the track was brought to the site from railhead or road by Fordson tractors.

Steam locomotives, of which there are 25, are used exclusively on the three-feet gauge track, while those working on the two-feet gauge tunnel lines are electric.

(ii) *Haulages* were required at many of the sloping adit mouths. These were by electrically-driven winches installed in sheds a safe distance from track turnouts, automatic overspeed brakes being fitted to the larger sets, such as the 65 h.p. winch, which served the 700 feet of 1 in 3 below the tunnel portal on Ben Nevis side.

(iii) *Shafthead Gear.* For the winding gear of the vertical tunnel shafts electrically-driven winches were used. These were required to overcome the difference in weight of the two cages with which each shaft was provided. At Shaft " C " in the Laggan–Treig tunnel the plant consisted of a 30-h.p. 440-volt Parkinson induction motor driving the drum through two sets of reduction gearing, one worm, the other straight spur. A foot-operated brake was provided in addition to the automatic solenoid-operated brake, which performed the double function of limiting speed and automatically stopping the drum when the cages reach the top and bottom of the shaft respectively. Each cage was provided with automatic steel sprags which act in the event of cable failure.

The heaviest load normally dealt with was a three-ton electric locomotive.

The cables were greased weekly with " Voco " grease.

(c) THE TEMPORARY POWER HOUSE.

This is situated at Monessie, where the River Spean, falling through a narrow gorge, provides a static head of some 100 feet in a distance of about a quarter of a mile.

An intake, whose screens are unfortunately ineffective in times of spate, situated above the gorge, leads to an unlined tunnel, nine feet by nine feet in section, driven through the rock for 1,400 feet. From the end of the tunnel an eight-feet diameter riveted steel pipe, 475 feet in length, takes the water through a surge chamber to the power house, where three Francis-type Boving turbines, running at 750 r.p.m., drive B.T.H. 3-phase 50-cycle 11,000-volt alternators rated at 1,250 kw. The effective head, with a 15-inch vacuum on the exhaust side, is 75 feet. Steel flywheels are fitted between the alternators and turbines to maintain the frequency against the surges which are common on temporary systems such as this.

The distribution system, at 11,000 volts, is by overhead lines on untreated spruce poles, which have a life of about three years. The voltage is stepped down where needed to 440 volts for power, lighting being phase to neutral at 250 volts. All H.T. equipment throughout the system is earthed to neutral.

Installation of Temporary Power Station.

(i) *Conveyance of Plant to Site.*

A railhead was established on the main L.N.E. Railway at the nearest convenient point to the site of the power house at Monessie.

As no siding was available, an unloading platform was erected beside the single track line which, of course, was available for off-loading only as the normal service of trains permitted.

The material was skidded from the drop-side wagons to the platform along well-greased 45-lb. rails laid on 12-inch by 6-inch timbers. From here it was lifted by a 3-ton crane and jacks into 2-foot gauge wagons, in which it was conveyed across a level field to a ramp leading down to a pontoon bridge across the River Spean—at this point 100 yards wide and two to three feet deep. A bridge of this type was forced on the contractors by a landowner who refused to sanction any more permanent structure.

The contractor's engineer admits that a weight was lifted off his mind when the last alternator stator, weighing ten tons in its packing-case, had safely crossed the river, as the type of bridge and the gauge (two feet) were both unsuitable for the loads to be carried.

From the far side of the river to the power house site the ground is so uneven, patchy, and steep that it was considered inadvisable to use bogies. Instead, clips for running direct on the track were secured to the bottoms of the packing-cases, and, by keeping the

track well watered, the coefficient of friction was sufficiently reduced to allow a 2-feet gauge locomotive to pull the load to within 300 yards of the site. Here the descent became so steep, about 1 in 2½—that the loads were lowered by winches, trees in plenty being available for anchorages.

The three portable compressors for the construction work were pulled across the stony river bed by a Fordson tractor on their bogies, which were shod with 2-feet by six-inch mild steel wheels, by a ¾-inch S.W.R.

The 8-feet diameter steel pipes, each length of which weighed 30 cwt., were transported on 2-feet gauge bogies provided with wooden cradles, one side of which could be withdrawn to allow the pipes to be rolled off.

The transport problems would have been greatly simplified had 3-feet gauge track and rolling stock being available.

(ii) *Erection of Power House.*

For erecting the columns, which weighed about three tons each, a 40-feet by 8-inch wooden derrick was used, the only vertical lift being one of four inches to bear the foundation bolts. The cross bracing was next lifted and bolted up, after which the travelling crane was erected. The turbines and alternators could then be handled while the corrugated iron walls and roof were going up.

The turbine breech pipes were drilled and riveted in position, loose flanges having been provided on all closure pipes.

For the main stop valves, joints of linoleum packing, which are still in use, were used because the correct packing had failed to arrive.

(iii) *Erection of* 11,000-*Volt Distribution System.*

This calls for no comment. The cost of erection was approximately £500 per mile.

It has been found that the bases of the untreated poles last well in the peaty soil of Lochaber, but that serious rotting at the cross-arm bolt holes takes place in about three years.

(D) INSTALLATION OF A TELEPHONE SYSTEM.

This is also overhead, on similar but lighter poles. The system is not automatic.

(E) THE PROVISION OF THE USUAL ERECTION PLANT.

(i) *Mechanical Excavators.*

These are all steam-driven Ruston-Bucyrus machines of standard pattern. The contractor's engineer has nothing but praise for the manner in which they have withstood the very arduous work they

have been called upon to do ; the spoil for the most part being blasted rock.

(ii) *Compressors.*

Until the permanent compressors were installed portable petrol-driven sets were used.

The permanent plant for the second stage was installed at three points—Loch Treig, adit " B," and Laggan Dam.

The following is a description of the largest of these, that at adit " B ":—

The house is 50 feet by 50 feet.

The plant consists of five " Sentinel " two-stage single acting compressors, by Alley & MacLellan, the stages being 45 lb. and 85 lb. per square inch, with a capacity for 750 cubic feet of free air per minute. Each is driven by a 150-h.p. B.T.H. 3-phase induction motor through belting tensioned by a counterweighted jockey pulley.

In addition to these, two Ingersol Rand Diesel sets of 100 h.p. with a capacity for 500 feet of free air per minute have been installed as spares, should the electric supply fail. Air at 80 lb. per square inch is distributed by 4-inch " Victaulic " piping.

(iii) *Water Supply and Pumping Systems.*

The water supply at Fersit Camp has already been described.

For the other points at which water is needed the purity of the supply is comparatively unimportant, and the nearest stream is therefore used. The pumps are electrically driven and feed storage tanks from which the further supply is by gravity. All main feed pipes are " Victaulic."

(iv) *Rolling Stock.*

For the outside work on the 3-feet gauge system short wheelbase steam locomotives of various makes are used. The latest " Sentinel" locomotives are considered the most satisfactory of all those in use.

A great variety of wagons has been used, and, owing to the very hard conditions in which they work, a good deal of repair and conversion work has been carried out, mainly on axles and wheel bearings.

In the tunnel the gauge is 2 feet and the 25-h.p. series wound electric locomotives carry their own 80-volt 258 A-H Ediswan " Ironclad " traction batteries, the charging of which is dealt with below.

(v) *Battery Charging Plant.*

At each adit and shafthead is a battery charging shed, consisting of a switchroom and a charging bay. The former contains a 440–60/110-volt B.T.H. Squirrel cage induction-motor generator set, fitted with an overload and no volt release, and having a hand-

controlled rheostat on the D.C. side. The charging panel is duplicated, so that two batteries can be charged simultaneously at different rates, should this be required.

The charging bay is roofed, and contains a concrete platform provided with steel rollers on to which the batteries are run off the locomotive for charging, the platform being, of course, at the same level as the battery floor of the locomotive.

(vi) *Smithies.*

At each adit and shafthead is a smithy whose main function is to sharpen the drills used in the tunnel and at the dams.

The plant consists of :—

An oil-fired muffle furnace fed by gravity from a 360-gallon tank mounted on a wooden pier outside the smithy.

An ordinary medium-sized anvil.

An "Ingersol Rand" compressed-air driven emery wheel for general purposes.

A tank with running water for tempering.

The muffle furnaces use about two gallons of Diesel oil per hour, and require re-lining about every six months.

A "Climax" drill sharpener which is capable of dealing with about 25 to 30 rose-type rock drills, as used in the tunnel, per hour.

The emery wheel is used mainly for putting the chamfer on the shank end of the drills, without which they are liable to jam in the chucks, thus causing waste of time at the working face.

The only skilled operation in the sharpening of drills is the tempering, as different steels are used for the different types of rock.

(vii) *Cranes.*

These are usually steam driven, of the ordinary swinging jib type, the largest on the works being for seven tons. In the case of those at the Treig Dam site and bed the back stay ends are mounted on trolleys running on parallel sets of 4-feet 8½-inch gauge tracks, so that the cranes can be used as pile drivers along the length of the dam, the stay ends being ballasted with sand.

(viii) *Stone Crushers and Screens.*

These have been installed at Laggan Dam, at both adits, and at Loch Treig, the stone used being, of course, granite. Wear on the crusher jaws and rollers is surprisingly low, replacement being necessary about every three years. The highly abrasive dust, however, is very hard on the bearings, which are not refitted but are scrapped when play becomes excessive.

(ix) *Concrete Mixers.*

Those for Laggan Dam are by Stothert & Pitt, of two cubic yards capacity, driven by a 22 h.p. Parkinson motor. No trouble with the

mixers or their motors has been experienced. For tunnel lining ½ cubic yard Miller mixers are used.

(x) *Contractor's Yard and Repair Shop.*

The contractor's yard at Fersit Camp is situated alongside the L.N.E. Railway, from which a siding is taken into the yard.

In addition to the full gauge track there are four 3-feet gauge contractor's lines, one of which runs practically the full length of the main repair shop.

The buildings in the yard are :—

A cement store, 200 feet by 20 feet.

A general store, 100 feet by 20 feet.

A travelling saw bench, 25 feet long.

An oil shed.

The main repair shop, with a foreman's office and a carpenter's shop under the same roof, the whole being 130 feet by 30 feet.

A wagon repair shop, 60 feet by 20 feet.

Of the above, only the following call for comment :—

The General Store.—As it is uneconomic to carry a large stock of spare parts, only one spare for the larger and more specialized items is carried, a replacement being ordered from the makers when the stores spare is drawn out. In the case of more commonly used and cheaper parts a floating minimum of, say, three or a dozen spares is maintained, while there is always an ample stock of the common sizes and types of nuts, bolts, rivets, etc.

In the case of bearings one spare of each size and type is kept.

The Main Repair Shop, which is called upon to undertake every shop repair required on the works, is equipped with a hand-operated overhead travelling crane and one each of the following tools :—

18-inch centre lathe.
9-inch centre lathe.
Automatic turret lathe.
Pipe screwing machine.
Planer.
Shaper.
Drilling machine.
Mechanical hack saw.
Tool grinder.
Radial drilling machine.
Sensitive drill for small jobs.

In addition there is the following equipment :—

A blacksmith's forge with an electrically driven centrifugal fan.
An oxy-acetylene welding and cutting plant.
A lead pot and ladles for re-metalling bearings.

Whitworth taps and dies up to 1½ in.
Brass taps and dies up to 3 in.
A long bench with parallel jaw vices and pipe vices.
An adequate stock of spanners, "Stillson" wrenches, chain tongs, chisels, etc., etc.

Power for the main shafting, which runs the whole length of the shop, is supplied by a 22 B.H.P. electric motor; certain of the machines have unit drive.

All big repairs to locomotives are carried out in this shop, but any dismantling which demands the use of a pit is done in a separate locomotive repair shop situated on higher ground, as the water-level at the site of the main shop precludes the sinking of a pit.

The personnel of the repair shop is as follows:—

Machine Shop.

1 Turner.
2 Fitters.
1 Welder (oxy-acetylene).
1 Burner (oxy-acetylene).
1 Blacksmith.
1 Blacksmith's Striker.
1 Machine Man on the planer, etc.
1 Boy on repetition work on the turret lathe.
1 Boy for answering the telephone, checking stores, etc.

Wagon repairs are carried out in the daytime by the repair shop staff assisted by a special gang consisting of:—

1 Blacksmith.
1 Blacksmith's Striker.
2 Labourers.

The wagon repair night shift is composed of:—

1 Locomotive Fitter.
1 Hustler, who assists the Fitter, and fills coal bunkers, etc.

Every locomotive driver on coming off shift enters in a special book details of any repair needed by his locomotive, which is attended to by the night shift if they are capable of tackling it; if not, it is done in the shops on the following day.

(F) SPECIAL EQUIPMENT FOR DRIVING THE TUNNEL.

The following items have already been dealt with: rolling stock, drills and their supports, concreting gantries.

The remaining plant and services are :—

(i) *Electric Light and Power.*

The former was at 250 and the latter at 440 volts A.C., but where possible pneumatic machinery was used because of the difficulty of preventing damage to wiring in the tunnel. Pneumatic plant has the further advantage of providing ventilation at the tunnel face. The wiring was T.R.S. cable, bakelite lamp holders with safety shrouds being used throughout.

(ii) *Water.*

This was required for the drills and was carried in " Victaulic " piping, with the exception of the last 20 to 30 feet, where flexible hose was used.

(iii) *Compressed Air.*

For this service 4-inch " Victaulic " piping was used also ; the pressure at the drills being 80 lb. per square inch. In addition to driving the drills, air was used for the motors of the " Sullivan " and " Holman " scrapers, and for certain of the tunnel pumps.

(iv) *Scrapers.*

These machines consist essentially of a steel chassis, mounted on 2-feet gauge flanged wheels, which can be clamped to the track where required, a pneumatically driven reversible winding drum, and a sloping steel apron up which the bucket of the scraper draws the spoil from the tunnel face. Skips are driven in under the stern of the scraper to catch the spoil as it is ejected from the end of the apron. The travel of the bucket, which is made fast to an endless S.W.R. having a few turns on the winding drum, is limited at either end by a snatch block, one on the back of the scraper, the other at the tunnel face.

The air motor, which has a maximum efficiency of 25%, is rated at 25 h.p. It therefore absorbs almost the entire output of one of the Alley & MacLellan 150-h.p. compressors, but as it enables the contractor to dispense with special ventilating plant this inefficiency can be tolerated.

(v) *Pumps.*

Although the Laggan–Treig tunnel is remarkably dry, a certain amount of pumping is naturally required.

The smaller pumps are usually driven by double-acting steam engines adapted for compressed air, a common unit being a " Cameron " reciprocating steam pump having a capacity of 200 to 300 g.p.m. at a 300 foot head. The efficiency of the set is 60–70%.

For heavier duty, *i.e.*, for draining the main sumps at the adits, Worthington multi-stage centrifugal pumps, driven by Parkinson electric motors, are used.

(G) SPECIAL EQUIPMENT FOR BUILDING THE TWO DAMS.

The only construction plant, peculiar to the dams, not so far described, is :—

(i) *The Mono-lower Bridge and Cranes at Laggan Dam.*

This is a steel box-girder bridge supported on concrete abutments and two steel crib piers with mass concrete foundations, the piers being continued up through the bridge to support the bedplates of seven-ton swinging jib cranes. These cranes have a maximum radius of 100 feet, with the jib horizontal, and have a fixed counterpoise of iron ballast ; they are powered by a 60-h.p. electric motor driving through a train of gears giving three speeds. Between them the two cranes command all that length of the dam site which is inaccessible from the banks.

(ii) *Pumps.*

For the coffer dams at Laggan, pumps similar to those in the tunnel, with the exception that they are electrically driven, are used.

At Treig Dam the deep narrow excavation for the corewall is drained by vertical spindle electrically-driven centrifugal 50 or 60 h.p. Worthington & Gwynne pumps suspended at the required depth by S.W.R.

Owing to the high proportion of sand in the water the pump bearings require renewal after three months' continuous running.

(H) SPECIAL EQUIPMENT FOR DREDGING THE OUTFALL OF LOCH LAGGAN.

This is being carried out at two points :—

(i) *In the Loch itself.*

The plant consists of a steel pontoon, 24 feet by 14 feet by 5 feet 6 inches, built by Gwynnes, in which are housed a Gwynne sand pump and its 145-h.p. motor, a 6-h.p. pump for priming, and outrigger trunnion bearings co-axial with the main pump spindle, which allow the angle of the suction line to be adjusted as required.

The delivery pipe, which deposits the spoil in semi-stagnant water, clear of the channel, is " Victaulic," supported on barrel rafts.

(ii) *Downstream from the Outfall of the Loch* the shallow twisty channel is being deepened and straightened by means of a Ransome & Rapier dragline, the details of which are :—

Type—480 ; capacity—2 cubic yards ; length of jib—50 feet ; caterpillar track, drive—440 volt. A.C.

The dragline travels along the river-bank, its own winding gear being used to warp it along where the distance is short.

LOCHABER WATER POWER
GENERAL PLAN

FURLONGS 8 4 0 1 2 3 4 5 MILES

N

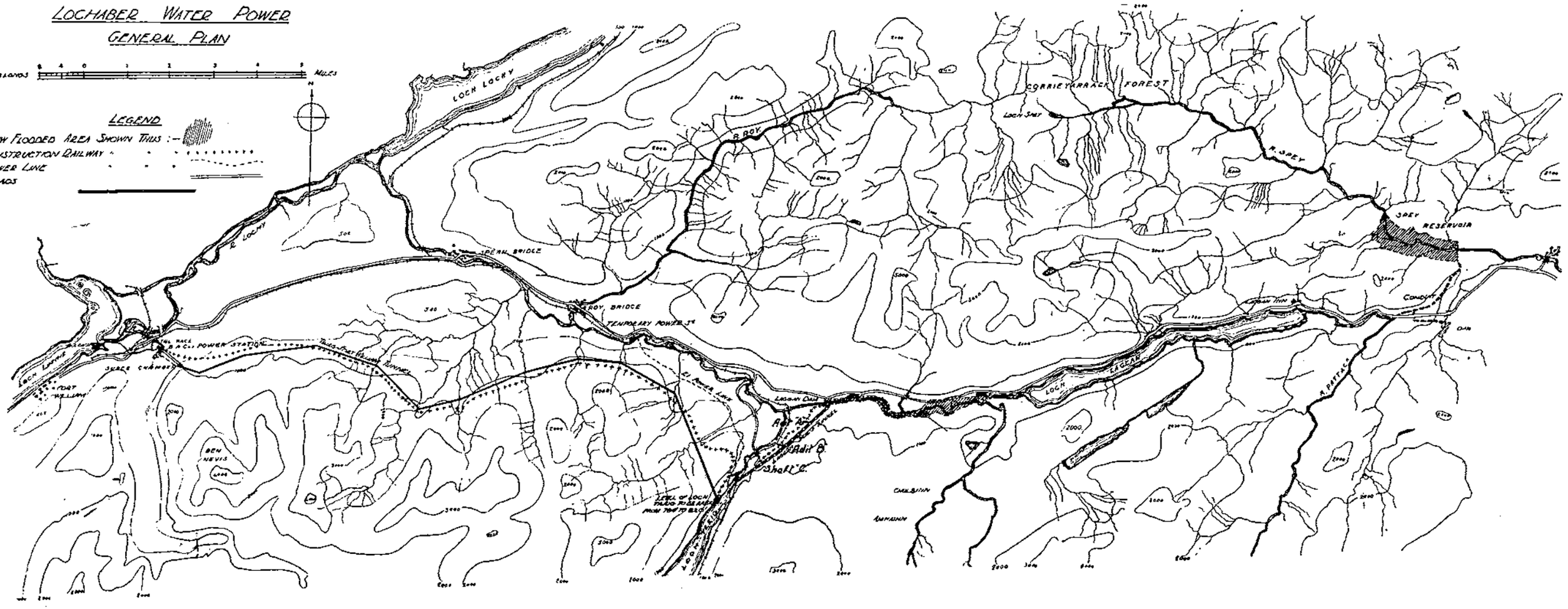
LEGEND

NEW FLOODED AREA SHOWN THUS :—

CONSTRUCTION RAILWAY

POWER LINE

ROADS



(j) THE ORGANIZATION OF THE PERMANENT RIGGING GANG FOR THE REMOVAL AND ERECTION OF CONSTRUCTION PLANT THROUGHOUT THE WORKS.

(i) This gang, which carries out all movements of plant, consists of:—

1 Leading hand.
4 Labourers.
A Fitter is lent to it when machines have to be dismantled.

(ii) The tackle used is as follows:—

One 3-ton all-steel hand derrick, with a 45-feet two-piece jib, the halves of which are readily split for ease of portability.

One 40-feet by 8-inch wooden pole, with a 3—2, 3-inch rope tackle and 3-inch snatch blocks.

Two 10-ton rack and pinion jacks.

Several 10-ton lift and traverse jacks.

Sheer legs, in various lengths for weights up to six tons, constructed of $2\frac{1}{2}$-inch steam, or 4-inch solid drawn steel, piping; the legs being plugged at both ends to give adequate bearing area for the pins.

$\frac{1}{2}$-inch to $\frac{3}{4}$-inch S.W.R. guys for the above, these being permanently shackled to the legs.

Five ton blocks for use with the sheer legs.

Shackles in various sizes up to one inch.

A variety of bulldog clips.

For skidding, suitable lengths of 45-lb. rail are used.

Holdfasts are 6-feet lengths of 25-lb. rail, ground to a point at one end.

Two 14-lb. hammers.

Four pinch bars.

This gear is transported by a Fordson tractor or lorries according to the nature of the ground to be traversed.

The help given by the Resident Engineer, Mr. B. N. Peach, B.SC., ASSOC.M.INST.C.E., and his staff, by the contractors' engineers, and by the proprietors of *The Engineer* in so kindly allowing the reproduction of photographs which appeared in their issues for April 25th, May 2nd, and May 9th, 1930, is acknowledged with the writer's grateful thanks.

In conclusion, anyone visiting the Lochaber water power undertaking cannot fail to come away with a profound admiration for the conception of the scheme as a whole by the directors and engineers of the British Aluminium Company, for the masterly technique of the consulting engineers, Messrs. Meik and Halcrow, in maturing this conception, and for the triumphant success of its execution in the hands of the contractors, particularly Messrs. Balfour, Beatty, to whom the lion's share of the work and the responsibility was entrusted.

ENGINEER RECONNAISSANCE.

By CAPTAIN R. E. WOOD, R.E.

[*Note.—This article was written before the publication of the new Appendix II to "Engineer Training," Vol. II.*]

INTRODUCTION.

IF any justification is required for plunging into the subject of Engineer Reconnaissance it is to be found in *Engineer Training*, Vol. II. In every phase of war we find one of the principal duties of the engineers in their task of assisting the other arms is that of engineer reconnaissance. Time spent in reconnaissance, we are told, is rarely wasted, and the corollary, that much time may be wasted unless reconnaissance has been adequate, is perhaps more applicable to engineer problems in war than to those of any other arm.

THE PROBLEM.

AN engineer plan, like any other, depends for its soundness and adequacy on an appreciation of the conditions prevailing, as revealed by the information at the disposal of the engineer commander.

Engineer information is obtained by three principal means :—

(1) Intelligence sources—agents, prisoners of war, maps, etc.
(2) Air reconnaissance and photographs.
(3) Ground reconnaissance.

Though air reconnaissance by engineer officers may be of value in special circumstances, *e.g.*, the passage of obstacles, or the alignment of roads in hill or bush country, trained air observers will normally produce the best results. It can, therefore, be assumed that the engineer reconnaissance referred to in *Engineer Training*, Vol. II, is mainly concerned with ground reconnaissance, and this is the subject now to be considered. This form of reconnaissance is perhaps most important and most difficult during an advance into enemy country such as is likely to occur in the early stages of a campaign. It is, therefore, essential that the personnel to undertake this duty should be adequately trained and organized and the problem thoroughly investigated in peace.

The subject will be considered under the following heads :—

(1) Tasks of reconnaissance parties.
(2) Method of employment.
(3) Means of communication.
(4) Composition and organization.
(5) Training required in peace.

Tasks of Reconnaissance Parties.

Reconnaissance tasks may be divided into the foreseen and the unforeseen. While the principles governing both remain the same, certain special features of each will be pointed out as they arise.

As in all forms of reconnaissance, the best results will be obtained by answers to definite questions (*E.T.*, Vol. II, 1926, Sec. 59 (3), and *F.S.R.*, Vol. II, 1929, Sec. 30). This will apply in the case of foreseen tasks. At the same time all personnel employed in reconnaissance work must be prepared, by intelligent observation, to furnish information not specifically asked for—the unforeseen task. To do this they must be given all the information available and a reasonable idea of the engineer commander's plan (*Cavalry Training*, Vol. II, Sec. 77). The importance of the time factor applies equally to all forms of reconnaissance.

As has been stated above, the most difficult tasks are those arising during an advance into enemy or little known territory, of which the main are :—

(*a*) Water supply—report on facilities, capacity and condition of existing developed supplies and location of new sources.
(*b*) Passage of obstacles—bridge sites and approaches.
(*c*) Reports on existing bridges—strength, state of repair or extent of damage.
(*d*) Reports on captured engineer material and local resources.
(*e*) Reports on possible landing-grounds for aircraft.
(*f*) Location of land mines, etc.

The time in which engineer constructional work can be carried out depends largely on the time taken to get materials to the site. Any method of saving time is, therefore, important—early information sent back, use of local materials, etc. In highly-civilized countries, engineer requirements can be largely foreseen or estimated by the other means mentioned in the problem, and dumps of material made in advance at some suitable point such as an area park or railhead. Reconnaissance is still required, however, to fill in the details of the picture—the nature of the site and its approaches, the best route, additional material required and so on. Early information on these points means that the M.T. carrying the materials can get on the

move earlier and may escape the inevitable road congestion in rear of an army. It is not suggested that all this is the responsibility of a reconnaissance party, as the site for a bridge, for instance, will be decided by the General Staff, probably after personal reconnaissances by G. and the C.R.E. Nevertheless it is on the data sent back by the forward parties that the latter reconnaissances will be based and much time will be saved if these data are furnished early and accurately.

An example of the importance of this point is provided by Captain Daldy, in his contribution to *The R.E. Journal* of September, 1933, "How Soon can you Guarantee to Complete a Medium Bridge?" In his conclusions, he admits that the time taken to get the materials to the rendezvous is the longest and most difficult to assess. Skill in reconnaissance is the means by which this time can be reduced and the force commander given a reasonably accurate estimate as early as possible. Although Captain Daldy deals with a mechanized R.E. unit, the principles will apply equally to a non-mechanized force.

So far we have dealt with tasks during an advance only, but reconnaissance will also be required in other phases of operations, particularly during a retirement. Here the important tasks for reconnaissance will be :—

(*a*) Demolitions.
(*b*) Creation of obstacles to the enemy's advance.
(*c*) Means to facilitate withdrawal.

The majority of these tasks will be foreseen and reconnaissance parties given definite questions to answer.

Method of Employment.

The principles of reconnaissance and the duties of the leader of a reconnaissance party, as laid down in *F.S.R.* and the training manuals of other arms, will apply in the main to engineer reconnaissance also.

In the case of large formations, reconnaissance may be ordered by the C.E. of the Corps, who will allot tasks and co-ordinate results, but responsibility for technical reconnaissance rests with the C.R.E. of the division (*E.T.*, Vol. II, Sec. 51 (2)).

Let us consider again our most difficult task, reconnaissance during an advance. For early information engineer reconnaissance parties must be as far forward as possible and should accompany either the advanced guard mounted troops or the vanguard, depending mainly on the degree of protection required. It must, however, be understood by all arms that these parties only accompany and do not form part of the body of troops concerned. Engineer work required to assist the progress of the advanced guard is the duty of the

engineers definitely allotted to it, a portion of whom will usually form part of the vanguard. *F.S.R.*, Vol. II, Sec. 38 (7), is quite clear on this point. It is nevertheless occasionally found in *T.E.W.T's*, and schemes that engineer reconnaissance parties are referred to as if they were units of the advanced guard. The duties of reconnaissance parties, particularly those with foreseen tasks, may carry them some distance from the main march route or may necessitate bounds from one reconnaissance task to another, which by no means coincide with the movements of the advanced guard. The only reference in the orders of the advanced guard commander should therefore be that " an engineer reconnaissance party is accompanying the vanguard " (or " advanced guard mounted troops," as the case may be). It should not, for the reasons given above, be included in the detailed distribution of troops or the march table.

A concrete example will serve to illustrate this point. Consider a division advancing, with one brigade group (including a field coy.) as advanced guard. Engineer reconnaissance is ordered by the C.R.E. and the party (or parties) required found from the two field coys. with the main body. This should preferably be included in the divisional order for the march. The advanced guard commander will almost certainly allot a section of his field coy. to the vanguard. There will thus frequently be two engineer officers with the leading troops, the officer in charge of the reconnaissance party and the section commander; but this is not a duplication of duties, since the former will have the definite tasks allotted to him by the C.R.E., while the latter is tied to the vanguard and the line of march. The reconnaissance party will, of course, pass on any information obtained to the field coy. with the advanced guard (and *vice versa*), probably by the messenger carrying the reconnaissance reports to the C.R.E. showing them to the field coy. commander on his way back. This will save time, since the majority of such reports will include sketches or diagrams not easily duplicated.

As regards the detailed employment of the party, it may frequently be necessary for two or more interdependent tasks to be carried out simultaneously. Thus, while one member of the party is examining a damaged bridge, a second may be sketching a site for a temporary bridge, and a third making a list of important material and stores found near at hand in an enemy dump, railway station or factory. Again it may be necessary for two alternative sites to be reported on by the same party. These conditions must be borne in mind when considering the strength of the party to be detailed.

Means of Communication.

It is essential that every engineer reconnaissance party should have its own means of communication (by messenger) with the

officer who ordered the reconnaissance. The reasons for this will be obvious when the following points are considered :—

(*a*) The communications of the advanced guard will be fully occupied and the engineer party will probably not be in close touch with them.

(*b*) Engineer reports will contain much technical detail, sketches, etc., which preclude their being sent by any means other than by hand.

(*c*) There is a considerable advantage in the report being carried by a man who has seen the task and can answer further questions if required.

The time factor demands that the messenger should have some form of transport, cycle or motor-cycle (or, in the case of a field troop or squadron, horse). Two such dispatch riders, as we may call our messengers, are desirable for each party, and if mechanized highly mobile forces are operating, motor-cycles will be essential. The mechanized field coy. has an increased establishment of motor-cycles, but a non-mechanized coy. should, it is considered, also have more available.

Composition and Organization.

(*a*) *Personnel.*

The strength and composition of a reconnoitring detachment is considered in *Cavalry Training*, Vol. II, Sec. 15, and this appears a good basis for us to work upon. Personnel required are divided into three categories :—

(1) Men to reconnoitre.
(2) Men to carry messages.
(3) Others—guides, interpreters, etc.

At the same time " it must be remembered that the number of engineers available for reconnaissance duties is limited " (*Engineer Training*, Vol. II, Sec. 59 (3)).

The number of men to reconnoitre in each party will depend on the number and magnitude of the tasks allotted to it, and also on whether time demands that two or more tasks have to be carried out simultaneously. It will be realized that any factor which tends to speed up the reconnaissance will also tend to reduce the number of men required. Such factors are : motorization of transport for the party and a high standard of training of the personnel. The question of transport is an important one and will be returned to later.

It would appear that the minimum number of " reconnoitrers " under normal conditions is probably 1 officer and 2 N.C.O's or Sappers, though with the two factors referred to above in full operation 1 officer and 1 N.C.O. might be sufficient.

As regards message-carriers, it has already been estimated that two dispatch riders should be provided, with motor-cycles if possible. It will be a great advantage if these men also are trained " reconnoitrers."

The number of " others " will vary and will depend partly on the form of transport.

(*b*) *Transport.*

E.T., Vol. II, Sec. 59 (9), tell us that " Officers of Field Companies are mounted for reconnaissance duties." It is doubtful, however, whether a horse is the ideal mount for work such as is here visualized. A horseholder would be essential but is not catered for in war establishment. Presumably the remaining personnel would, under present conditions, have to be mounted on the company bicycles.

It is suggested that a better method would be to provide each field company with a light car for reconnaissance work. Such a car could carry up to four persons—a driver, 1 officer, 1 N.C.O., and (if required) a guide, interpreter or additional reconnoitrer. If this scale is considered too lavish, one or two cars might be provided for the divisional engineers, to be allotted by the C.R.E., as required. There seems to be at least as good a case for this car as for the survey and reconnaissance cars of an artillery brigade.

Such a means of transport gives this reconnaissance party both speed and mobility. It may be argued that a car would not be popular with an infantry vanguard, but, as already pointed out, this reconnaissance party will normally carry out its work by bounds, from one task to another, need not move at all until its first bound has been made good by the forward troops, and can often use routes other than the main line of advance. Unforeseen tasks on the line of march could not, of course, be carried out by this means, but such reconnaissance can safely be left to the engineers with the advanced guard who are primarily concerned with it.

Training in Peace.

It is with diffidence that one suggests any addition to an over-full training programme, and training in reconnaissance is already part of the normal training of the individual N.C.O. and promising Sapper (*E.T.*, Vol. II, Sec. 11 (2) (ii)). When the multiplicity of items in individual training is considered, however, it seems doubtful whether much instruction beyond the elementary stage can ever be given in the section or company. What is, therefore, suggested now is that special instruction for selected men should be carried out, with a view to raising the standard of reconnaissance work to the level it is considered that modern warfare demands. If it is important for every engineer unit to have its specialists in musketry,

Lewis-gunnery, anti-gas and the like, surely it is equally important to have experts in one of its first and most important jobs in war —reconnaissance.

How is this training to be carried out? It is, of course, essential that every N.C.O., as before, should learn the groundwork of reconnaissance, *i.e.*, map-reading, sketching and writing reports, in his own unit. One or two selected men should then be given further instruction calculated to make them expert in the preparation of reports and sketches, and to develop their powers of observation and initiative. Skill in reconnaissance requires constant practice in the carrying out of definite tasks and men who have been specially trained can be given such practice periodically. The special instruction referred to above should, it is suggested, be carried out annually under the C.R.E.'s supervision, a suitable class being six to eight men from the Divisional Engineers. Further centralization might result in greater uniformity, but the number of men who can be properly instructed at one time is limited. In India such classes are, however, best carried out at the headquarters of Sapper and Miner Corps.

Each unit should then have always in its ranks some half-dozen or more trained men, from which its reconnoitrers and also, if possible, its dispatch riders can be selected.

The further stage of training now suggests itself—the reconnaissance party, working as a unit, and carrying out definite tasks. This might be a regular feature of the collective training programme. By this means will be obtained not only skill in reconnaissance, but speed in transmission of reports and the confidence engendered by team-work.

CONCLUSION.

What has, in effect, been suggested above is that each field unit of engineers should have an intelligence section properly trained and organized in peace to carry out engineer reconnaissance. Its duties in war will be mainly concerned with foreseen tasks, which, except perhaps on the N.W. Frontier of India and similar terrain, appear to be the most likely to arise under modern conditions.

In concluding this plea for a study of the problem, stress must again be laid on the importance of engineer reconnaissance. The whole tactical plan of the commander may depend on the rapid solution of the engineer situation involved, and this solution will itself depend largely on the accuracy and speed of collection of engineer information.

A SWIMMING POOL AT TIENTSIN, CHINA.

By MAJOR G. MACLEOD ROSS, M.C., M.ENG., A.M.INST., C.E., R.E.

IN April, 1932, the 1st Battalion, The Queen's Royal Regiment, decided to expend certain funds at their disposal on a swimming pool for the use of the troops in Tientsin. A suitable site was chosen within the barracks and the Royal Engineers were commissioned to design and supervise its construction.

The funds available not being large, the dimensions of the bath were limited to a length of 45 feet and a width of 21 feet, whilst the depth varied from 4 ft. 6 in. to 8 ft.

The site chosen was in the south-west corner of the Barrack Square, between the walls of the tennis courts and the R.E. Yard. Placed thus it was certain to be extremely accessible for the bulk of the troops of the garrison.

The design adopted was as shown in the sketches. The section of wall had to be capable of withstanding thrust in two directions, since the summer water table level is very high. The floor being on a slope was anchored by means of three beams protruding below the underside of the floor, and running across the width of the pool.

A very careful specification was got out, based on the experience of the Municipal and Water Engineers to the British Municipal Council. It will be noted that it was clearly stated that the tank must be watertight. This is a requirement which is occasionally left out of reservoir and pool specifications, and may result in considerable loss to the promoters when the tank is tested and found to leak.

It was also decided to eliminate the use of any patent waterproofing compounds and to rely solely on grading the aggregate carefully. A time-table (Clause 46 of the Specification) was produced to cover the placement of the concrete, and it provided that the floor should be poured on one day and the walls on a second, continuous working being required on each day.

On the practical side the only problem which gave occasion for much consideration was the point at which to make the break in pouring, as between floor and walls. It was decided that this must be at the smallest possible cross-section, having regard to the question of suitably supporting the shuttering. Photo 1 indicates the shuttering erected to pour the floor, and some ingenuity was required to support the inner inclined portion of shuttering suitably.

The shuttering, as shown in Photo 2, together with the framework necessary to support the boarding to be required on the second pouring day to contain the concrete for the walls, was erected as soon as the excavation was complete. The steelwork followed. This required most accurate checking and wedging out to ensure the specified cover of concrete over the rods, and a full week was spent in setting the considerable and complicated steel frame in its correct position.

All aggregate and cement was dumped on the site and carefully measured to ensure that sufficient was available.

China is the country par excellence in which unlimited labour is always available, and it is still the custom to deal with the mixing and placing of large masses of concrete by manual labour. On this job, in order to ensure proper mixing, to reduce the skilled supervision, and to ensure that floor and walls should be placed respectively during the hours of daylight of two working days, a concrete mixer was insisted upon. Emergency lighting was also to hand, in case of breakdown, and forced recourse to hand-mixing. As it proved, this was nearly required, since, when pouring the floor, the mixer's ancient prime mover failed, and during the final spell, from noon to seven p.m., hand-mixing was done. In spite of this mishap the whole of the concrete was got in just before dusk.

The labour was carefully organized into mixers, carriers, and rammers: these in their turn being followed up by the masons, who trowelled the surface of the floor as soon as it was sufficiently dry.

For the benefit of those who have never had the pleasure of seeing a Chinese organized job in progress let it be said that in spite of mechanical mixers the job is always black with labour. Starting at six in the morning a never-ending stream of coolies carried wet concrete from mixer to floor. From time to time they were urged to greater efforts by the bloodcurdling yells of their foreman. At noon a completely fresh gang was put on, whilst the original crowd took food. Throughout the heat of the day these gangs worked without a break, their only sustenance being a hastily-snatched drink from the water-butt supplying the mixer. Skilled supervision was provided in the form of two reliefs each of an officer and a clerk of works, one directing the mixer, the other the ramming.

The subsequent placement of the wall concrete followed according to programme, and, being of less volume than the floor, was more readily accomplished.

Probably the best tribute to the care and skill with which the job was put through, is to be found in the examination of the concrete after the shuttering had been stripped, and on testing the pool for leakage. In the first case it was found that the ramming had been done so conscientiously that the walls were absolutely clear of air holes and required no attention with trowel and mortar whatsoever.

1.—Pouring the floor.

2.—Pouring the walls.

A swimming pool at Tientsin, China 1-2

3.—The completed pool, showing shower baths, etc., in the right hand corner.

4.—The completed pool from the deep end.

A swimming pool at Tientsin, China 3-4

As regards leakage, it was found that the care in grading had resulted in an absolutely watertight job.

Water for the pool is taken from the municipal supply, which comes from tube wells 400 feet deep and semi-artesian in character. Water costs 60 cents per 1,000 gallons. The bath contains 27,000 gallons, and the water is changed about twice a week. The R.A.M.C. look after the chlorination daily, and a mild solution of copper sulphate is used to prevent fungus growth on floor and sides, and in addition imparts a pleasing greenish-blue colour to the water.

This job was put out to competitive tender on a design and specification only, and the lowest and accepted tender was that put in by the Triennial Contractor. In consequence the skilled supervision was much assisted, since it dealt with a Chinese staff with whose work it was already familiar. The tender price was $4,500, or about £300 at the current rate of exchange. Certainly no one has ever had a pool built for them at such low cost, including as it did pool, diving-stage, drains, water-supply, dressing-bench and pegs, shower baths and urinal.

Recent advices indicate that the United States Army Troops in Tientsin propose to follow the excellent lead given them by the Queen's Royal Regiment, and intend to establish a pool within their compound in 1934. It is also gratifying to learn that they are considering the adaptation of the design prepared for the British pool.

CONSTRUCTION OF A REINFORCED CONCRETE SWIMMING POOL AT THE BRITISH INFANTRY BARRACKS, TIENTSIN.

Abridged General Conditions.

Examination of Works.

1.—All parties tendering are required to carefully examine the plans and sections in addition to the Specification and ascertain for themselves the peculiar nature and value of the different works, and to include for the same in their tender, as no allowance whatever will be made for any alleged deficiency of description.

2.—Omitted.

3.—Omitted.

4.—Omitted.

Plant and Materials.

5.—The Contractor shall provide all plant, tools, tackle, shoring, staging, labour and materials necessary for the completion of the works. The Contractor shall occupy only such area as the O.C.R.E., Tientsin Area, may direct.

Imperfections.

6.—If at any time during the progress of the works or within the period of maintenance, any imperfections or insufficient workmanship shall appear, the Contractor shall forthwith make good the same at his own expense, the true intent and meaning of the Specification being that the whole of the works shall be delivered up to the Officer Commanding 1st Battalion Queen's Royal Regiment, properly and completely finished and perfect in all their parts and in conformity in every respect with the contract.

Accidents and Damages.

7.—The care of the works and of every part thereof during the progress of the same, and until the O.C.R.E. Tientsin Area, has certified that the whole of such works have been executed and completed to his entire satisfaction, and for and during the "period of maintenance," shall remain with the Contractor, and the Contractor shall be held responsible for all the accidents arising from any cause whatsoever, whether the same shall happen to servants or employees of the Contractor or to other persons or property, and be chargeable with all risks attending the execution of the work.

Foremen.

8.—The Contractor shall keep upon the works thoroughly competent foremen, at least one of whom shall be conversant with architectural drawings and can speak and understand English.

9.—Omitted.

10.—Omitted.

ABRIDGED SPECIFICATION.

Scope.

11.—This contract is for the construction of a perfectly watertight reinforced concrete swimming bath, and it is understood that acceptance of his tender implies that the Contractor undertakes to construct such a watertight enclosure, payment for and acceptance of the work being dependent on this essential condition being attained.

Excavation.

12.—The Contractor will excavate and stack the spoil as directed for returning round the bath walls. No spoil will be removed off W.D. land unless ordered. Excavate all trenches for drain or water pipes, minimum invert level being four feet below top of British Municipal Council manhole shown on plan. No earth to be returned around walls of bath until bath has been finally tested and proved watertight to the satisfaction of the O.C. R.E. Tientsin Area.

All returned earth to be well rammed and watered in six-inch layers.

Shoring.

13.—Supply all necessary shoring and centering and undertake any pumping necessary to ensure the whole of the work, brick filling or concrete being put in "in the dry."

Centering.

14.—The frames of the centering shall be built up of planks of not less than one and a half inches in thickness and shall contain as many braces as may be necessary to prevent undue deflection from the weights of the freshly-laid concrete. The lagging shall be carefully close-jointed and fastened with sunk nails or screws. The centering or other false-work shall be planed smooth under all exposed surfaces or concrete and shall receive a coat of oil or whitewash. No centering shall be removed without instructions in writing from the O.C.R.E., Tientsin Area, and in no case within one week of date of completion of concrete laying.

Broken Brick.

15.—Broken brick to be of approved local stocks, broken to two-inch gauge. No broken brick shall be laid until the excavation has been inspected and approved by the O.C.R.E., Tientsin Area.

Reinforcement.

16.—The reinforcement shall consist of medium steel reinforcing rods as shown on the drawings. Particular care must be taken that all bars are cut and bent to the exact lengths and shapes required. Welding will on no account be permitted.

17.—Joints where unavoidable shall be given a "lap" of at least twenty-five times the diameter of the rods joined, and they shall be wired together.

18.—All reinforcement shall be built up with iron wire of No. 22 B.W.G. so as to form a rigid framework incapable of distortion during the process of concreting.

19.—All metal shall be perfectly free from earthy or greasy matter. All reinforcement put into the moulds will be examined by the Engineer or his authorized assistant, and no concreting shall be proceeded with until the reinforcement has been duly examined and approved.

Cement.

20.—All cement to be *Chee Hsin, Onada* or other approved make.

Stone.

21.—Broken stone to be hard *Tangshan* limestone broken or crushed to required gauge.

Sand.

22.—The sand shall be clean coarse *Lungkao* or *Peitaiho* sand free from all earthy or other foreign matter.

Mixing.

23.—The mixing shall be done by machine, only a batch mixer shall be used. One machine mixer driven by electric motor, steam engine or gasoline engine, shall be kept on the job at all times during the progress of the work and maintained in good working order. It shall be of not less than one-half cubic yard per batch capacity.

Water.

24.—The quantity of water added to the mixture shall be such as to make a moderately wet concrete, the slight tamping of which will bring

the water to the surface. Special care must be taken to prevent the incorporation of any dirt, sawdust, wooden chips, etc., into the concrete.

Cement Concrete.

25.—The cement concrete shall be composed as follows (proportions measured by volume) :—

For walls and floor of bath :

1 part Portland cement.
2 parts *Peitaiho* or *Lungkao* sand.
4 parts broken stone.

Of the broken stone one-third shall be one-inch stone, one-third shall be one-half-inch stone and one-third shall be one-quarter-inch stone. The mix shall be carefully graded and after being deposited in the forms, in layers not exceeding six inches in thickness, must be thoroughly tamped and strongly rammed into place, until the water flushes to the surface, so as to make as dense and compact a concrete as possible and one which is completely watertight. The floor and walls must form a perfectly watertight enclosure and the contractor will be held responsible that the concrete is sufficiently well made so that it is watertight. Any leaks which may develop must be made good by the Contractor at his expense.

Proportioning Ingredients.

26.—All ingredients, including water, shall be accurately proportioned for each batch of concrete. Cement, sand and stone shall be measured in measuring boxes. Each batch must be mixed at least two minutes after all the ingredients are in the mixer.

Handling.

27.—All concrete must be carried in tin-lined baskets or wheelbarrows.

28.—Workmen shall not be allowed to step upon or to rest materials upon the reinforcements after it is in place, and ample run-ways for the workmen shall be provided, strongly blocked up so as to clear the reinforcement.

Transporting.

29.—Immediately after mixing the concrete must be transported as rapidly as possible and placed in the forms, concrete which has acquired initial set must be thrown away. It shall not be placed in any of the forms, nor in any part of the work, neither must it be used for re-tempering.

Pouring.

30.—After the whole of the reinforcement has been set up, checked and passed, the floor of the bath will be poured in one continuous operation. As soon as this has set to the satisfaction of the O.C.R.E., Tientsin Area, the centering for walls will be erected, after which the whole of the walls will be poured in one continuous operation, care being taken that they are built up evenly all the way round.

Finish.

31.—The exposed face of the walls and floor to be worked up to a smooth hard face with steel trowel and extra cement mortar (1 to 3). Floor to be trowelled as soon after placing of concrete as possible.

Protection.

32.—All exposed surfaces of unset concrete shall be protected against the rays of the sun with sacking or matting. After the concrete has set it shall be sprinkled with water twice a day for at least eight days. Provision shall also be made to prevent damage from heavy rainfalls.

33.—Construct cement concrete surround to bath, suitably spike-rolled to make non-slippery, currented away from bath to saucer channel, 12-in. girth.

Fresh Water Inlet Pit.

34.—Build brick inlet pit in cement mortar 9-in. walls rendered inside P.C. plaster 1 : 3 to contain water meter, valve, etc., at shallow end of bath and laying connecting pipe from pit to bath (meter, pipe and three-quarter-inch reducing tee provided and fixed by W.D.).

Fitments.

35.—Supply and fix 1½-inch galvanized iron pipe as handrail all round bath.

36.—Supply and lay six-inch cast-iron outlet pipe with suitable cast-iron grating, connect to valve (supplied by W.D.), make connection to and supply six-inch stoneware glazed Kailan Mining Administration pipe. Supply and lay four-inch stoneware glazed Kailan Mining Administration pipe from urinals and showers to join six-inch line. Supply and lay three-inch cast-iron or galvanized-iron overflow to bath to join into disconnecting manhole. All above cast-iron and S.W.G. pipe to be laid on foundation of four-inch Portland cement concrete (1 to 8). S.W.G. pipe to be jointed in cement mortar (1 : 1) and the whole system to withstand a water test.

37.—Construct manhole for valve pit on outlet pipe in nine-inch approved stocks in cement mortar rendered in ½-inch P.C. plaster 1-3 inside. Supply and fix wrought-iron rungs and cast-iron cover to approved weight.

38.—Construct disconnecting manhole all as drawing. Supply S.W.G. trap and cleaning eye and make connection to British Municipal Council manhole.

39.—Build around two sides of bath 4½-inch wall with 9-inch piers at 9-feet interval, 8 feet above ground-level, using approved local stocks in Portland cement mortar.

40.—Provide 35-feet run of seating in American pine with mat cover over and 60 wrought-iron hat and coat pegs fixed to existing wall on battens.

41.—Provide galvanized corrugated-iron lean-to roof over two shower standards. Partitions to be galvanized corrugated iron on American pine scantling. Supply and lay three-quarter-inch G.I. pipe with brass control cock from three-inch inlet pit to shower-bath. Supply and fix brass cock to control each shower, and supply G.I. and copper rose.

Shower compartments to drain into a 6 in. x 6 in. surface gully in S.W.G. with cast-iron grating.

42.—Provide galvanized corrugated-iron lean-to roof over urinal. Supply and fix two glazed ware urinal basins, flat back type (to be approved) and connect to four-inch drain.

43.—Provide and fix wooden steps into bath. To be made in Chinese oak and painted four coats white lead.

44.—Provide and fix diving-stage in American pine as drawing.

Payment for Water.

45.—All water for concrete, mortar, testing bath or any other purpose will be paid for by the Contractor at the rate of $1.00 per 1,000 gallons.

Working Time-table.

46.—The following time-table will be strictly adhered to, and the Contractor will allow for this when accepting the period (6 weeks) allowed for completion of the contract :—

Day 1. Pour concrete of floor and trowel face as work proceeds. Protect floor with damp bags.
,, 4. Final touches to timber centering for walls.
,, 5. Pour walls.
,, 11. Striker centering. Protect walls with damp bags.
,, 12. Rub down interior faces of walls. Complete outlet connection.
,, 13. Fill bath to six inches above outlet connection to test tightness of this joint.
,, 32. Fill bath half-full and look for leakage from joint between floor and walls.
,, 33. Fill bath to underside of handrail.
,, 34. 5 p.m., make up water-level as necessary to a marked point.
,, 35. 8 p.m., check water-level.
,, 36. Ditto.
,, 37. Ditto. If level has not dropped more than half an inch below the marked point earth may be filled in around sides of bath.

Test.

47.—As soon as agreed by O.C.R.E., Tientsin Area, the bath shall be filled with water to the underside of the handrail. It will be allowed to stand for forty-eight hours, after which any loss of water will be made good. The water-level will thereafter be noted at twelve-hour intervals. For acceptance the water-level may not drop more than half-inch in three days.

Clear Site.

48.—On completion the Contractor shall clear the site of all *débris*, shall trim any spoil banks and generally leave the site neat and clean to the satisfaction of the O.C.R.E., Tientsin Area.

(Signed) G. MACLEOD ROSS, *Major, R.E.*,
Officer Commanding Royal Engineers,
Tientsin Area.

Tientsin,
18-5-32.

MISHMI, 1912-13.

By LIEUT.-COLONEL W. E. BRITTEN, O.B.E., R.E.

I.

IN the year 1911, a certain adventurous officer of the Indian Army took six months' leave and went to China. Thereafter all trace of him was lost. At the end of the six months, he was definitely absent without leave, and his regiment were worried about him. Then, one day, a ragged, emaciated and haggard individual, accompanied by an equally disreputable-looking Indian, reported himself to the British Political Agent at Sadiya, in the N.E. corner of Assam. He had, he said, come across China, accompanied only by his Indian Army orderly, and had entered India through the Lohit valley; after leaving Chinese civilization, such as it was, his path had not been easy. The Chinese and Thibetans had been engaged in one of their periodical disagreements; the Chinese had suspected him of being Thibetan, and the Thibetans Chinese. He had bluffed his way through the disputed territory (in one case, it was said, by displaying a gaudy advertisement from the cover of his last English magazine, and pretending that it was a passport from a high Chinese official), and finally entered the Lohit valley, the home of the Mishmi folk. Here again his reception had not been friendly. Mishmi territory, though nominally under the control of the Indian Government, was unadministered, and almost totally unexplored, for the simple reason that it was susceptible of neither administration nor exploration, for causes which will appear later. The Mishmis, however, had seen no immediate advantage in cutting his throat, and he had been left to get through their country as best he could. So at long last he had arrived back in British territory.

Apart from such information as he had been able to gather of the peoples through whose countries he had passed, he brought back certain pieces of parchment which he had found stuck on trees along the tracks in the Mishmi country. These were Chinese proclamations, and to him unreadable, but translated, they turned out to be proclamations calling upon the "Monkey Folk," as they rudely called the Mishmis, to look not to the British Rani (*sic*) for their help and succour, but to the much more powerful Chinese, who would shortly be passing down that way.

Now in all probability the Government of India had reason to

believe that this might be no idle threat. To any armed force, burdened with impedimenta on the western scale, the country was as impassable as thick jungle, precipitous hillsides, and unfordable rivers could make it, but the Chinese had already shown that they could march armies prodigious distances, through terrible country, and still strike a blow at the end of them. As witness the slant-eyed Hazaras of Afghanistan, descendants of a Chinese army of occupation of a few centuries back. At any rate, our explorer was publicly reprimanded for overstaying his leave, and privately thanked for the information received, and in the autumn of 1912 a little expeditionary or road-making force composed of two Companies of Sappers and Miners, and two Companies of Pioneers, assembled at Sadiya in N.E. Assam for the purpose of cutting a mule-track up the Lohit Valley, through the Mishmi country and up to the Chinese frontier, in order that the Mishmis might be subjected to a little counter-propaganda, and the Chinese politely told to keep their own side of the fence.

So much for what was commonly believed to be the *raison d'être* of the expedition. The writer has been able to trace no official confirmation of this story, and it may have been the sheerest fabrication on the part of his informant, an Assistant Political Officer at Sadiya, but at any rate it will serve as an introduction to the chronicle of the adventures of the Mishmi Road Expedition.

II.

In October, 1912, the 20th Company, to which the writer was attached from Military Works, was at Kirkee, when it received the orders to mobilize. This is a comparatively simple operation for an Indian Field Company, since except for two extra British officers, and its 2nd-line transport mules, its peace and war establishments are identical. The two extra British officers duly joined, and the Company officers were then Paris (O.C. Coy.), Richardson, the regular subaltern, Bamberger, and the present writer. The two latter were persuaded to entrain without any special difficulty, but not so the 2nd-line mules, who may have had some inkling of what was in store for them. At any rate, the junior subaltern learnt a lot of Hindustani words which he had not come across when working for the Lower Standard a few weeks before, and was particularly struck with the *drabis'* (Indian drivers') apparent acquaintances with their charges' ancestry, especially on the female side.

The ten days' journey across India was uneventful. In those days Indian troop-trains ran to somewhat leisurely timings, which included a daily halt of four hours during which Indian ranks cooked food for the following twenty-four hours. It was during one of these halts that a newly-joined mule ran amok. It had been decided, perhaps somewhat rashly, to get all the mules out and exercise

them. This particular mule, perhaps maddened by the sunlight after several days' incarceration in the dark, seized a driver's hand in its jaws, and hung on like a bulldog. It was an unpleasant sight. The mule stood like a rock, while several men held up the wretched driver, fainting from pain and fear. Every expedient was tried to induce it to open its jaws, but without success. Finally, it had to be thrown, still holding on to the driver's hand, and its jaws prised open with steel wedges obtained with considerable difficulty from the Company equipment, of course right underneath everything else in one of the railway vans. The driver bore the ordeal with marvellous courage, but unfortunately had to be left behind for skilled medical attention at the first military cantonment. The only other casualty was a Sapper who insisted on sleeping with his feet out of the carriage window. Another train removed the best part of one foot, and he, too, had to be left behind.

Otherwise the Company was intact when it reached Saikhwa Ghat on the Brahmaputra, whence it was conveyed by stern-wheel steamer four miles up to Sadiya, the base of the expedition.

III.

For the first fifty miles the road lay through the plains, a dense jungle of mighty trees and thick undergrowth. Only a track existed, and this had to be improved for S. & T. carts, and the few rivers bridged. These rivers contained at this season only a trickle of water, but their channels, and the *débris* high up on their banks, showed what they would be like in the rains—unfordable and unbridgeable. No effort was, therefore, made to put anything but temporary bridges of trestles or crib piers over the actual water, work for which ample seasoned timber in the shape of uprooted trees lay ready to hand.

It was during this stage that the first Mishmis were seen. They were friendly enough, but not attractive. Of slightly Mongolian features, they were indescribably dirty and unprepossessing, and their language a succession of grunts obviously beyond the capacity of any member of the force to learn in the short time available. Small parties of five or six, including women and children, would stand for hours watching the Sappers work. All smoked, including the children, and were seldom seen without pipes in their mouths. Many had goitres, which did nothing to improve their general appearance, but these did not appear to inconvenience them in any way, and we saw none of the cretins so common amongst European hill-folk who are afflicted with these growths.

Although the Mishmis of the lower hills, of which these were specimens, were said to be happy folk, never known to work, fight, or wash, military precautions were neither at this stage nor subsequently entirely relaxed, and at successive stages up the road strong

stockades were built and guarded by small detachments of Gurkhas or Assam Military Police. Farther up in the hills, the Mishmis were said to be a more turbulent folk, but it can be said now that unfortunately they never showed any symptoms of hostility to the little force in their midst—unfortunately—because their failure to do so undoubtedly deprived all ranks of the frontier medal which would otherwise have been their perquisite. Incidentally, it would also have done something to lessen the monotony of long and arduous days of work on the road, unbroken even by an occasional day's *shikar*, in spite of the fact that the country was full of game, and the rivers of big *mahseer*, all unused to the wiles of man.

In fact, the only holiday that can be remembered throughout the expedition was Christmas Day, when Company Sports were held. These attracted a large audience of Mishmis, who watched the exertions of the Indian troops with impassive faces and in complete silence. All efforts to induce them to show their own physical prowess entirely failed. A scramble for coins or biscuits attracted a few of the more daring small boys, but as this quickly degenerated into a free fight for all, it had to be hastily terminated. Only the greasy pole aroused any obvious interest. No Sapper succeeded in getting more than half-way, and as each man staggered and fell into the water, the Mishmi sportsmen grunted, and their women-folk squealed with joy. After about half an hour, the prize was still unclaimed, when a Mishmi pushed his way forward, lit his pipe, climbed on to the pole, walked out to the end, removed the prize, and walked back, still smoking his pipe. After the natural high roads of the Mishmi country, artificial greasy poles were apparently easy money.

IV.

Fifty miles from Sadiya the plains section ended, and in mid-November the Lohit valley proper became our highway. This was everywhere a gorge, with more or less precipitous and jungle-clad banks. The north bank had been chosen for the road, which ran throughout its length fairly close to the Lohit. As the hills ascended from the river-bed up to the highlands of Thibet, with occasional small plateaux on which the Mishmis built their villages and planted their scanty crops, it followed that the farther we got from the river, the higher was our road, and to avoid steep gradients every effort was made by the laying-out party to keep as near the river as possible.

As soon as the force had got into the foothills, the work very quickly sorted itself out. Upon the Pioneers fell the bulk of the pick and shovel work, and the cutting of trees and undergrowth; upon the Sappers the more difficult rock work necessitating blasting, and the

bridging of the streams which ran from the north into the Lohit. The Pioneer Companies leapfrogged through each other as they completed their stages, the Sappers going right ahead to deal with their longer tasks, the two Field Companies being seldom together. Ahead of everybody, but seldom more than a day's march, went the laying-out party, consisting of Bocquet with a small escort and a few Sappers to clear or otherwise mark the alignment.

Very early in the proceedings it became obvious that the Mishmi track would be of little assistance. This track was made and used by people who went bare-footed, and carried their loads on their backs supported by a brow-band. This meant that they went practically on all-fours over any difficult place. Many such places were steep rock faces, and the track merely a series of fissures offering foot- and hand-holds, or the trunks of trees supported by shorter logs wedged into the fissures—in all cases quite impassable to Europeans or Indians wearing boots, and unaccustomed to progressing on all-fours. When the track came to such a place, it was necessary to take the road either above or below the rock face by a series of zig-zags, and when this was impossible to blast a track out of the rock itself. On several occasions the latter procedure necessitated the suspension of logs from crow-bars driven in higher up, the Sappers working their jumpers from this precarious platform, with an almost sheer drop of several hundred feet below them.

The splitting up of the force into detachments, each working independently from its own camp, soon involved transport difficulties. Mules could only get through to road-head, and all detachments ahead of it must be supplied by other transport. Thus it became necessary at an early stage to enlist the help of the Mishmis as porters, and this proved to be a matter of some difficulty. The force had no efficient interpreters—a smattering of Assamese common to one or two members of it and to a few Mishmis, was the only means of communication—and in addition payment was difficult. The Mishmis apparently did most of their trade, such as it was, by barter between Thibet and N.E. Assam, and money had little value for them. They would certainly recognize no coin smaller than the rupee, and payment in these soon led to currency troubles. A certain amount of trade goods had been taken up, in the hope of recovering from the Mishmis some of the rupees paid to them, but this had little success. The reason for this was somewhat curious. It was seen that the Mishmi women-folk were commandeering the rupees, drilling holes in them, and hanging them in necklaces round their necks. Now the adornment of one's women-folk with expensive jewellery may be a strong inducement to work amongst the men of civilized nations, but it was evident that in male Mishmi circles such an idea was regarded as sheer foolishness. If the ladies wanted more rupees, they could

go carry loads for them. As for themselves, they would stay at home, keep an eye on the pigs and the children, and smoke, grunt, and scratch, the three national pastimes. Feminine vanity thereafter was responsible for supplying a very small number of porters, and as these soon proved insufficient for the force's needs, porters were enlisted in the Naga hills, and sent up the road.

The arrival of the first contingent of these gentry caused a sensation amongst the Indian soldiery. The Nagas arrived carrying a long length of S.W.R. cable for the first suspension bridge, an impossible load for pack transport. There had been rumours of the possible arrival of Nagas, a race whose national sport was said to be head-hunting, but the Sappers, decent men, had few ideas about the savages they were to consort with until they saw them arrive, swinging round a bend in the track, with the cable, like a long snake, on their shoulders. Their dress consists of a piece of string which supported, at the back a large *dah*, and in the front a very short and very narrow strip of ribbon, grotesquely inadequate except as a gesture, a snap of the fingers in the face of Aryan convention. There might be two opinions about cutting off heads as a sport, thought the soldiery, but about that sort of thing—distinctly and emphatically no. Thereafter the Indian ranks treated them with a lofty contempt which fortunately the Nagas did not appreciate as such.

The Nagas did not rise in popular estimation by their behaviour on their first night in camp, which there happened to be on the bank of the Lohit. Dropping their loads of wire, the Nagas to a man made a silent rush down to the water's edge. There they were seen to be turning over the larger boulders pouncing upon something that they found underneath, and popping it into their mouths. Closer investigation showed that the something was the largest and most repulsive-looking green slug that Western imagination can conceive. But this was only the *hors d'œuvre* of their evening meal. The *plat du jour* came after their Government ration of rice. This was a large and mangy dog, probably bought or looted from a Mishmi village on the way up. The unfortunate animal was knocked on the head, barely singed over a wood fire, and then devoured with horrible completeness. It was not a good introduction to our new transport, but it must be said that they worked well, gave little trouble, and showed little inclination to take Indian or Mishmi heads. They were also very cleanly in their personal habits other than eating, possibly thereby showing their foolishness, since everyone else in the country, except the Mishmis, suffered severely from the bites of a particularly poisonous little fly. This fly frequently settled on the Mishmis, but was seemingly unable to penetrate their tegument of dirt; at any rate it caused them no apparent inconvenience.

V.

In mid-December the 20th Company began their first suspension bridge. Unfortunately the writer has lost all technical details as regards spans, size of cables, etc., but a general description of this and subsequent bridges will suffice to show the nature of the work.

First, as to site. As all indications showed that during the rains all the rivers rose to incredible heights, it was necessary to find a site where the piers would be well above flood-level, and hence a narrow gorge was preferable. This, on the other hand, caused difficulties as regards anchorages for the cables, and, unless rock suitable for crowbar anchorages was available, a compromise between a precipitous gorge and a lower and more vulnerable site nearer the water's edge was inevitable. This often necessitated a detour of several miles before a suitable site could be found.

Next, as to materials. As has been described, S.W.R. for cables and slings was carried up by porters. This together with bulldog clips, spikes, nails, and mild steel bars, worked up by the Company blacksmiths into screwed eye-bolts for slinging the transoms, was all that was supplied from the base. All the timber was selected from dead and well-seasoned trees cast upon the banks by previous spates, and was then sawn up into the scantlings, required for transoms, road-bearers and decking, by the Company sawyers.

The production of the large amount of timber required was, therefore, the deciding factor, and the sawyers were kept busy at their trade from dawn till dusk. Even then, each bridge took from fourteen days to three weeks to complete. The biggest bridge was 300 feet in span. The bays were 8 feet, and width between ribands 6 feet. They were calculated to carry pack mules in single file.

Six such suspension bridges were built, three by the 20th Company, and three by the 6th Company.

On first arrival at the site of some of these bridges, it was first necessary to get a party and an S.W.R. and traveller across the river. The only means of doing so was the Mishmi bridge. This was merely a cane ring traveller sliding on four or five jointed canes, each as thick as one's finger, stretched between two stout trees. After tying a bunch of leaves in the top of the ring where it bore on the canes, there to be crushed and act as lubricant, one climbed head first into the ring, head towards the other bank, looped one's legs over the canes, and hauled oneself across (see Photos). Progress was comparatively easy until the lowest spot was reached, thereafter it was a stern uphill pull, although the Mishmis got a thrust on the canes with their bare calves, and made very light work of it. They were also careful to look ahead for the joints in the canes. These were made by lashing two overlapping lengths of cane together for several inches. When

the sliding ring met one of these joints, it would stop with a violent jerk, and the unsuspecting passenger would narrowly escape being shot out, to fall a hundred feet into the rapids below. The Mishmi, however, was prepared, and by pulling down on the cane with the joint, allowed the weight to be borne by the remaining canes.

Volunteers to cross such bridges were rare. One havildar who volunteered looked down half-way, lost his head, and stopped, powerless to move hand or foot. Rescue was out of the question, since the "bridge" would not carry two. At last, after several minutes of sickening suspense on the part of the spectators, he pulled himself together, and completed the journey.

VI.

By January 21st road-head was some forty miles up the Lohit valley. Progress was slower than had been anticipated. A mile in two days, falling to a mile in three days, would obviously not carry the road up to its desired end, the Thibetan or Chinese border, then believed to be at Walong, some seventy miles further on. Hitherto the weather had been friendly, but now it showed definite signs of breaking. The Government of India, prompted by the Government of Assam, gaily talked of April or May as the months in which the rains would start and make further progress impossible, but by the end of January signs were not lacking that this estimate was hopelessly optimistic. A rainfall variously put at from 200 to 350 inches per annum, falling upon a jungle-clad hillside of steep shale, showed that the making of a *kucha* road could be a heart-breaking operation. Even the preliminary rainstorms caused big landslides, in which huge sections of the hillside avalanched down into the river-bed, carrying with them in several cases mule convoys, or working parties, luckily with few serious casualties, except to the force's morale.

The supply problem also began to get serious, owing to breaks in the road, and to sickness amongst the mules through overwork. It had proved impossible to live on the country. The Mishmis were lazy, and grew only enough for their own requirements, and nothing would induce them to sell grain or livestock to the force. The livestock consisted chiefly of pigs, of little use to a force largely composed of Mohammedans; most of the British officers had Mohammedan servants, and the expression on the faces of the *naukar-log* when one youthful Mess Secretary produced a fine sucking-pig for the Mess cured him of any further experiments on these lines. Incidentally, the close examination of a Mishmi village a few days later made him very thankful that the experiment had failed, as the pigs are the local scavengers.

From February 10th to 19th it rained steadily. Only the British officers had tents, those only single-fly, grass-roofed huts being built

Mishmi crossing cane bridge.

"Close-up" of above.

Mishmi, 1912-13

for the troops at each halt. These let in the rain copiously, and it was a marvel how the men contrived to cook their food and dry their clothes. Only the catarrh germ was lacking to make life unbearable, but luckily this had not accompanied the force beyond the first few marches, and there was consequently very little sickness.

The country also now began to appear most unfriendly. The hills were swathed in swirling mist almost down to the river-bed, thunderstorms passed interminably up and down the valley, and in the few bright intervals the hot sun awoke the myriad leeches to fresh activities. Even the telephone, at times our only link with civilization, had taken unto itself an unfriendly demon: only a field line, hung from the dripping branches, it became heavily charged with static electricity which would leap out upon any unsuspecting operator who gave it a favourable path to earth. In this wise a Gurkha officer, noted for his extremely loose and baggy shorts, entered the Mess hut one wet morning, and put out his hand towards the telephone. Whereupon the demon jumped from the instrument to his outstretched hand, travelled thence through his sodden clothes to the seat of his generous shorts, whence it leapt to the ground with a loud report, to his extreme discomfort and the spectators' merriment.

Suggestions to higher authority that the situation generally had lost its humorous aspect met with little response. The rains did not start until April, the O.C. Force (Lt.-Col. Tylden-Pattenson) was told, and any showers that we might have met with were accidents for which the Government of Assam could not be expected to accept responsibility. So on we went.

At the beginning of March one of the more serious accidents occurred. A landslide caught a working party, dropped its B.O. (Greswell) unconscious some thirty feet down the *khud*, and crushed the leg of a Sapper. Unfortunately the M.O. (Carey-Evans) was some miles back down the road, and his Indian ward orderly arrived on the scene with what he believed to be the world's finest cure-all, a bottle of ammonia emetic. This he applied externally to the unconscious Greswell, and was about to apply it internally as well, when Greswell came to, and thus probably saved his life. Luckily Carey-Evans arrived soon enough to be able to amputate the Sapper's leg successfully.

By the beginning of April, it was reported that the 50-mile section through the plain had become a sea of mud. Carts could not function, and coolies and elephants were being requisitioned to keep the L.-of-C. open. Only the barest necessities of life were coming through, the troops were on short rations, and the clothing situation was also getting serious. Many of the soldiery were bootless, and were wearing their shorts back to front. Another, and this time fatal, accident occurred, a Jemadar and a Sapper of the 6th Company being

killed by a landslide, and the situation had become so bad generally that preparations were being made to burn or bury stores, and to run for it.

Then, at the end of April, a temporary lull occurred, and for a few days it appeared as if it might still be possible to cover the remaining twenty-five miles that separated us from Walong, where the country was said to become more open, and road-making was likely to be less dangerous and heart-breaking. There was even talk of leaving a portion of the force behind, to build a stockade, and live on the country throughout the rains, but a few days later the rain started again in earnest, and this time a retreat was definitely ordered. So bad became the conditions, and so many the breaks in the road caused either by landslides or by mountain torrents in full spate, that it almost looked as if it would be necessary to abandon many of the mules, and to trust to the supplies dumped along the road to feed us on our return. Fortunately, this was not necessary, although many temporary and precarious footbridges had to be hurriedly constructed to get the mules over. Some of these consisted of a couple of trees hastily felled, and covered with a sketchy decking of smaller logs and brushwood, which whipped alarmingly under the mules as they picked their way across. Luckily by this time they were all veterans, and the hard and incessant work had deprived them of their usual sense of humour, so they crossed in safety. In places where the track had almost entirely disappeared, and they saw no sense in sliding down the *khud*, they sat down resignedly under their loads, and waited for the Sappers to do something about it.

Whatever stores remained at road-head, or at the dumps after the last units had passed through, had to be abandoned. Efforts were made to place them in charge of Mishmi headmen, but these gentlemen plainly showed by their expressions that the goods were left entirely at our own risk.

The disposal of such "medical comforts" as the force could not carry inside or out was more difficult. The Mishmis, true highlanders, had shown that they would walk many miles for a "dram," and to have left a case of medical brandy in a Mishmi village would probably have caused inter-tribal warfare. A last memory of road-head was a line of Mishmis squatting along the side of the track, heads back, mouths open, whilst the Medical Officer went along the line emptying a bottle of brandy into the open mouths as he went.

VII.

Had we then known it, our position was considerably more precarious than we imagined, as we were completely in the air. The first big bridge, a solid affair of massive crib piers filled with large boulders, across a river far too wide for a suspension bridge, had been

swept away, and no trace of it remained. Luckily, a third Field Company had been working up another valley west of the Mishmi country, and this Company was able to find a gorge higher up the river where a suspension bridge could be put across. This necessitated a diversion of many miles, but the work was completed in record time, and the Mishmi force was able to get safely back to Sadiya and civilization. By the middle of May, the weather had again cleared, and the hot sun dried the plains section so quickly that it was difficult to believe that a few days before our arrival the mules had been up to their bellies in the mud.

All desire to remain in the country had, however, left us, and after a few days in a river steamer, during which the B.O's drank enormous quantities of iced lager, and the Sappers lay about the decks and slept in the hot sun, the Mishmi country had become an almost forgotten nightmare.

Beyond the fact that neither the Chinese nor the British have seriously availed themselves of the road so laboriously hacked out of the unstable hillsides, there is little more to be said. The zig-zags lasted about seven years, and a rough track is still kept open for administrative purposes. Three of the original suspension bridges were still standing as lately as 1931, though the original decking had mostly disappeared and been replaced by the Mishmis with bamboos, placed longways down the bridge.

Otherwise the Mishmis have learned little from the Fieldworks Course given them in 1912-13. They still dislike work, smoke too much, and wash not at all, and when they feel the urge to cross a river, sling three or four canes across between two stout trees, and slide across on a cane ring traveller.

Perhaps there is method in their madness. If all our own rivers were only to be crossed in this manner, possibly our income tax would not be five shillings in the pound—and would not be collectable even if it were. Who knows?

CHANGING GROUND-LEVELS IN BENGAL.

By J. DE GRAAFF HUNTER, C.I.E., SC.D., *Hon. Member of the Institution of Royal Engineers.*

IN Vol. XLVII, June, 1933, pp. 231–241 of *The R.E. Journal*, is printed an article by Sir Sidney Burrard, entitled "Movements of the Ground-Level in Bengal," which owes its origin to a note which I published in the *Survey of India, Geodetic Report*, Vol. VI, pp. 104–106. Any criticism coming from Sir Sidney Burrard is very welcome. Having served under him for a dozen years, I appreciate his unique knowledge of the scientific operations of the Survey of India which for many years he directed so ably. When he left India in 1919, followed by Sir Gerald Lenox Conyngham in 1920, I felt that my own responsibilities were tremendously increased and that henceforth two great sources of information and guidance would cease to be readily available. That I have hitherto made no reply to this note by Sir Sidney Burrard is simply due to personal circumstances during a period of change, which have denied me until recently the necessary facilities for thoroughly going into such matters.

It was a surprise to me that Sir Sidney found my explanation of a system of spirit-levelling discrepancies so difficult of acceptance. I will endeavour to reconcile the objections which he raises. My explanation originated from the necessity of accounting for a batch of apparently contradictory observational data; it is only those who are concerned with the publication of data who can realise how very embarrassing such a situation is and how urgent it becomes to find a way of dealing with it! At first I thought my explanation was mainly a practical method of harmonizing results, but it struck me as the most interesting case which had arisen in the long history of Indian levelling. Even so, I did not perceive at once the full interest of the case.

Sir Sidney Burrard, feeling strong convictions against my theory, suggests that the true explanation is "the occasional inferiority of levelling of 1862" (p. 239). Spirit-levelling was begun in India in 1858, so it was then in its early days. If we reject the results of the period up to 1872 wherever they seem to conflict with what followed, my explanation and the need for it almost disappear. But I feel that that would be a very pessimistic thing to do; and it seems unfair to our predecessors, unless good reason can be adduced. Let us consider some of the evidence.

In 1910, Sir Sidney published Vol. XIX of the *Account of the Operations of the Great Trigonometrical Survey of India*, in which a wealth of information regarding the first level net of India, observed 1858–1909, can be found. Details of every line forming the net are given, including the values of differences of level between successive bench-marks, as found by the two levellers—for all the work was done by double levelling. From the discrepancies between results by each leveller an estimate was made of the probable error of the whole line and also of the probable error generated per mile. Unless one is to doubt the *bona fide* character of the work, which I have no reason to do, these probable errors give an unbiased measure of the degree of precision of the work. I propose to examine some of the old work with the help of this great levelling publication, which I allude to simply as Vol. XIX.

A very important circuit is that numbered XVII (Vol. XIX, p. 364) formed by the lines whose numbers are shown in brackets between the terminal stations, *viz.*, Purnea (73), Pirpainti (74), Howrah (77), Ramganj (76), Purnea. The closing error was the greatest of all the 29 circuits. What of the probable errors? Some details, taken from Vol. XIX, are tabulated :—

Line number	73	74	77	76
P.E. of difference of heights of terminal B.M's in feet...	±0·0265	±0·0498	±0·0604	±0·0263
Length of line in miles ...	36·75	251·09	351·69	68·81
P.E. per mile in feet ...	±0·0043	±0·0032	±0·0032	±0·0032
Seasons	1871–2	1862–3	1899–1902	1871–2

Deduced P.E. of circuit, accidental error only	±0·0867 ft.
Deduced P.E. of circuit, including mean systematic error found for all India	±0·256 ft.
Actual circuit misclosure	+1·466 ft.
Total length of circuit	708·34 miles

The average accidental error per mile, deduced from the whole of the level net is ±0·004 ; so the old lines bear comparison with that. But the actual misclosure is more than five times the combined accidental and systematic error expected. The betting against this is well over 1,000 to 1. It does not seem right to blame the levelling in view of its deduced P.E. ; so we must search for another explanation.

Now Sir Sidney, while discounting Calcutta as a good place for bench-marks on account of its instability, says (*R.E. Journal*, p. 236), "It is possible that Calcutta has sunk 0·20 feet in the last 50 years, but it cannot have sunk 2 feet. The mean sea-level determinations at the Kidderpore Tidal Observatory fully support this view. So the misclosure in the circuit cannot be explained by any tenable assumption of changes of level of Calcutta."

It could be suggested that the error was due to blunder in reduction of the levelling records. As regards this, I can only say that my acquaintance with the computations of the Survey of India make me consider this to be very unlikely. Moreover, a single blunder would not account for the gradually increasing (with both time and distance) discrepancies which occur.

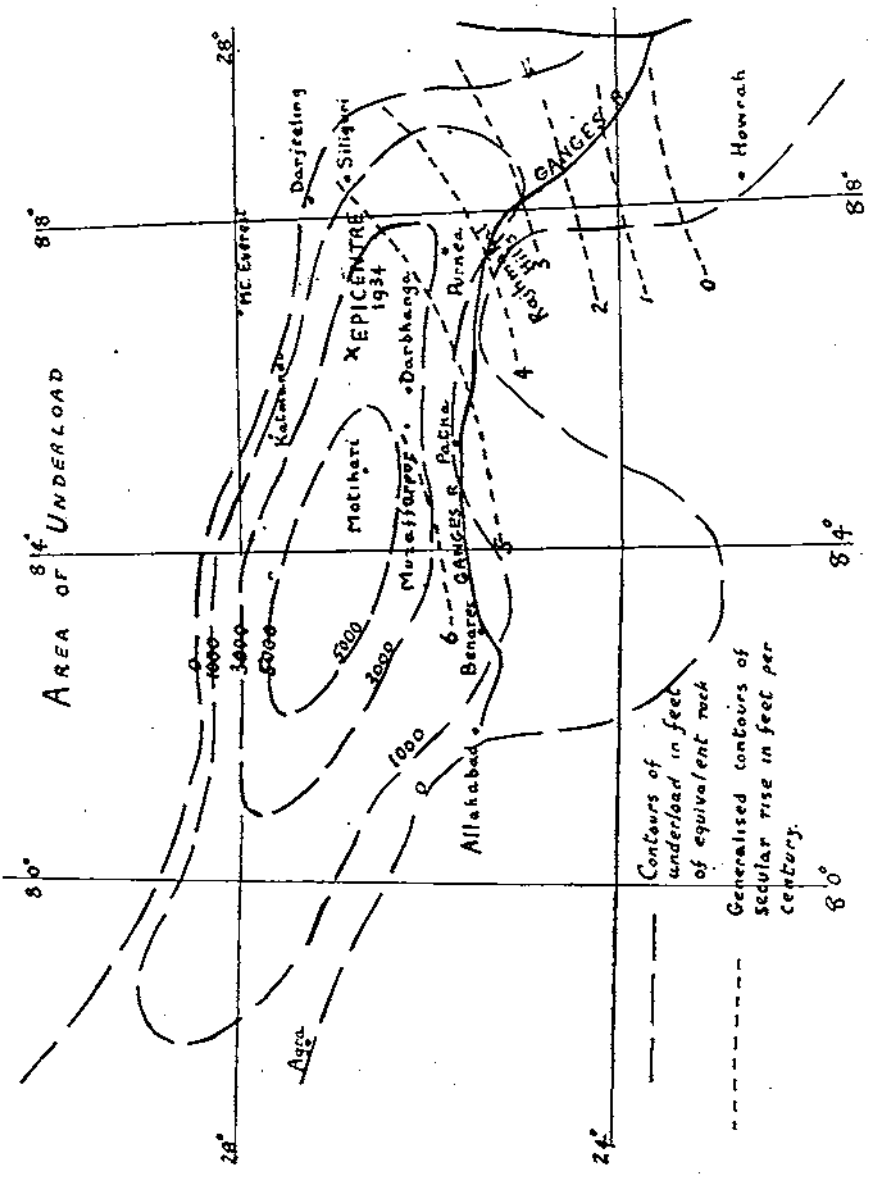
It is with this rather complex state that my proposal competes successfully, reducing the discrepancies in all cases to what might be reasonably expected in view of the precision indicated by the interior evidence of the work itself. As a mere piece of explanation of results of observation it is, numerically speaking, a great success. It is, moreover, the only plausible explanation so far suggested. In what way is it objectionable ?

Sir Sidney (p. 234) estimates that the " historic rise " of the land surface amounts on average over 5,000 years to about one foot per century. But, he adds, " the geodetic rise of the bench-marks . . . is something quite different, for the latter can only be due to an uplift from below of the rock foundations upon which the silt of the plains is resting." This is indeed my view. Why should not that occur ? So far as I understand his note, Sir Sidney considers that the suggested rise would have changed the course of the Ganges in a way different from what has actually occurred. He describes the migration eastwards of the Ganges, to join the Brahmaputra, when formerly it ran southwards into the sea.

The Ganges is prevented from responding to the changes of slopes indicated by my six and five feet per century contours by the higher land of the Chota Nagpur Plateau to the south, and it is only after passing Sahibganj (lat. 25°3, long. 87°6) and rounding the volcanic rocks of the Rajmahal Hills that it is unfettered in its choice of course. About here it crosses my 4 and 3 contours. A reference to *Geodetic Report*, Vol. VI, Chart XXI, will show the actual contours found from the levelling data, while Chart XXII represents a generalized set of contours. In the neighbourhood of Purnea the 4 and 3 contours both have an upward kink (Chart XXI) which would harmonize with the historical change of course, described by Sir Sidney. I discussed the case of this feature near Purnea in para. 8 and found some evidence of reality. Nevertheless I felt that the generalized contours of Chart XXII gave as much detail as was fully justified. Fuller data might reveal similar kinks in the 2 and 1 contours. But it would have been mere guesswork to have drawn them much differently from what was done in view of the data on which they depend. I am not competent to discuss and assess all the causes contributing to the change of course, but I believe that rivers change their courses for more reasons than changes of general level ; and the changes of level which I have suggested would amount on average at most to less than one-fifth of an inch per mile after a

century, which need not dominate a river having a fall of three inches per mile.

Geology is full of inferred risings and sinkings of land. Why



should we refuse to believe, just where our measurements suggest that this part of the earth is changing in level, that our measurements are trustworthy? Besides, this is an area in which the rising of the land might readily be believed and indeed expected, as I will now explain.

For many years the Survey of India has measured the deviation of the vertical, and from the accumulated results I was able to draw contours representing the form of the geoid in India. The question of explaining the form of these contours and testing to what degree isostasy was existent in India has been much studied in the Survey of India during the last ten years. An answer is given in Chart XIV of *Geodetic Report*, Vol. V, which shows a mass-distribution which accounts for the geoidal form shown by observations to exist. This chart (which also was published with my paper, "The Hypothesis of Isostasy," in Monthly Notices of the R.A.S., *Geophysical Supplement*, 1932, January, as Chart D) indicates a large region of excessive underloading, averaging over 3,000 feet of equivalent rock over an area of 100,000 square miles. I am not an enthusiastic isostasist, but I am not surprised to find that this underload—the biggest known underload, to the best of my knowledge—is actually undergoing slow adjustment by the uplifting of the land. It would have a very long way to go—some 6,000 feet in places—before perfect isostasy was attained. At present this is the greatest known example of the failure of isostasy. I can think of no region in which uplift is so natural a consequence of anomalous deficiency of density in the underlying crust.

On 15th January, 1934, a destructive earthquake occurred in Bihar. The epicentre is given in *Nature* for 27th January as lat. 26°8, long. 86°3, as determined from the Kew and Bombay seismograms. From accounts of destruction of houses, particularly in Muzaffarpur, Darbhanga, Motihari and Patna (mean position 26°0, 85°3), one might expect the epicentre to be rather more westerly. Accepting, however, this provisional fixing, we see that it lies 140 miles east of the centre (27°, 84°) of the region of underload. The epicentre also lies in line with the contour, showing greatest rate of change of level—6 feet per century—in my hypothesis. This contour also passes 70 miles south of the centre of underload, tangentially to the 5,000-foot contour.

This earthquake cannot have relieved the underload to any great extent, but it is evidence of the great state of stress difference which exists locally, and sustains my theory of rising ground. Nevertheless some changes of level are likely to have occurred, for the earthquake was followed by flooding. It is to be hoped that this may be investigated by renewed spirit-levelling.

A DESERT RECONNAISSANCE SURVEY.

By MAJOR H. DE L. PANET, R.E.

IN recent numbers of *The R.E. Journal* two interesting articles have described surveys of widely different types. Both these surveys were carried out by officers with recent specialized experience and reached a high degree of accuracy in their results. The following article describes the ground investigation of an air-observer's report which, while aiming at a comparatively low degree of accuracy as a survey, has perhaps certain points of interest outside the usual run of R.E. work.

A direct broad-gauge (5 ft. 6 in.) railway connection between Bombay and Sind has been under investigation by many engineers since the first survey by Captain Gracey, R.E., in 1879, but all the suggested alignments have followed the northern edge of the Rann of Catch, skirting the edge of the desert itself and turning north at Rahim Ki Bazaar to join the existing broad-gauge line at Badin. This course follows the two sides of a right-angled triangle, and no records exist to show why the direct route north-west across the desert along the hypotenuse of this triangle had not been adopted.

In 1922–23, on first joining Indian State Railways, the writer was posted as Assistant Engineer of a reconnaissance survey to investigate this direct cross-desert route. Several trial lines were surveyed, but no suitable alignment was found. The results of this 1922–23 survey were not, however, accepted as conclusive and it was decided in 1927 to send a railway officer to fly over the desert and to report if a likely route could be seen from the air. He was also to take photographs.

This flight was made in February, 1927, and the observer's report was absolutely contrary to the report of the 1922–23 ground survey. He reported that the sandhills were comparatively low, with gentle slopes on either side, that the main tracks observed following the approximate line of flight were well defined and looked fit for a motor-car, and that in several places large pools of water were seen. His conclusion was that a good broad-gauge alignment with flat grades and easy curves could be obtained without any difficulty.

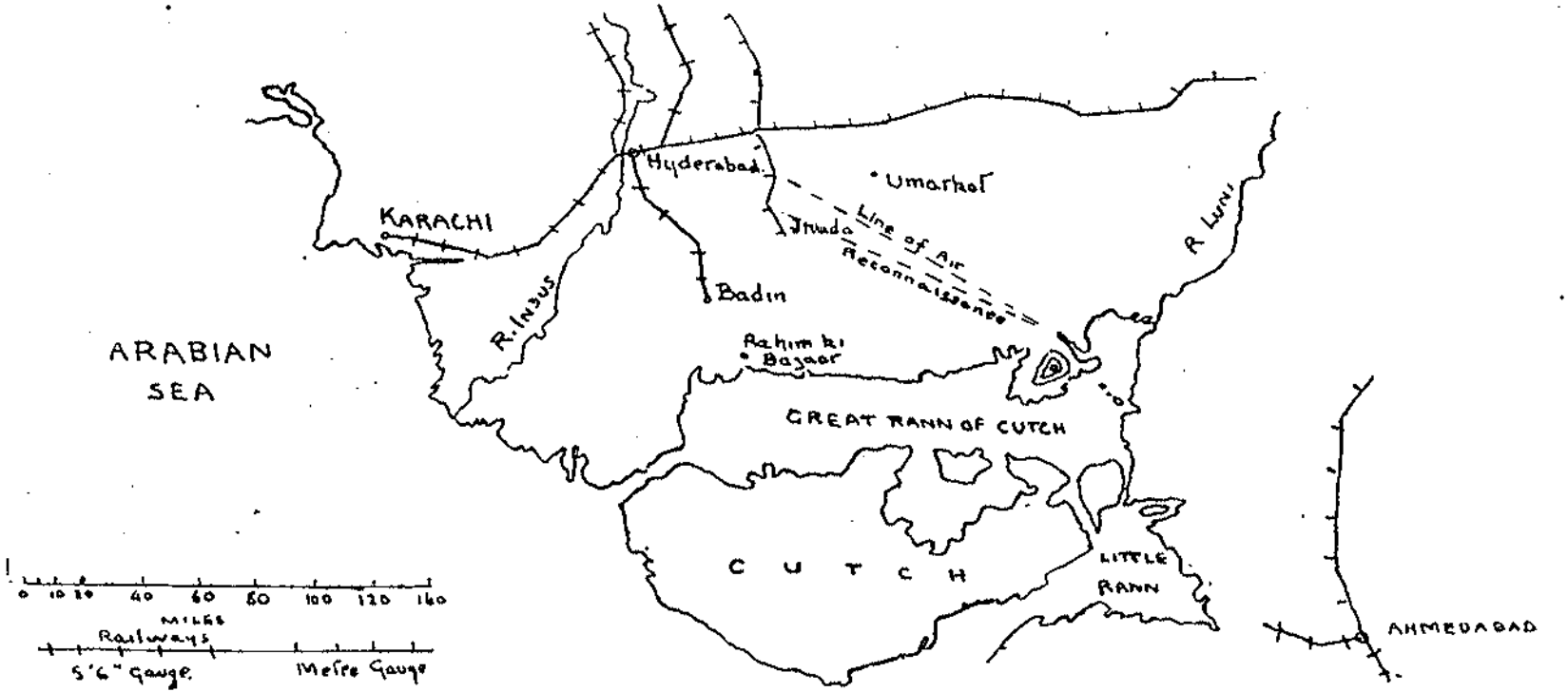
As the line of flight reported by this observer followed approximately one of the rejected routes of the ground survey, further investigation was considered necessary, and on return from leave in March, 1927, the writer was ordered to carry out the reconnaissance described in this article.

The Thar district of Sind, which includes the portion of the Indian Desert in British territory adjacent to the Marwar desert of Jodhpur State, is described in the gazetteer of Sind as follows :—

> "A strong wind from the south-west and west-south-west blows over the Sind desert and runs over Rajputana in the months of March, April, May and June. At the end of April or in May, when the wind is most violent, or in what the natives call the *Chaliha*, or forty days, the wind has at times a velocity of forty miles an hour and it is apparently hardly less violent at night. The whole atmosphere is charged with dust and fine sand, the crests of the ridges are all in motion and scarps of drift sand form on their north-east ends. The people who live in the desert describe this time of year as almost intolerable, and indeed, with the fearful heat day and night, the sand in their mouths, eyes, food and clothing, the want of water and the almost sleepless nights, it must be as near a realization of the infernal regions as they can expect to find in this world."

The country is for practical engineering purposes unmapped. The 1/1,000,000 and ¼-in. to 1 mile survey of India maps show no detail in the desert except conventional signs for sandhills, and the former map, until corrected from information gained in the 1922–23 railway reconnaissance, showed form lines with an error of several hundred feet in height. Some 1874 revenue maps, 1 in. to 1 mile, give a very good idea of the position of the main sandhills, but show no heights except occasional spot levels and are out of date as regards tracks, wells and villages.

The main obstacle to a good alignment across the desert consists of a tangled belt of sandhills, ten to twenty miles wide, along its western edge, this belt being widest and most confused in the south-west corner, and narrowing towards the north. East of this the sandhills assume a typical formation which extends over the greater part of the desert. This formation is not unlike a hand, half-clenched with fingers slightly spread. A series of sandhills rise from south-west to north-east, from the finger-tips to the line of knuckles, at a slope of about one in ten, to a height of 150 to 200 feet. Here they join to form a zigzag line of bluffs running from south-east to north-west and dropping sharply at slopes as steep as one in three into the open valley beyond. In these valleys, of widths varying from a quarter of a mile to a mile, fresh series of sandhills are formed and rise in their turn to the next line of bluffs. The valleys, however, are not continuous but are separated by sandhills which carry on through the line of bluffs, and heavy work with steep grades is necessary to break through from one valley to the next. The sandhills are at


ARABIAN SEA
KARACHI
Hyderabad
Umarkot
Jhuda
Line of Air Reconnaissance
R. Luni
R. Indus
Badin
Rahim ki Bazaar
GREAT RANN OF CUTCH
C U T C H
LITTLE RANN
AHMEDABAD
0 10 20 40 60 80 100 120 160
MILES
Railways
5'6" Gauge
Metre Gauge

present fairly stabilized, and only occasional moving hills were seen by the survey parties.

Apart from the more obvious rise and fall due to the sandhills, there is a marked rise and fall in the main ground formation which was not discovered till the 1922 survey. The tracks cross the lowest necks between sandhills, but are heavy going through loose sand with frequent steep slopes, and in the desert itself wheeled transport is unknown. Water, usually brackish and varying widely in intensity of smell, is from wells up to 200 feet deep and, except perhaps immediately after the scanty monsoon, there is no standing water anywhere.

Owing to the approach of the hot weather and sandstorm season, when no form of accurate instrumental survey is practicable, it was decided to send out one officer with a small camp party to "travel over the route of the flight, paying special attention to the areas photographed from the air, to endeavour to fix these photographs accurately on the 1-in. map and to check the relative heights of sandhills shown in them by aneroid barometer and Abney level." The officer was further ordered to take barometric observations throughout the cross-desert part of the route in order to be able to report on the possibility of a direct line.

The first task was obviously to cultivate some familiarity with the instruments to be used. The Abney level was an old friend from tool-cart equipment, but a barometer had so far been only a decorative object to be tapped by senior officers, and had never been considered as an instrument of survey. A hurried reference to "Close" produced very little information—that estimable textbook does not descend to "approximate" surveys—but another Sapper came to the rescue, Colonel Sir G. R. Hearn's *Railway Engineers' Field Book*. Armed with this, two aneroids, two Abney levels, a tape, a temporary subordinate from the by-ways of Lahore—who turned out a very bad choice—and enough men to pitch tents and load camels, the survey party left Lahore at the beginning of March for Jhudo, on the western edge of the desert, from which the aerial survey had begun. The writer had been out in the desert until the middle of April in 1922 and knew from bitter experience that there was little time to lose.

Collecting camels took some time and at the last minute the civil authorities announced that the party must be self-supporting in rations. This meant the purchase of grain and more delay haggling for camels to carry it, and incidentally laid the train for a correspondence that went on for months after the survey ended, because only the Very Highest Authorities can authorize the purchase of rations and They had unfortunately not been consulted.

The first strip of photographs, of which a portion is reproduced on

page 296, was fixed from the air as being 24 miles away. The officer-in-charge, who had not been on a camel for three years and had just come back from long leave, rashly decided to do the march in one day and regretted it bitterly for the rest of the trip. Once found, the strip was comparatively easy to recognize because it included a Government school, probably the only rectangular building in the whole desert. Unfortunately the air observer had sent out no ground parties and had fixed his position by time of flight on a 1/1,000,000 map with what proved to be an error of 7 miles, and it was only after a very long and hot 35 miles on a very inferior riding camel that the ground observer returned in despair to his camp, to find it pitched in the compound of the long-sought Government school!

The next day was spent observing the diurnal wave of the barometer, as being a duty that required the minimum of exertion. An attempt was made to teach the camp subordinate to read and record barometric readings in camp, but he was not an apt pupil, and as one aneroid ceased to function on the fourth day his training remained incomplete. The check would, in any case, have been of little value as on two days out of three he was moving camp himself.

The air observer, in his report, had explained his method of estimating approximate ground forms from the shadows. As the first strip had been taken earliest in the day, when the sun was in its most favourable position for casting shadows, a detailed survey was made along a portion of this strip with Abney level, measuring tape and aneroid, with check rays by Abney level. The resultant longitudinal section proved that the Abney level and aneroid values for relative heights agreed with quite sufficient accuracy for a reconnaissance of this type, and also showed the difficulty of interpreting ground forms from non-stereoscopic vertical photographs. For instance, the east bank of the valley at the junction of photographs 4A and 5A is by shadow measurement only about 40 feet high, while by actual measurement it is 100 feet.

This detailed survey of part of strip A showed that the photographs were fairly consistent to scale and that barometer readings with clinometer check rays gave sufficiently accurate relative levels. It would, therefore, be possible in future to accept photographic scale as correct and to take the heights of the principal features without the delay of ground-chaining. The difficulty was to find the strips of photographs on the ground. The first day's effort had given some idea of the possible range of error in the map positions given from the air, and the search of a circle of seven or eight miles radius in enclosed country is, on a camel, a very slow business.

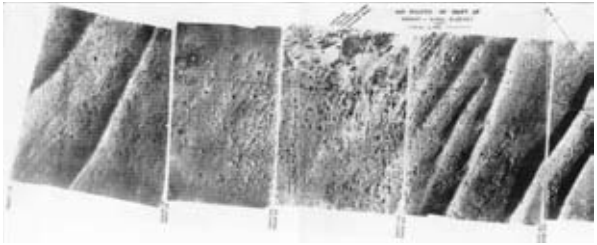
The problem was eventually solved by the help of local inhabitants, but not until several days had been wasted in trying to recognize areas which to the untrained eye presented no distinguishing marks

whatever. The route flown is far south of the Jodhpur air-mail route and no aeroplane had previously flown over the country. The villagers formed the fixed idea that Government were going to acquire at fabulous prices all the land over which the machine had flown, and that the land party were there to identify that land. First enquiries as to the line of flight therefore produced a maze of zigzags and spirals, as each informant in turn swore to high heaven that the machine had passed directly over his particular hut or patch of cultivation.

Once disabused, with difficulty, of this pleasing notion, a conference of village elders would discuss, at length and in detail, a strip of photographs laid on the ground and roughly oriented, and after much argument would come to an agreement and appoint a guide who could go straight to the ground photographed, in one case over eight miles away from the scene of the consultation. These villagers were quite illiterate and could not possibly have understood a map, but in their daily travels they got a good bird's-eye view of the various valleys as they crossed the ridges between them. Once given the general idea of an air photograph, the rest was easy to a people whose knowledge of local detail and power of observation are amazing. From the back of a camel, eight feet above the ground, they can recognize in the loose sand the footprints of individual camels and tell you who has passed that way recently. One man, when asked how he knew his way when there was no visible path, replied that he smelt it. But the preliminary explanation of what an air photograph was and how it worked was a wearisome and intricate task.

Aneroid readings were taken throughout the journey and checked where possible by clinometer rays and pacing. The results were accurate for relative heights but entirely misleading for reduced levels. The barometer had obviously been fairly active, as readings at the same camp and at the same time on successive days showed differences of as much as 150 feet. Even so, it was a little disconcerting to find on arrival at the Rann of Cutch, about 10 feet above sea-level, that the camp was 80 feet underground. Enquiries in Lahore showed that there had been, during the survey, a sudden deep depression over Sind, which explained the antics of the barometer, but as the relative heights between observations close together in time proved accurate when checked by clinometer, and as these were the important factors, it was not considered necessary to correct the compiled longitudinal section with the weather readings in order to try to produce heights above M.S.L.

The air survey had been hastily arranged and full advantage could not be taken of its possibilities. The observer had not seen the plotted results of the 1922 survey and had no knowledge of the characteristic ground forms of the desert or of the obstacles to a



A desert reconnaissance survey

railway alignment which he was trying to avoid. Had camps been sent out to fix definite points, and these points been included in the photographic strips on a smaller scale to include a larger area of country, it is possible that study of the photographs might have shown gaps in the sandhills which would give sufficient probability of a good alignment to justify further ground survey. As carried out, the air survey affords a good example of the deceptiveness of non-stereoscopic air photographs in the interpretation of heights, particularly when the engineer interpreting them has no personal knowledge of the general formation of the ground surveyed. As plans, with their accurate representation of every minor detail, the photographs were far superior to plane-table sheets, and if they had been printed on non-glossy paper to take pencil marks, form lines could have been sketched in with quite fair accuracy in the field and would have provided enough information for locating and estimating a trial line.

The question of a second air survey is now under consideration, and if undertaken the experiment will be of great interest. The fact that all the engineers who, since 1879, have investigated this railway have rejected the trans-desert route, goes to show that an alignment across the southern part of the desert is not practicable. A ground survey party in this type of country is necessarily tied to existing tracks and sources of water supply, and reconnaissance is limited to 10 or 15 miles on either side of the track. There is, therefore, still a possibility that a good line can be found which passes through some comparatively waterless area untouched by previous surveys, and an air survey is the best way to look for it. It is, however, in the writer's opinion, unlikely that a satisfactory cross-desert route will be found, unless perhaps north of Umarkot, which is outside the area with which this particular survey was concerned.

A DEMOLITION RAID.

By ANONYMOUS.

IT may be remembered that in the December issue of *The R.E. Journal* Captain A. C. Shortt gave a description of a recent Staff Exercise conducted in Belgium, with a view to studying the lessons to be learned from the famous landing near Ostend, which the 1st Division studied so carefully in 1917, but never finally carried out. Readers of the article may remember that, besides the main objective of the landing (the hoped-for turning of the right flank of the German line), a quite subsidiary operation was proposed. It was hoped that, supposing the landing were successful, it might be possible to silence the 150-mm. coast defence batteries at Raversijde, just south-west of Ostend.

This little operation presented many interesting tactical problems to those engaged upon the exercise, but there was even greater divergence of opinion upon the technical questions involved. It is, therefore, thought that a few tentative notes upon the Sapper side of this enterprise might be of interest, as little can be gleaned from text-books, and there is a possibility that dashing raids with the object of pure destruction may form a not uncommon feature of future mobile warfare.

It will first be necessary to try briefly to repaint the picture.

The Raversijde batteries were a thorn in the flesh of the British monitors operating against the Belgian coast. They were mounted in concrete emplacements, concealed in the low sand-dunes just behind the long straight esplanade. They had very accurate long-base position finders, searchlights and perfect telephonic communication up and down the coast—in fact, a typical case of the land gun having everything its own way against the ship. Each battery was provided with concrete cover for command posts, men and ammunition. The dug-outs were very roomy, and had at least 12 feet of earth cover. Small expense stores, also in concrete, and fitted with shell lifts, formed part of each emplacement.

These were the left-flank batteries of the German coast defence system, but had been sited well out of range of our guns behind Nieuport, and were in fact so far from our lines that they could not be included in the objectives chosen for the landing force. Their destruction was, therefore, to have been the duty of a special raiding detachment, consisting of a pack battery, a cyclist battalion, a

company of infantry, three tanks, and of course the Sapper demolition party. As soon as possible after the landing, this force was to move with speed for about two miles along and parallel to the coast, capture the batteries, silence the guns, and then to return to the comparative safety of the main body, which meanwhile had been making good its own objectives.

This exciting scheme had at least three possible snags. First, there ran, at right angles to the coast, a German rear line, whose concrete pill-boxes and barbed wire showed clearly on the air photographs. The raiders would have to cross this line, and prayed that it would not be manned. Secondly, close to the coast, was the one main road feeding the German front line along the Yser. The raiders could only hope that their right flank would not be troubled by odd folk who might happen at that early hour to be in the vicinity of this road. Thirdly, there was the certain knowledge that the strong and very mobile reserve to the whole coast defence sector lived in Ostend. As the raiders were to operate *towards* Ostend, there was a strong incentive so to arrange matters that they would be heading for home before the Ostenders sallied forth on their bicycles and in their armoured cars. The unpleasantness of these thoughts was, however, mitigated by the hope that the sudden and unexpected landing would have caused enough confusion to produce that blessed lull before the counter-attack during which daring deeds are sometimes done.

Let us now turn to the Sapper subaltern, whose section was to play the central part. He had merely to put out of action a matter of eight guns. On the other hand, several hundred souls were embarking on this bicycle ride in order to get him and his merry men to the scene of their work. Failure to silence each and every gun might, therefore, be looked upon as being in poor taste. Not only this, but the job which he had to do well, he also had to do exceedingly fast, for the safety of his large escort (and of himself) depended largely upon the result of the race between his sappers and the Ostenders.

There were also the following points perhaps peculiar to this particular operation:—

1. Although there was ample time for training and preparation, there seemed to be a strange lack of information upon rapid gun silencing.
2. There were eight separate demolitions, spread over a distance of at least 600 yards, and he was the only officer.
3. During the landing and the raid all stores would have to be carried on the bicycles, and for part of the time by hand.
4. Heavy casualties might be experienced among his men.
5. The batteries would probably be under fire during the work.

6. It would be impossible to insist upon any but the crudest of safety precautions before firing the charges. To attempt to do so might cause endless delay. The effects, however, of flying splinters might be very serious to those working in neighbouring emplacements and upon the escort left at each battery to mop up.*

Everything seemed to point to the adoption of the very simplest and most fool-proof plan, in fact, to the training and loading of every man in the section exactly alike, so that casualties or mixing up of parties could not cause the failure of any charge, through the non-arrival at the gun of some special store, a particular N.C.O. or man, or even of orders to fire.

Now for the guns themselves. They were known to be about 30 yards apart in each of the two four-gun batteries, and were known to have epaulements about three feet high. They were believed to be standard "five point nines," that is to say they were just like the gun which used to stand on the Chatham Square, but of course fitted with a coast defence central pivot mounting. They would have sliding breech-blocks, necessitating the use of brass cartridge-cases, fitting into chambers of about 6¼-in. internal diameter. The block would slide in well-fitting run-ways in the rather massive breech, and when closed there would always be a space of about ¼ inch between it and the face of the chamber. This space accommodates the rim of the cartridge. It could not, however, be overlooked that there was a chance that the Raversijde guns were a "special line" of Mr. Krupp, and the unexpected must be prepared for.

What is the best, surest and quickest way of silencing these guns, under the conditions of this raid? The following suggestions have been made:—

1. To use the standard method of loading a shell into the muzzle and another into the breech, and firing the gun. This is not very certain with base fuzed armour-piercing shell, and in any case requires knowledgeable fuze setting. The large explosion might damage neighbouring parties, but most important of all would be the delay and uncertainty. The shells, fuzes, cartridge and primer would all have to be found and fitted up. A heavy shell would have to be loaded into the rather inaccessible muzzle, and finally the sappers would have to find out how to fire the gun. A good method for one's own gun, but not for someone else's.
2. To attack the mounting, buffer, or the elevating or traversing gears. A very small charge, if cleverly placed, might make

*A naval landing party is said to have suffered seriously in this way when destroying guns on Gallipoli.

it necessary to dismount the piece and to bring up some part of the cradle or mounting as a replacement—a long operation, perhaps even longer than bringing up a new piece. On the other hand, some departure from the expected design might lead unsupervised sappers to destroy nothing but some quite easily replaceable component. Arrangements for placing and fixing the charge could not be accurately rehearsed.

3. To blow up the cartridge or the shell expense stores placed so close to the gun-pits. To start with, the exact position of these stores was not known for certain, and in any case they might be found empty after the rapid firing that had no doubt been concentrated upon our landing vessels. To make a real certainty of detonating unfused armour-piercing shell, and more so of igniting brass-cased cartridges, is more difficult than would be expected. The effects upon the actual gun would be by no means certain, whereas the large explosions would be very unpleasant for those near by.

4. To attack the chase of the piece with (say) a necklace charge. This is the weakest part, but on the other hand, the cutting off of the end might not actually silence the piece, though, of course, its shooting would be affected. This treatment would involve work outside the emplacements, with the danger of bullets or splinters causing casualties and delay.

5. To detonate a charge inside the breech. This, at first sight, seems to be the most massive point of attack, but this rather obvious method has the following advantages :—

   The breech is obvious and unmistakable.
   The party would be protected by the emplacement.
   The explosion would occur in the emplacement, which might reduce flying *débris*, especially if the gun were first elevated to the full.
   It would be unnecessary to use a charge calculated to blow the breech to smithereens, as even a small distortion would make it impossible to slide the block, or to insert and fire with safety a fitting cartridge-case.

What about the explosive to choose ? In 1917, it was thought that thermit might be ignited in the bore, with the hope of producing enough molten steel to damage the gun or to weld itself to the inside. This avoided all danger of accidents during carriage, and eliminated the flying splinter problem. Experiments show, however, that the large mass of metal tends to conduct the heat of combustion away too quickly to make success certain.

The plastic explosives would be admirable but for the fact that they are so unsafe under fire. This was essentially an operation where dangerous explosives seemed out of place, especially on the pontoons before the landing.

Guncotton with its reliability and safeness is not really suitable, as the slabs are difficult to make up into charges for rapid placing, and are very hard to fit against the inside of the chamber.

Ammonal might be thought to be too slow in its action for cutting thick steel, but experiments seem to indicate that it is at least as efficient as guncotton, when used in a gun chamber.

The tricky point, and one upon which there is lack of data, is the settling of the charge to be used. Our text-books tell us that a charge of about 35 lb., if well tamped with earth in the bore, will blow a 150-mm. breech to pieces. It is suggested that half this charge, even if untamped, would make it impossible to move the breech-block. In this case, it would seem that an increase in the actual charge would be preferable to tamping, which might be very badly done, and would doubtless cause considerable delay.

It is suggested that the following might have been a sound plan of action, in order to make a certainty of accomplishing the object.

Ammonal would have been made up into cylindrical waterproof canvas bags, each 12 inches long and six inches in diameter, holding 10 lb.

Every man of the section, except the officer and serjeant (say, 30 men), would be loaded as follows:—

In his pack—One bag of ammonal.

In his pockets—Four fuzed detonators in a tin, two slabs of guncotton, two primers, matches, string, wire, and jack-knife.

Thus, even in the event of only two men reaching each gun, there would be enough explosive for a 20-lb. charge in the breech, and a 4-lb. charge of guncotton to use against the traversing gear, in case of partial failure.

The men would be very carefully drilled on captured guns, and would be told off to the various emplacements, the first battery being in charge of the serjeant and the more distant one of the officer. Immediately the men reached the gun-pits they would insert their charges, close the breech (leaving two fuzes sticking out), and elevate the gun to the full. As soon as the four guns were elevated the man in charge of the battery would know that sufficient men had reached the emplacements, and he could run along and give the order to fire. If all went well, the operation should not take more than five minutes, but to this estimate might well be applied a factor of safety of, say, 6!!

REPORT ON THE DEMOLITION OF THE L.M.S. RAILWAY POSTERN ARCHES, AT SHOTTLE, BY ROYAL ENGINEER UNITS OF NORTHERN COMMAND, ON 24th SEPTEMBER, 1933.

1. Brief History.

In the neighbourhood of Derby, a viaduct was built by the Midland Railway in 1860 under rather peculiar circumstances. A local landowner took up an uncompromising attitude towards the construction of a railway across his property, and insisted upon a bridge being built to carry his farm traffic in place of a level crossing which would otherwise have been made; in consequence the railway was obliged to build him a bridge, approached by eighteen postern arches, and they did this as inexpensively as possible, with the result that the viaduct had ever since been an unreasonably costly structure to maintain. In recent years the ownership of the property had changed, and the only user of the viaduct was the village postman; so, early in 1933, the railway obtained parliamentary powers to replace it with a level crossing.

During the previous year the District Engineer had been in touch with the C.R.E., in connection with Sapper officers' instructional visits to some bridges that were being built; when the removal of the viaduct was sanctioned he appreciated that the R.E. would be glad to demolish it with explosives, and very considerately offered it them. The task offered a great opportunity for practical experience in actual demolition of brick arches, and therefore was accepted readily; detachments of all the Field and Army Troops Companies in the Command (regular, S.R. and T.A.), as below, were collected to carry out the work in combination:—

55 Field Company	3	officers	and	24	O.R.
106 and 107 A.T. Coys. (S.R.)	2	,,	,,	12	,,
46 Div. R.E. (T.A.)	3	,,	,,	18	,,
49 Div. R.E. (T.A.)	3	,,	,,	18	,,
50 Div. R.E. (T.A.)	3	,,	,,	18	,,

These were concentrated in a camp close to the site of the viaduct on the afternoon of Saturday, 23rd September; the administrative arrangements for the camp were placed in the hands of 46 Division (T.A.), and the adjutant of the Divisional Engineers was appointed Camp Commandant.

2. DESCRIPTION OF THE STRUCTURE.

Figure 1 is a dimensioned drawing of the viaduct; for the purposes of the demolition the piers and abutments were numbered, and the groups of arches between the thick piers were numbered as sections. The masonry consisted of ordinary red brick, but in one or two places patches of blue brick occurred which was of an extremely tough texture; the general appearance of the brickwork was one of dilapidation, cracks were showing in several places, and one of the arches had been strutted with timber. The roadway was unmetalled; the arch haunches were filled with brick rubble, over which, at a depth of two feet from the surface, was a course of unmortared bricks; the thick piers consisted of a shell of $13\frac{1}{2}$-in. mortared brick, filled with unbonded but mortared brickwork.

3. PLAN OF DEMOLITION.

The S.M.E. was consulted as to what experiments should be included with the practical work, and in reply desired that the possibility of destroying arches and piers by charges laid at intervals, in boreholes, instead of in a continuous line, should be investigated, and suggested certain figures as a guide; owing to circumstances the tests were mainly confined to the arches. The conduct of the demolition consequently assumed a triple aspect, being partly a practical task for the benefit of the railway, partly training for the troops engaged, and partly experimental in service methods of demolition; all of these considerations in various ways governed the method by which the task was executed.

The allocation of tasks to units was as shown in Fig. 1. Each T.A. Divisional R.E. was given one of Sections I, II, and IV of the viaduct to demolish by attacking the arches from above; the charges for one arch in each section were specified, and the charges for the others were left to the unit's own choice within the lines required by the S.M.E.; it was pointed out that it was desirable to find out an economic figure for charges laid at intervals, both of explosive and labour, and that in order to do so instances of under-charging would be welcomed. Section III was entrusted to the regular Field Company; the piers were to be destroyed, and the charges for them were specified. In Section V the charges were laid in the spandrels, touching both arch rings, the chambers being cut from the underside of the arches (see Fig. 2); each unit was allotted a pier (see Fig. 1); in some instances the charges were specified, in others they were left to the unit's own choice. Figure 3 is a diagram showing the amounts and positions of the charges that were eventually laid; many reasons governed their variation, but related only to the particular circumstances of this demolition, and have no

general interest. Figure 4 shows in detail the arrangement proposed and adopted by 46th Divisional R.E., which will be referred to again. The units were allotted their tasks three weeks beforehand, so as to give them time for practising the work.

Each unit was required to bring its own tools. Explosives (gelignite and commercial detonators) were supplied by the L.M.S.R., except for a certain amount of guncotton and service instantaneous fuze (F.I.D.), which were used partly for the experimental purpose of comparing the labour involved in laying guncotton and gelignite, and partly for the training benefit of using F.I.D. The L.M.S.R. provided the necessary staging and a second compressor (additional to the service one that was brought), as well as a smith and forge for re-sharpening the drills.

The laying of the charges was ordered to begin at 6.30 a.m. on Sunday: provisional times were fixed for the explosions, governed by the railway requirement for their personnel to be able to clear the line in time for the afternoon train to pass at 5 p.m.; the times though were open to adjustment, as the railway staff were willing that the clearing of the *débris* of the section spanning the line should be carried on during the intervals while the charges in the other sections were being prepared. Owing to the unsafe appearance of the masonry it seemed possible that the destruction of any one arch might bring about the collapse of the neighbouring ones also, except where the thick piers would act as buttresses; so it was decided to blow all the arches in each section simultaneously; in order to conform with certain arrangements connected with a party of military spectators the order of demolition was: V, IV, III, II, I.

Section V was prepared for firing electrically, with an alternative fuze system. The unit responsible for each pier was responsible for connecting its charges with its east side neighbour, and one unit was detailed for the mains and exploders. The total number of detonators in circuit amounted to 43; the current needed was within the range of a pair of exploders, coupled as described in *M.M.E.*, Vol. IV, page 31, and no difficulty was anticipated in carrying out this method. Sections IV, II, and I were at first ordered to be prepared for firing by fuze (safety and F.I.D.) with an alternative electrical system; this was done with a view to the training benefits to be gained from the more difficult method of fuze firing. Section III was to be fired electrically, with alternative safety fuzes laid to each separate charge; F.I.D. was not to be used as this section was the one that it was essential to demolish in time, and the reliability of F.I.D. was doubted.

4. Narrative of its Execution.

During Saturday afternoon the chambers for all charges were prepared, and railway personnel put up protective planking and

tarpaulins in front of huts and the windows of neighbouring buildings; some partition walls underneath arches 18/19 and 19/20 were half-demolished, by hand and compressor, but the work proved heavier than had been anticipated and was left to be completed with explosives on the following morning. In the course of cutting the chambers patches of blue brickwork were encountered in two places, and they gave remarkable figures for impenetrability, in one instance a man succeeded in cutting only to a depth of $\frac{1}{2}$—$1\frac{1}{2}$ inches in an hour's work, and the power drills made even less impression; finally these patches had to be avoided.

The charging of Section V commenced at 6.30 a.m.; and the section was ready for firing by 9 a.m. The electric firing of the circuit of 43 detonators failed, owing to the faulty coupling of the exploders, and only the centre pair of charges in pier 16 detonated, blowing a hole in the centre of the pier and leaving the rest of it intact (see Fig. 5). The alternative fuze system was then employed; the fuzes of piers 16 and 17 had been damaged by the explosion, and were, therefore, not lit; the remainder, after being inspected by officers, were fired. With the exception of three charges the F.I.D. failed entirely, and the circumstances are described in detail in para. 8 below; the only charges that detonated were the two that lay furthest from the firing point in pier 18, and the centre one of pier 15; these explosions caused a hole in the middle of pier 15 (see photo. 7) and the destruction of half of the two arches adjoining pier 18.

It was by now 10 a.m., and the work was considerably in arrear of time, and it was essential to demolish Section III, spanning the railway line, quickly; so Section V was left for the time being, and work continued on the other four sections.

As the F.I.D. had proved itself quite unreliable, orders were given that for the rest of the work charges should be fired electrically; alternative fuzes of F.I.D. were to be provided, the several lengths were not to be connected to each other, but left loose, for joining only in case of necessity. The charges of Section IV were exploded first; they proved entirely successful; the whole of the brickwork fell except for a narrow strip of arch 12/13, which most fortunately stood, and provided the single instance of under-charging that had been looked for from the experimental point of view (see photos. 2 and 3). This strip was felled at the end of the day without difficulty, by hand. Section III was then charged and fired; the explosion cut the piers away from beneath the arches perfectly, and the arch over the railway dropped on to some vertical baulks of timber, which the railway staff had placed for the purpose of breaking up the masonry into blocks that could be handled conviently by a steam crane (see photos. 4 and 7). From this time onward the railway personnel cleared the *débris* during the intervals

No 1.

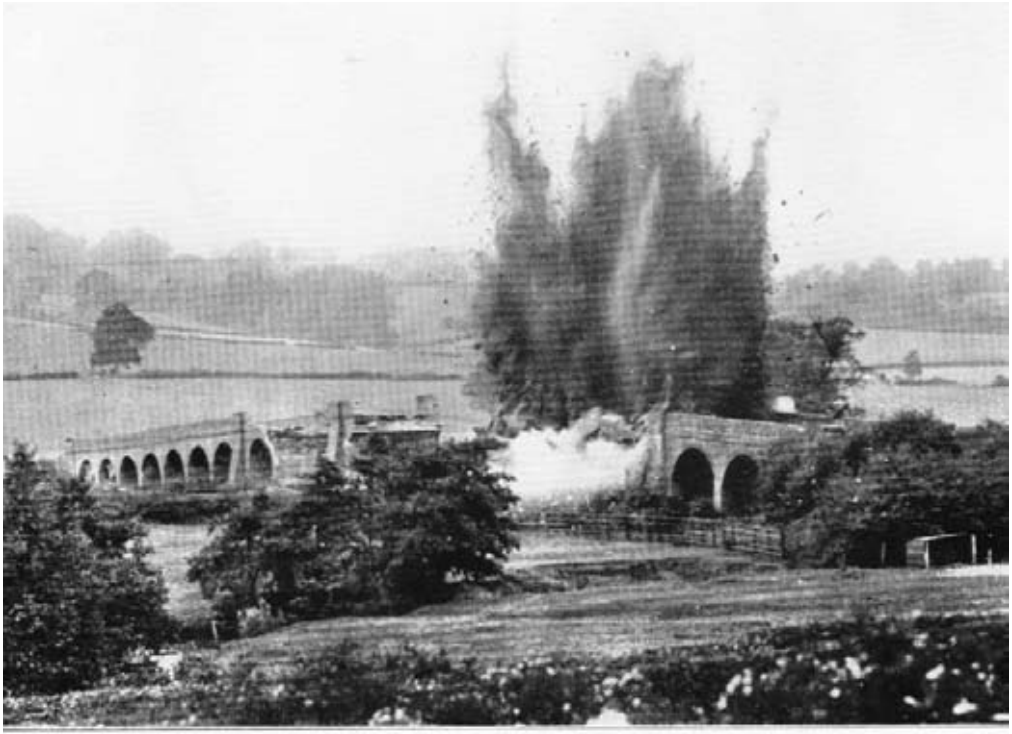
No. 2

Demolition of LMS railway postern arches at Shottle 1-2

No. 3.

No 4

Demolition of LMS railway postern arches at Shottle 3-4



No. 5.

Demolition of LMS railway postern arches at Shottle 5

No. 6.

No. 7.

Demolition of LMS railway postern arches at Shottle 6-7

while the R.E. were laying other charges, and withdrew whenever it was necessary to clear the site for an explosion.

It had been observed that the explosions in any one section were not having any effect on the brickwork of the adjoining Section, as had been feared might happen, and so the charges of both Sections II and I were laid at the same time, though exploded separately; no difficulty was experienced, and both sections were demolished completely by 1 p.m. (see photos. 5 and 6).

The peak in the falling parapet which is visible in photo. 5 appears to be at the point above pier 5, the brickwork having been broken by the explosions on either side of it, at the centres of arches 4/5 and 5/6. This photograph indicates the effectiveness of the 20-oz. charge at 1½ feet distance from the parapet in arch 5/6. But for the trouble that had been incurred with Section V, which still remained to be destroyed, the charges in these sections would have been reduced for test purposes; but under the circumstances it was not thought desirable to risk any incomplete demolition.

Work was then recommenced on Section V. The electric leads were repaired where damaged, and re-connected into three groups—piers 14, 15, and 16 in one, piers 17 and 18 and the walls under arch 18/19 in a second group, and pier 19 with the walls under arch 19/20 as a third.

Each of these groups was within the capacity of a single exploder. The first group amounted to 12 detonators; those of pier 16 were commercial low-tension detonators, described by the civilian agency that supplied them as having a resistance of about 1·3 ohms. and needing a current of about ·5 ampere; thus they corresponded to service detonators, and it will be seen from the narrative that they proved almost the same but slightly more sensitive; those in the other two piers were service No. 13 detonators. The firing of the first group produced the explosion of all the commercial detonators in pier 16 and one service one in pier 14, leaving three charges in pier 14 and the remaining four in pier 15 unexploded (see photo. 7). The continuity test for the second group showed that the leads of pier 17 were damaged, so the pier was disconnected and only the remainder fired; it will be remembered that the charges at the northern end of pier 18 had already been exploded (by fuze); the result of this second explosion was to destroy the pier completely and to bring down the whole of the arch joining it with pier 17, but to leave intact a long length of parapet from pier 15 to pier 19 (see photo. 3). Later, when time could be afforded, the charges of pier 17 were re-connected and blown without any difficulty; the remnant of parapet then collapsed. The third group was also blown successfully and without incident.

The grouping of service with commercial detonators was an error

that at the time was not appreciated ; it is, perhaps, a subject that requires mention in the *Manual*.

Arches 13/14 and 14/15 still remained standing, but the fall of arch 15/16 when pier 16 was destroyed had exposed the charges in pier 15 ; fresh detonators were placed in these charges, and then piers 14 and 15 were blown separately, each producing the complete collapse of its arch. This completed the original work by 2.30 p.m., and in spite of the delays it was finished in time for the railway personnel to effect the necessary clearance of the line.

On the L.M.S.R. staff's request for the R.E. to blow down also the remains of the thick piers, Nos. 4, 7, 10 and 13, if it could be arranged, the detachment of 55 Field Company was left behind for the purpose. The demolition of these piers had not been included in the main operation because the text-book calculations for such piers under conditions of emergency on service gave heavy charges that would have been liable to damage the neighbouring farm, and they had consequently been left for destruction by hand later ; however, an experiment of light borehole charges, based on the mining formulæ given in Sections 49 and 74 of *M.M.E.*, Vol. IV, had been designed, and was intended to be given trial after the demolition of Section III ; the delay that took place in Section V, though, prevented this from being done.

It was extremely unfortunate that this experiment could not be made, as the effect of the charges on the arches being spaced at intervals shows that there is every reason to suppose that the method of driving boreholes diagonally downwards towards the centres of piers, and of determining their charges by mining formulæ, would be well suited to normal service conditions. This work brought home the fact that the drills at present provided with the Reavell compressor are inadequate in length and in diameter ; a length of 10 feet and a diameter of 2 inches appear to be desirable.

5. Analysis of Results.

(*a*) *General.* In general, the method of laying charges at intervals, instead of continuously, proved entirely satisfactory. The following conclusions have been drawn from the point of view of two kinds of demolition : (i) brickwork in which the charges can be spaced at regular intervals, such as an arch ring chambered from beneath, or a pier ; (ii) an arch attacked from the roadway, when it is desirable to allow the passage of traffic at the same time as the bridge is being prepared for demolition.

(*b*) *Labour.* The figures for the labour and time taken in cutting chambers varied enormously ; a working figure for cutting through 13½-inch brickwork and making a chamber in loose brick rubble filling behind was 1—1½ man hours, the greater part of which was

taken in making the chambers; this figure is exclusive of the time taken in erecting any staging. A certain amount of work was done with the compressors, but in horizontally driven shallow holes they gave no advantage over hand cutting, the weight of the tool being burdensome.

In excavating the pits for the charges laid above the arch rings in Sections I and II, the figures for labour in arches 2/3, 3/4, 4/5, and 6/7 will be given for comparison, as the arrangement of those charges will be referred to later: the total labour involved in making the eight holes required in arches 2/3 and 3/4 was 6·7 man hours; but the labour needed for the four pits in arches 4/5 and 6/7 (see Fig. 4) was about 4 man hours; actually the same amount of labour, 6·7 man hours, was expended, but in the course of the work it was found that more than one man per pit was wasteful, and that one man could dig a pit and make the chambers in an hour.

(*c*) *Charges.* The size of charges deduced from this operation refer solely to 13½-in. brick arch rings.

(i) Fig. 5 shows the extent of the effects of various single charges. It will be seen from arch 12/13 that the extent of the shattering effect of a small charge of gelignite (12 oz.) coincides with the theoretical angle of 45°; pier 16 shows that a much larger charge (48 oz.) had a very similar extent for its shattering effect, the increase of the explosive by 36 oz. only adding to the extent of the gap by about 6 inches in either direction (*N.B.*, the measurement 5 feet is an approximate figure only, observed at the time). The observed result of the single explosion in pier 14 confirms this (see Fig. 5). In piers 15 and 16 it was noticed that the brickwork was also disintegrated for a distance of about 12 in.— 18 in. round the gap that had been blown. Photograph 2 of Section IV explosion, shows a 16-oz. charge, laid 2 ft. 6 in. from the outside of the parapet, producing an effect at that distance; in this instance the parapet collapsed immediately afterwards, but the moment at which the photograph was taken the direct effect of the explosion was taking place and can be seen dislodging about 4 feet of brickwork before the collapse of the whole took place. The evidence of arch 11/12, therefore, is that 16 oz. gelignite have an effect reaching to 2 ft. 6 in.; arch 12/13 also provides evidence that two charges of 12 oz. and 21 oz. will bring down a 13½-in. arch ring over an interval of 4 ft.

The sum of the above observations appears to be that the width of gaps cut by small charges will correspond with an angle of 45° from their positions; also that charges in the neighbourhood of 1 lb. have a disintegrating effect to a distance of 1 ft. 6 in. further. Therefore it seems that for 13½ in. brickwork, charges of 12 oz. or less would be effective at intervals of 5 ft.

(ii) It has been suggested in sub-para. (c.i) above that for 13½-in. brickwork an economic arrangement would be charges of about 1 lb.

at 5-ft. intervals; this demolition, however, produced evidence that larger charges were effective over wider gaps than that, for in arch 3/4 charges of 3-lb. gelignite at 9-ft. distances were effective. There is every reason to assume that this arch fell as the direct result of its own charges, and not through the indirect effects of other explosions, because the evidence of arch 12/13 showed that a strip of 2 ft. 3 in. of arch ring was capable of standing. The arrangement of the charges in arch 3/4 (see Fig. 3), combined with the method of digging a pit for the centre pair, as shown in Fig. 4, should prove very convenient for bridge demolition on service, as traffic could continue to pass by the 9-ft. spaces while the work was in progress (see Fig. 6). As a guide to the minimum quantity of explosive needed to effect the collapse of the intervening 9 ft., Mr. R. T. McCullum when demolishing Crofton Tunnel (*vide* his paper read to the Institute of Civil Engineers in 1931) found that charges of 20 oz. of ammonal laid at 7-ft. intervals in an arch ring of 18 in.—27 in. thickness left legs standing between the gaps, and that charges of 16 oz. placed at 3 ft. 6 in. intervals were effective. The experimental arrangement of 48-oz. charges for a 9-ft. span of 13½-in. brickwork seems, therefore, to have been a well-judged trial by 50th Divisional Royal Engineers.

6. Experience Gained in the Use of Power Tools.

The absence of any advantage in power-driven tools when used horizontally in cutting shallow holes (*e.g.*, through arch rings), in comparison with hand cutting, has already been noted. Power tools showed themselves to be unsatisfactory for attacking the underside of arches owing to the horizontal or slightly upwards angle at which they have to be used. On the other hand for driving a deep hole diagonally downwards (*e.g.*, into a thick pier) they proved very efficient, and the desirability of service equipment containing long, wide drills came to notice. Comparative figures for the rates of cutting brickwork by hand and power were not obtainable, but if such figures are to be given in service Manuals it would appear that they should contain a qualifying remark as to the additional time and labour required in making a higher staging for power tools in order that they may be used downwards.

The Reavell service compressor gave a good deal of trouble through boiling more or less continuously and in being difficult to restart, owing chiefly to the dogs of the starting handle wearing smooth—a defect that has had to be remedied several times during the past year with this particular machine.

The Ingersoll-Rand compressor provided by the L.M.S.R. was a larger machine and showed a distinct advantage in being capable of driving more tools; it was also handier to move about. The

service compressor was distinctly difficult to move over uneven ground, which was a defect for service conditions that came to light.

7. The experience gained in Military Engineering from the demolition can be summed up as follows :—

(*a*) For service demolitions a continuous charge across an arch or pier should not be necessary, except when laid against the outside face. The interval at which internal charges can be laid is derived from the theoretical line of rupture of the masonry, and depends upon the thickness of the masonry ; the experience of this particular work was that a wider spacing than $\frac{4L}{3}$ was possible with overcharging. For charges sunk from the surface of the roadway, the most suitable arrangement will probably be a central pit with two charges laid in chambers on either side, and two other charges at either side of the road, leaving a passage for a double line of traffic between them and the pit (see Fig. 6).

(*b*) For 13½-in. brickwork the size and spacing of the charges found to be effective was as follows : the most economical interval is probably in the region of 5 ft. (4 ft. was proved effective) ; and for this spacing charges should not exceed 1 lb., and it may well be found that less than 12 oz. would suffice. A spacing of 9 ft. is possible with charges of 3 lb., and this would be a convenient one for roadway demolition. Insufficient evidence was obtained to draw any conclusions as to the minimum amount of explosive required for thick masonry piers.

(*c*) Power-driven tools are only satisfactory in brickwork for cutting deep bore-holes downwards, as in thick piers ; they are not suitable for attacking the underside of arches. The drills supplied with a service compressor should admit of 2-in. bore-holes being driven to a length of 10 feet. A service compressor needs to be mounted on a carriage that can be moved easily across uneven ground.

(*d*) *M.M.E.*, Vol. IV, should include further information on the subject of commercial electric detonators and their use..

8. Behaviour of Service Detonating Fuze (F.I.D.).

All electrically-fired charges, except in a few instances, were fitted with an alternative fuze system of firing, consisting of a length of safety fuze attached to instantaneous detonating fuze that branched to the several charges. The junctions between the safety and instantaneous fuze varied, some being made with primers, and others with detonators ; the joints between the F.I.D. branches and mains were made with detonators (commercial caps) as illustrated in *M.M.E.* Vol. IV, plate 3.

All units demurred at having to make detonator joints, and wished

to be allowed to use junction boxes filled with ammonal; the other, though, was insisted upon as ammonal does not form part of the service equipment of a field company, and it was considered desirable for training purposes to adopt service methods. The F.I.D. failed almost completely, the main cause being its shearing at bends through its own internal action; on S.M.E. advice a minimum radius for bends of 9 in. had been stipulated, and actually units worked to an easier curve than that, but shearing was observed to take place on very easy bends.

In detail, the failures occurred as follows:—In pier 14 the safety fuze was joined to four lengths of F.I.D. by capping them all with commercial detonators; the effect of the firing was to blow off the ends of the F.I.D. without setting up detonation. In pier 15 the five F.I.D. branches were wound round two guncotton primers that were detonated from safety fuze; of those only one branch detonated. In all other instances the F.I.D. mains detonated, but sheared either themselves or in the branches. In piers 18 and 19 the joints of the branches to the F.I.D. main were made with two commercial caps, and these acted successfully but the joints sheared at the bends almost universally, although of not less than 12-in. radius, and in some cases very much more.

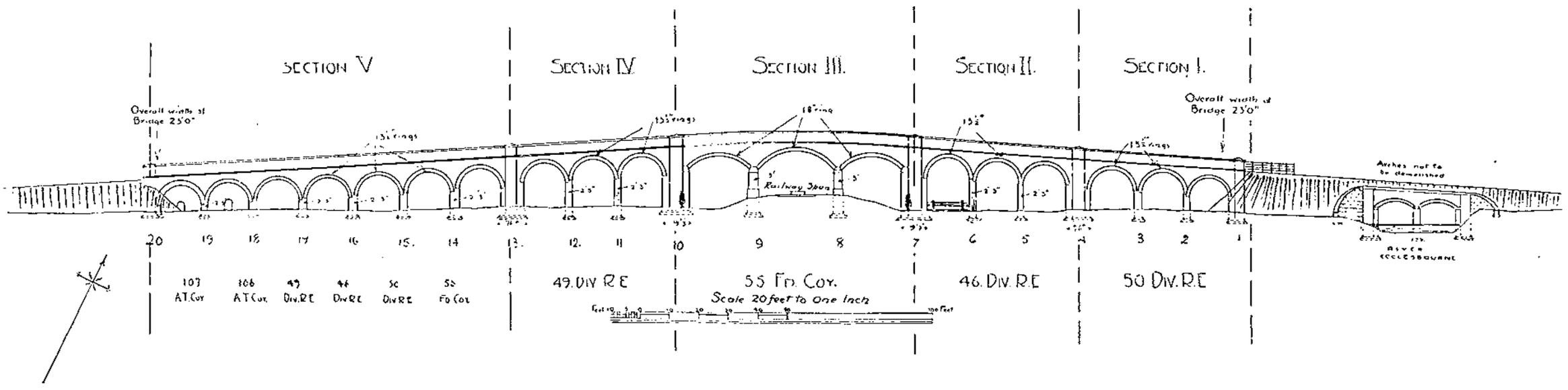
The F.I.D. issued had an old appearance, and it is possible that in one or two instances it had been damaged through kinking while being carried; even apart from this it showed itself extremely unsatisfactory as a service article. Joining the branches with the mains was a laborious process; the use of adhesive tape for binding the detonators, which one unit adopted, made that work a little easier.

9. THE CO-OPERATION OF THE RAILWAY COMPANY'S STAFF.

A feature to be recorded was the consideration shown by the L.M.S. Railway Staff, firstly in appreciating the training value that the work would afford the R.E., and secondly in their conduct after the offer had been accepted. The Assistant District Engineer, their direct representative, gave every possible help, providing whatever material was asked for, and carrying out jobs that were incidental to the demolition but had no particular value as military training.

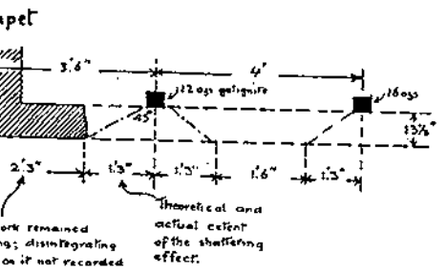
FIG. 1.

L. M. & S. R. SHOTTLE
BRIDGE Nº 7



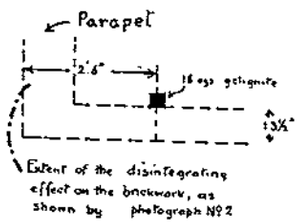
Sketches shewing the observed effects of various charges

Fig 5.



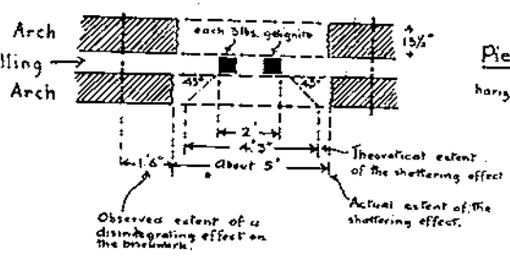
Arch 12/13

vertical cross section



Arch 11/12

vertical cross section

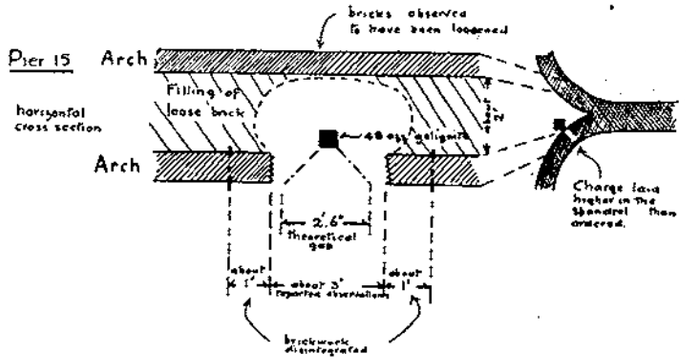


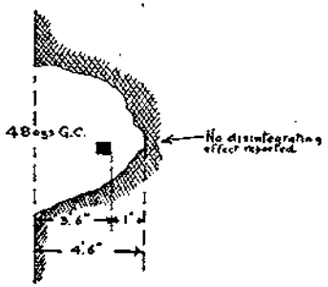
Pier 16

horizontal cross section

Sketches shewing the observed effects of various charges

Fig. 5 (contd)





Pier 14

side elevation

Fig. 6.

Suggested Excavation for Charges in a Roadway

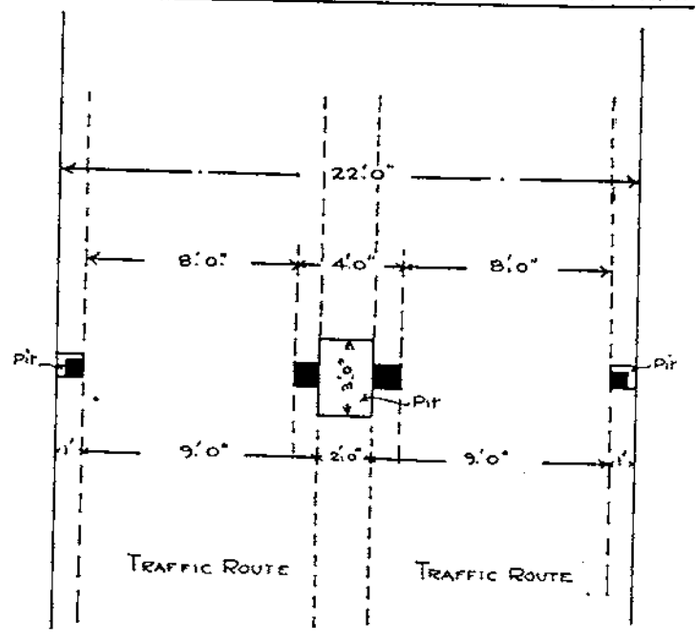
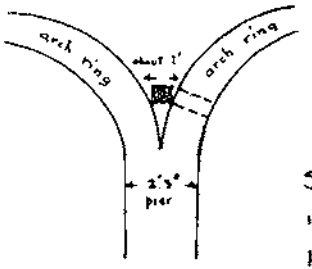


Fig. 2.

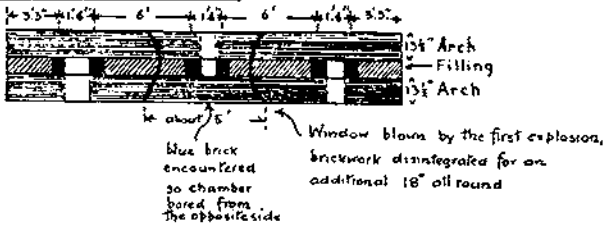


Sketch showing the position in which the charges were placed in Section V.

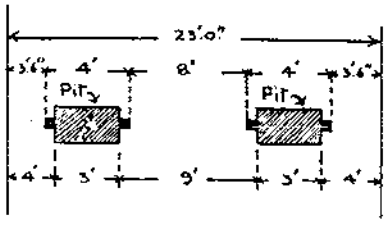
Fig. 4.

Drawings showing the arrangement of charges by 46 Div. R.E.

Pier 16, Horizontal cross section



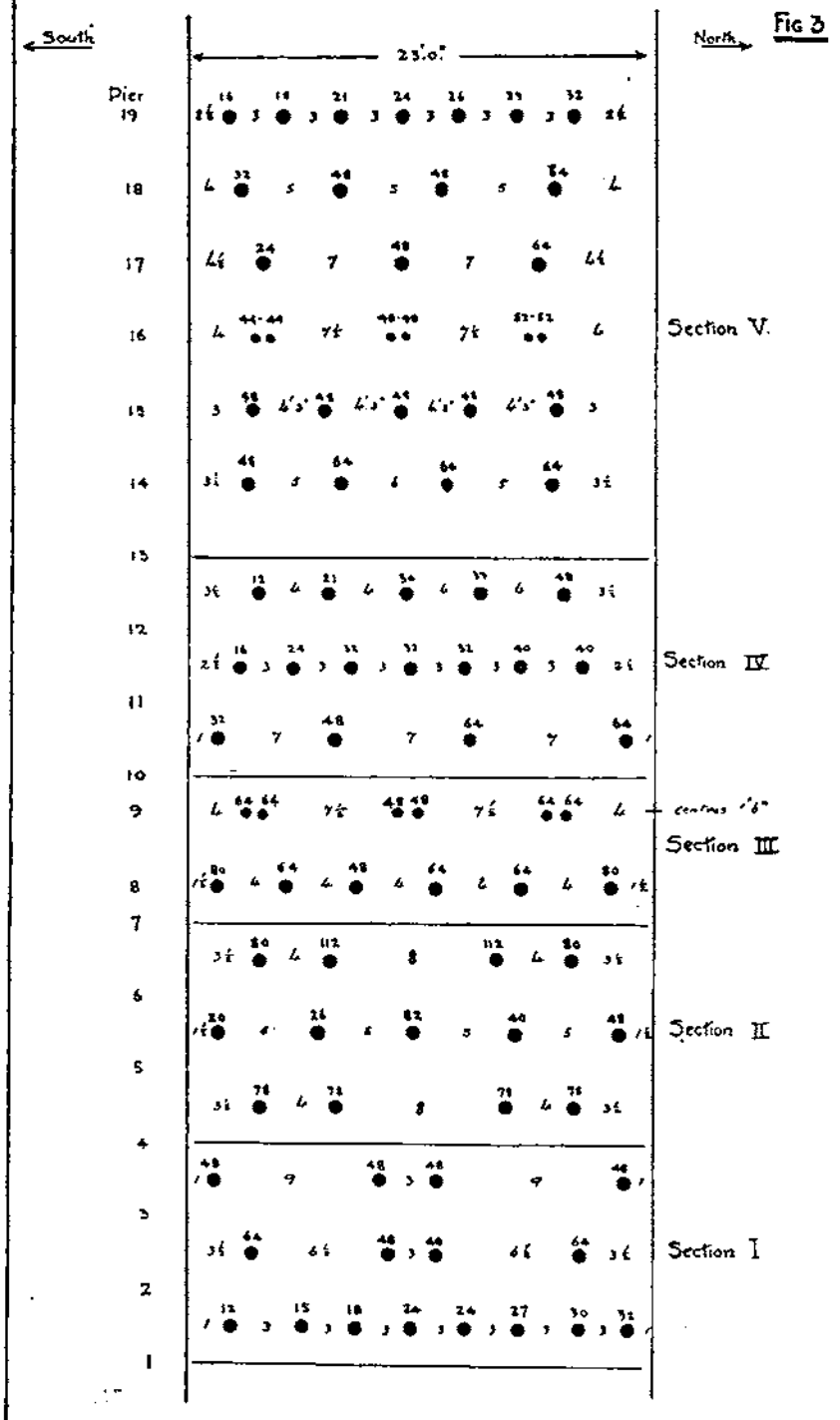
Arches 4/5 and 6/7, in plan



Sketch shewing the sizes & arrangement of charges

(Dimensions are given in feet and ounces)

Fig 3



MEMOIRS.

MAJOR-GENERAL SIR ARTHUR ROBERT FORD DORWARD, K.C.B., D.S.O.

Col. Comdt. R.E. and Colonel, Q.V.O. Madras Sappers and Miners.

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MAJOR-GENERAL SIR ARTHUR DORWARD, late R.E., died on 25th March, 1934, after a long illness, at Terreno, Palma, Majorca, where he had been living for the last two years, at the age of 85.

The name of General Dorward will always be linked with that remarkable military episode which, at the opening of the present century, marked the beginning of the long series of troubles that have since agitated China. On that occasion he played his part in the traditional manner of the British soldier called upon to cope with a grave emergency. He was indeed an officer of whom the Corps of Royal Engineers had every reason to be proud. Though he did not pass the Staff College, or attempt to qualify for high appointments in other respects, yet he showed such a keen business insight and strength of purpose that he always excelled in difficult circumstances. He possessed a distinction of bearing and of speech and a high ideal of duty which impressed all who knew him, and enabled him to deal successfully with Orientals generally, and also with the international contingents with which he came into contact in China.

Arthur Robert Ford, son of James Dorward, Inspector-General of Hospitals, Madras, was born at Ootacamund on July 13th, 1848. He was at Edinburgh High School and at Cheltenham, and from the Royal Military Academy was gazetted into the Royal Engineers in July, 1865. He played football and cricket for the Corps, and both in the routine of peace soldiering and when ordered on active service he acquitted himself admirably. In 1870 he went to India to join the Madras Sappers and Miners, and was almost at once selected for service in the Public Works Department. For his irrigation work during the famine of 1876-7 he received the thanks of the Madras Government. Early in 1879, on the outbreak of the Second

Afghan War, he applied to return to his Sappers and Miners. The request was granted, and he was placed in command of a field company allotted to the Khyber Force under General Ross. There in the winter of 1879-80 Dorward took part in the lesser but strenuous operations near Kam Dakka and in the Kama District. In 1881 he was promoted captain. Four years later he again went on active service in Burma, and for nearly a year he held command both of the British R.E. and of the Indian Sappers and Miners who took part in that campaign. He was mentioned and awarded the D.S.O. in 1886, and in the following year he received a brevet-majority. He was promoted lieutenant-colonel in 1894, and three years later he commanded the Royal Engineers in Jamaica for two years. In 1898 he was promoted brevet colonel, and this rank was made substantive in August, 1899, when he was appointed Colonel on the Staff at Wei-hai-wei with the command of the British troops in North China, while he became responsible for the civil administration of the concession.

This was his opportunity. At that time the South African War was in prospect, while unrest was simmering in China. At first, early in 1900, when the Boxer trouble began, the Royal Navy forced the Taku forts, landed parties of seamen, and advanced towards Tientsin. But more troops were required, so Brigadier-General Dorward arrived on June 26th with some small reinforcements to assume command of the miscellaneous British forces, the American marines, and a Russian contingent, also later a party of Austrian marines. Fighting took place outside Tientsin, until the city was finally taken after a smart action later in July. Soon the Indian division, commanded by General Gaselee, arrived in China, and Dorward was thereupon left to conduct the minor operations in North China lying outside the sphere of General Gaselee's relief of the Peking Legations. He also conducted a small expedition to Tu-liu and discharged various other duties with complete success.

Finally, he was left at Wei-hai-wei as Military and Civil Commissioner to carry out the terms of the settlement that followed the fall of Peking. In this capacity he levied taxes, built roads and bridges, undertook public works, and administered justice with an iron hand. Several pirates were shot by his orders. When he left the British Concession was pacified and contented, while the public funds were in credit. Later, he went to Shanghai in command of troops, and was finally recalled to England in April, 1902. He was made a C.B. and then a K.C.B. for his work in China.

Before the end of 1902 Sir Arthur was again sent to the East, this time as Colonel on the Staff and Commander of the British troops in the Straits Settlements. In July, 1905, he was promoted major-general, and had to leave Singapore to assume a higher appointment —namely, that of Major-General in charge of Administration in South

Major-General Sir Arthur Robert Ford Dorward, KCB, DSO. Colonel Commandant, RE and Colonel QVO Madras Sappers and Miners.

Africa. In this country Dorward remained until his retirement in July, 1910, on reaching the statutory age of 62.

Four years later the Great War broke out. With the growth of the new armies novel problems for accommodating the freshly-raised troops arose, and Sir Arthur Dorward was summoned from Norway by Lord Kitchener to undertake the hutting of Colonial troops on Salisbury Plain. When that was done he was appointed Inspector of Hutting at the War Office, having supervision of all military camps and roads in Great Britain and Ireland, and held the post till the end of the War. He was a Colonel Commandant of the Royal Engineers, also Colonel of the Queen Victoria's Own Madras Sappers and Miners. He was a Fellow of the Linnean Society. He was unmarried.

MAJOR-GENERAL CYRIL MOSLEY WAGSTAFF, C.B., C.M.G., C.I.E., D.S.O.

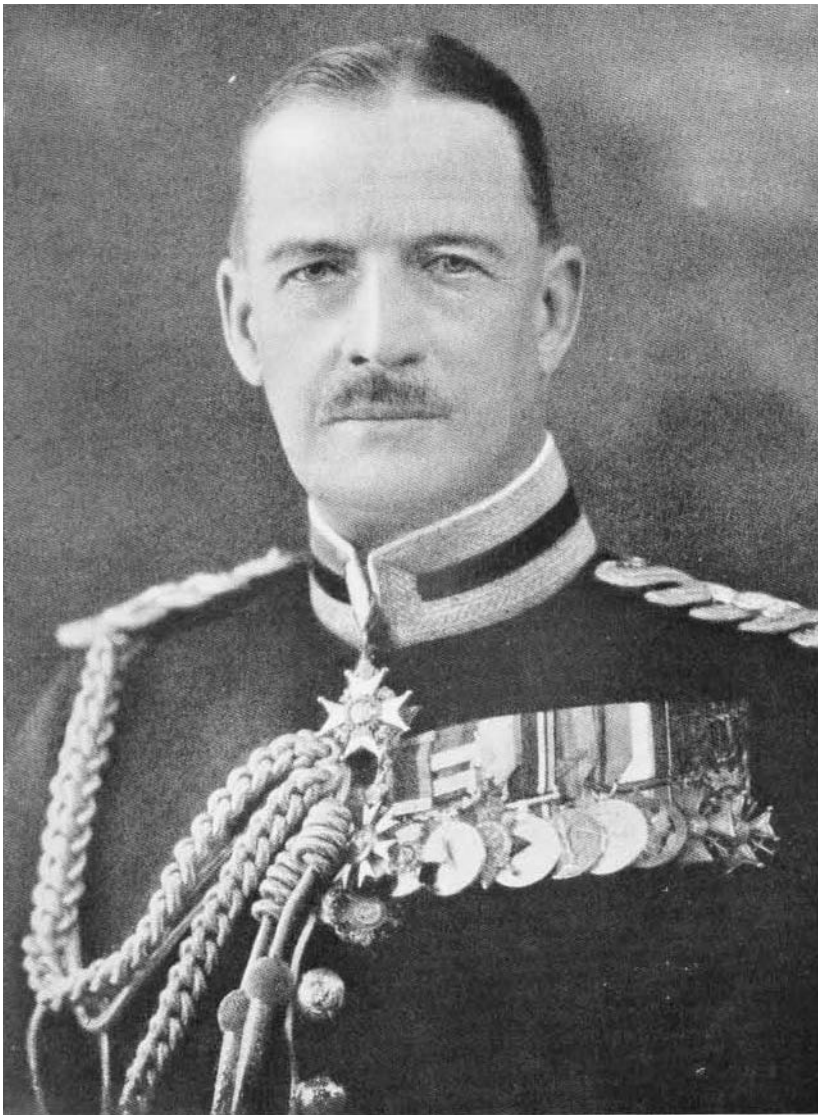
(Reproduced by kind permission of the EDITOR, *R.M.A. Magazine.*)

THE death of General Wagstaff at the comparatively early age of 55 has robbed the Army in general, and the Shop in particular, of an officer who was not only a very gallant and distinguished soldier, but was also one of the most human and lovable characters of his time.

After passing through the Shop he obtained his commission in the Royal Engineers in June, 1897, and, after undergoing the usual young officer's courses at Chatham, he went to India, where he was posted to the Q.V.O. Madras Sappers and Miners at Bangalore. It was not long before he began to make his name in the field of sport, and he represented his Corps in the regimental polo team, a game at which he well might have become first-class. But the exigencies of the Service took him to Rawalpindi, from which station he had his first taste of active service in the Zakka Khel Expedition of 1908, a campaign which earned him his first medal.

After a couple of years at the Staff College, at Quetta, where he showed himself to be one of the leading characters of his Division, he was selected in 1912 for a General Staff appointment at Army Headquarters, Simla, an unusual honour for a Regimental Captain, which was his rank at the time. It was here that he made his first real mark; he was ordered to prepare the Government of India *War Book*, a document which practically constituted the Mobilization Orders for all Government departments in time of war. There were some who affected a sort of contempt for the energy with which he pushed this work through—work which they considered, in their ignorance, to be wholly unnecessary to the requirements of a peaceful India which was unlikely to be disturbed by European or other convulsions. For this work, which he completed in the face of not a little official opposition, he obtained a well-merited recognition in the shape of the Companionship of the Order of the Indian Empire. Incidentally his work was finished and published barely one month before the Great War broke out, and he had the satisfaction of seeing that his labours had not been in vain.

The Great War gave him opportunities which he was not slow to seize, though from start to finish his only idea was to give of his best in the service of his country. Starting in Gallipoli with the "Anzac" Army Corps, for the staff work of whose landing on the memorable 25th April, 1915, he was largely responsible, he became



Major-General Cyril Mosley Wagstaff, CB CMG CIF DSO.

less than a year later G.S.O.1, of the 5th Australian Division, with which he went to France. His unfailing tact and good humour endeared him to the Australian troops, but the entry of America into the war meant for him yet another transfer. In September, 1917, he became head of the British Mission at the headquarters of the American Expeditionary Force in France, a post which he filled with the greatest success until the end of the war. An American officer, speaking of him when in that appointment, made the significant remark that Wagstaff was the finest character of any nationality that he had ever met in the course of a long and varied career. The esteem in which he was held has been testified to by several American officers who have visited England since the war.

His appointments subsequent to the war included Brigadier-General, General Staff, at the Northern Command Headquarters in India ; G.S.O.1, at the War Office, and the command of the Nowshera Brigade in India ; during the first and last of these appointments he again saw active service on the North-West Frontier of India.

His last appointment was his nomination to be Commandant of the Shop in July, 1930. He had long hoped for this appointment, for which his temperament, his character, and his affection for the youth of the nation so well fitted him, and I can well remember his genuine pleasure on hearing that he had been selected for it. It gave the greatest scope for his leading characteristics—his devotion to duty, his anxiety to give of his best for the younger generation, and his humanity. I imagine that there must have been few Cadets who did not respond to his genial nature or who did not realize how anxious he was to do his best for them ; and yet he knew when to put his foot down and dealt severely with those who did not come up to his own high standard of what was required of an officer and a gentleman. His services in the Great War earned for him eight mentions in dispatches, besides the D.S.O., the C.M.G., and four foreign decorations. Withal he was modest, almost to the degree of self-effacement, and yet he had a career behind him of which any soldier might be proud.

As an intimate friend of his for more than a quarter of a century, I can say that I never met a more genuine man, a more simple soul, or a more lovable character. He was so completely devoid of guile that he could hardly believe that it existed in others. If he had enemies (and I have never met them) they were certainly not of his making. He was not spared to become (in the worldly sense) a great man, but he will stand for all time in the memories of those who served with and under him as an example of a man whose guiding principle through life was " Service, not self."

J.R.E.C.

LIEUTENANT-COLONEL PERCIVAL HOPE KEALY.

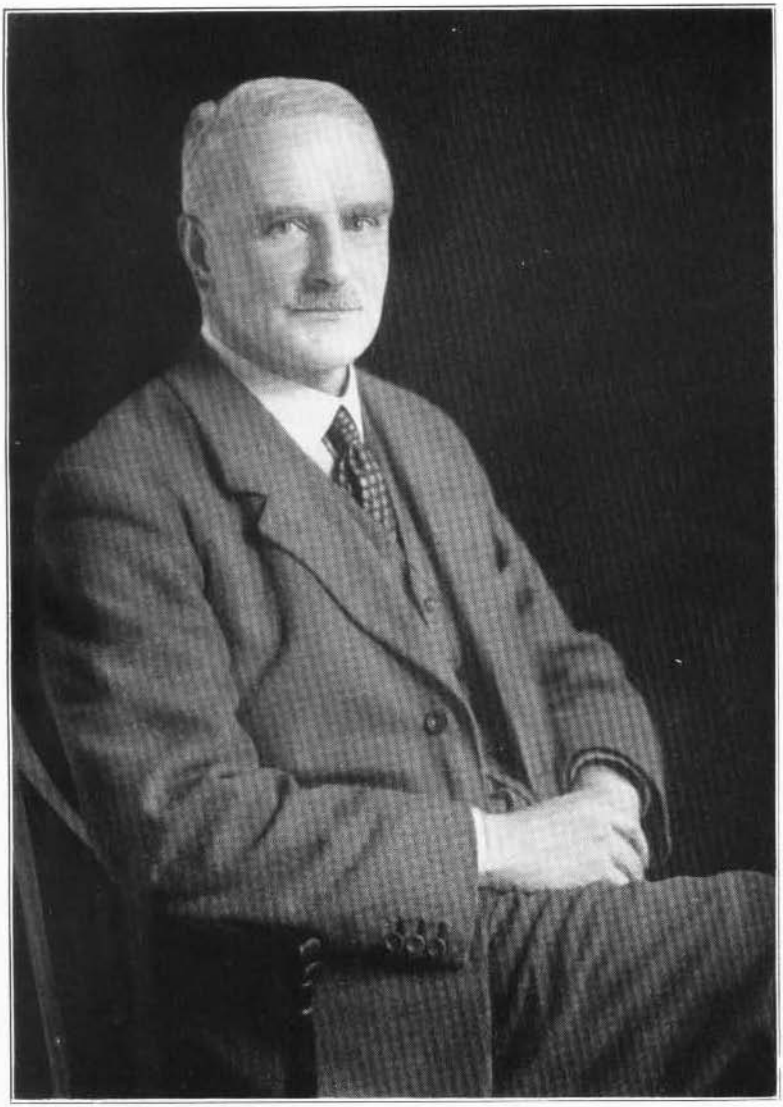
LIEUTENANT-COLONEL PERCIVAL HOPE KEALY died suddenly from heart trouble on the 11th April, at the age of 56, as Secretary of the Institution of Royal Engineers, just as he had completed the preparations for its Annual Meeting.

He had little luck in his career in the Corps, the whole of which was practically passed in India in the Military Works Service, and he did not reach the rank to which, by his high character and abilities, he should have attained. It was consolation to him that his brother officers elected him Secretary of the Institution and Editor of *The R.E. Journal*, a choice which he in every way justified.

He was born at Gosport on the 6th June, 1878, the fifth and youngest son of J. R. Kealy, M.D. One of his brothers is Sir Herbert Kealy, K.C.I.E., of the Indian Civil Service, and the others became respectively a doctor, a schoolmaster and a naval chaplain. He was educated at Portsmouth Grammar School and Epsom College, where he went with the idea of becoming a doctor; but he soon realized that engineering was more to his taste, and, after becoming a prefect and getting into the Sixth Form at 15, he passed into the R.M.A., Woolwich, where he played in the Rugby team. But although robust both in physique and mind, anything beautiful in nature or art delighted him, and to a certain extent he himself painted.

Kealy received his first commission on the 27th July, 1897, and went to India immediately on the completion of his two years at the S.M.E. In India he remained until 1915, employed throughout on Military Works. In 1902, when Garrison Engineer at Roorkee, his first wife died, after a year of marriage, and he exchanged to Lucknow. This brought him both misfortune and happiness, as the officer who took his place at Roorkee was ordered to Somaliland and Kealy thus missed going on active service; but at Lucknow he met in 1905 the lady who became his second wife, Miss Alice Marian Robson, daughter of the late John Robson, a civil engineer. Immediately before the war, he was Garrison Engineer, New Delhi, engaged in building the new British and Indian Lines, which both in design and execution marked a considerable advance on previous work of that nature.

Promoted major in October, 1914, he went to Mesopotamia in April, 1915, as Field Engineer to the 12th Division (G.O.C., Sir George Gorringe), which was almost immediately engaged in operations for the purpose of driving the Turks from the neighbourhood of Ahwaz on the Karun. The most important engineer work was the bridging of the Karkheh River, which was discovered to be several times as wide and much deeper and swifter than had been reported; but it was accomplished on improvised pontoons without the loss of a man. Soon after, in the advance up the Euphrates to Nasiriya in July, carried out with a shade temperature of 120°, Kealy was taken



Lieut.-Colonel Percival Hope Kealy.
Secretary, The Institution of Royal Engineers.
1st October, 1927—11th April, 1934.

Lieut-Col Percival Hope Kealy

ill with dysentery, invalided and sent home. He remained in England, doing duty as D.O. at Leeds, until June, 1916, when he returned to India, where he was to spend another ten years. At the end of the War, he was A.C.R.E., Sialkot, where an immense amount of work was being done in preparing camps for British troops and in adapting barracks as hospitals.

In 1920-21, he was Assistant Director of Military Works for over a year, and in 1921 was Deputy Chief Engineer, Northern Command. In 1922, in which year he was promoted Lieut.-Colonel, he went as S.O.R.E. to Rawalpindi, was then officiating C.R.E., Poona District, and from October, 1924, to September, 1926, C.R.E., Meerut District. He then retired on an Indian pension, his lack of war service standing in the way of his further promotion. A year later he was elected Secretary of the Institution.

In the affairs of the Institution Kealy exhibited the same application, thoroughness and dislike of slovenliness which marked his career in Military Works. In his hands *The Journal* improved and prospered. He greatly facilitated the labours of the Council and its Committees by the lucid manner in which he put forward the matters for discussion and the accounts, and shortened their sittings by always being able to answer on the spot any question which was put to him.

The R.E. Museum was an object of his special care ; he improved it greatly, took great pains to secure articles from all sorts of outside sources, and was indefatigable in tracing such things as he considered should be in the custody of the Corps. He devoted much time in research as regards the history of the Corps and of field engineer methods, and spent the leisure of the last years of his life in compiling a one-volume account of the development and deeds of the Corps, entitled, *Follow the Sapper*, designed for the general reader, young officers and other ranks. The typescript of the book he offered to the Council, who hope to publish it in due course. He also gave much assistance, as Lieut.-Colonel E. W. C. Sandes specially desires should be mentioned, in the compilation of *The Military Engineer in India*, which he liked to speak of to its author as " our child."

About six years ago his heart began to give him serious trouble, and, though he appeared to improve in health, his days were numbered : yet he carried on cheerfully and uncomplainingly, and did not allow his work to suffer. The typescript of his book completed and all the balance sheets and reports for the Annual Meeting prepared, he passed away. An upright gentleman, a good friend a a first-class engineer and officer, it was a pleasure and an educati to work with him.

He leaves a widow and four children, one daughter, married Major C. W. L. Harvey, M.C., of the Indian Political Department and three sons, one a lieutenant in " The Queen's," one at Sandhurst and one at Wellington. J.E.E.

MARSHAL VISCOUNT UEHARA.

WITH reference to the article entitled "Famous Engineers of the Allied Armies," by the late Colonel B. R. Ward, which appeared on pages 66-68 of the January, 1917, issue of *The Royal Engineers Journal*, the following appreciation is published by kind permission of the Editor of *The Army Quarterly* :—

"Marshal Viscount Uehara, Chief of the General Staff of the Japanese Army from 1915 to 1923, who died on the 8th of November, 1933, the day preceding his seventy-seventh birthday, was one of the great figures of the Russo-Japanese War; and, as Oyama, Terauchi, Kuroki, Oku, Nogi, Nodzu, Kawamura, Kodama passed away, Uehara came to occupy a more and more commanding position in the Imperial Army. With the possible exception of the late General Baron Tanaka, on whom fell the politico-military mantle of Prince Yamagata in 1922, resulting in his eventual elevation to the Premiership, no Japanese soldier wielded so much power and influence as the former second-lieutenant of Engineers, in which branch Uehara was commissioned in 1879.

"His character and natural ability, enriched by study in France when a subaltern, had carried him to the rank of major-general by 1900 at the age of forty-four; and his services as Chief of Staff of the Fourth Army during the Russo-Japanese War brought him promotion to the rank of lieutenant-general and a peerage.

"After the war, Uehara commanded successively the 7th and 14th Divisions until 1912, when he became Minister of War; he resigned after less than a year's tenure, owing to the Diet's refusal to sanction his programme of two additional divisions, but his eclipse was only temporary. After a short spell as G.O.C., 3rd Division, and as Inspector-General of Military Training, he became Chief of the General Staff early in the Great War; at the same time two other Engineer officers held equally high office in the Allied Armies—Lord Kitchener and Marshal Joffre.

"Uehara received the G.C.M.G. on the occasion of Prince Arthur of Connaught's Mission to Tokyo in 1918 with a Field-Marshal's baton for the Emperor. He was created a Viscount and promoted to the rank of marshal after the conclusion of peace. Since 1923 his advice was often sought by the Supreme Military Council, and by the Board of Marshals. Perhaps the strangest feature of the old warrior's career was his attainment of the highest military rank and offices despite his being a member of the Satsuma, or naval clan; but few men, either of Satsuma or Choshu, rendered greater service to the State, and he has an assured place in the Japanese Valhalla."

All Reviews of Books on military subjects are included in the provisions of K.R. 522c.

BOOKS.

Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

FOCH. THE MAN OF ORLEANS.

By LIDDELL HART.

(Eyre & Spottiswoode. First Cheap Edition, 8s. 6d.)

It falls to the lot of some men, whether due to circumstances or to some personal characteristic, to have attached to their name an almost legendary glamour. To some it has been vouchsafed to wear this halo during their lifetime, for others the legendary reputation has continued or grown as the years go by. In these days of critical biography the retention of any false or exaggerated glory becomes more and more difficult as time rolls on. No longer are historians and biographists content to accept at their face value the reputations attained by great men in their lifetime. Evidence is sifted, usually with an impartial hand, to get a true picture of the subject. True, the personal views of the author will often sway his judgment, but usually the result is to present an accurate picture of the individual and his work. While such investigation often changes the accepted view, and expunges some of the glamour from a name, it generally brings out in more striking clarity the true worth of the subject.

Personal characteristics and conditions of service, combined with the adulation of Sir Henry Wilson, served to surround Foch in his lifetime with a halo of legend. Now that the cold light of history is turned on the Marshal some of the legendary foundation of his reputation is shaken and the glamour consequently somewhat dimmed. On the other hand, where the foundation is sound the halo shines all the more brightly.

Liddell Hart's study is chiefly directed to an examination of the teachings of Foch, though ample consideration is given to his application of the art of war and to his political and strategic outlook in the consideration of the terms of the armistice, as well as his personality and private life.

In his earlier chapters and in a very valuable appendix, the author makes a critical study of Foch's teachings as shown in his writings, *The Principles of War* and *The Conduct of War*. He shows that Foch was not only a disciple but a chief apostle of the Grandmaison School of the offensive. How this teaching was modified slowly though never obliterated, by his experience in the hard school of war, is dealt with in later chapters.

His teaching of tactics is shown to be based on a study of a very few wars, mostly those of Napoleon and that of 1870, with a meticulous investigation of certain comparatively small episodes. The results of his early application of his peace theories are fairly described and discussed, and it is made plain that, in spite of his own dictum that in war one has not time to learn and must apply the results of peace-time study, Foch did learn much as the war progressed.

As a co-ordinator of action in 1914, and as Commander-in-Chief in 1918, it is shown that it was not so much by his detailed direction that Foch affected the battle, but rather by his energetic and indomitable spirit.

Here we get to the point which gives the book its title. Liddell Hart successfully shows that it was not so much the mind of Foch that helped the Allies to final victory

but his spirit. Here he is linked with the "Maid of Orleans," as the representative of the gallant spirit of France, calling *tout le monde à la bataille*, and infusing into them the spirit to hold on, and to fight back, when things seem at their worst.

Liddell Hart is to be congratulated on a study which, while it may dim the glory of Foch as the director of operations, throws into strong light the gallant spirit of the leader who carried the Allied armies to victory. Relationships in his different spheres with politicians and soldiers, French and Allied, are well described.

This new and cheaper edition is well got up and excellent value for the price. The maps are on the whole good, though many important names and details dealt with in the text are omitted.

R.P.P-W.

NAPOLEON AND HIS MARSHALS.

By A. G. MACDONELL.

(Macmillan & Co. 7s. 6d. net.)

In 1804 Napoleon, as Emperor of the French, appointed 18 officers to be Marshals of the Empire. Of these, four were honorary Marshals, Kellermann, Lefèvre, Perignon, and Sérurier; whilst the remaining 14 were on the Active List. Of these 14, Berthier, the eldest, was aged 51, Moncey 50, five were over 40, and the rest under 40, the youngest, Davout, being 34. Between 1807 and 1815 eight more marshals were added to this list. In birth they varied from the son of a prince (Poniatowski) to the son of a working mason (Augereau), and but five of them came from military stock. In 346 pages the author describes in outline Napoleon's military career, dealing with the characters and actions of the various Marshals as they come into the picture. For those starting on the study of military history the book should prove of the greatest interest, whilst the advanced student will be glad to have so much information put together in such a convenient form. The general reader will find the story of the Marshals full of romance: how Bernadotte founded the Royal House of Sweden, Murat became King of Naples, and others became Princes and Dukes, mostly carrying with them through life the marks of their humble origins.

It was in Spain and Portugal that the British Army met the Marshals of France. Napoleon himself visited Spain only once, when his plans were upset by Sir John Moore's move against his communications. Masséna, Soult, Ney, Mortier, Bessières, Victor, Augereau and Macdonald were all in Spain in 1810. After Masséna's failure to eject the British from Portugal, Marmont arrived at Salamanca in 1811 to take command, but he fared no better than Masséna and was well beaten at Salamanca. The only one of the Marshals who appreciated service in the Peninsula was Soult, who lined his pockets well as Viceroy of Andalusia.

From incidental mention of Wellington in this book, it would appear that the author has a poor opinion of the British leader's military capacity, and also of his personal character (pp. 214 and 327).

P.H.K.

LAWRENCE OF LUCKNOW.

By J. L. MORISON, D.LITT.

(G. Bell & Sons. 15s.)

The claim of Henry Lawrence to be regarded as one of the greatest of our Indian administrators is set forth by Prof. Morison in this volume, and few, after reading it, will differ from the author. A great deal of study, a large amount of original research, and the painstaking collection of materials from all and sundry, including the descen-

dants of Indians who had known the great "Larens sahib," have gone to the making up of a work which must be regarded as one of the best ever written touching British rule in India.

The author devotes a chapter—a most interesting one—to the state of India during the 'twenties and 'thirties of last century. The picture is not flattering either to the civil administration or to the soldiers; some of the greatest thinkers in India were already doubting the permanence of our rule there. Metcalfe, for instance, is quoted as saying that "we appear to have passed the brilliancy and vigour of our youth, "and it may be that we have reached a premature old age."

It was into this society that Henry Lawrence, a subaltern in the Bengal Artillery, "a raw Ulster lad, with little to help him but some notable family virtues and the "grace of God," was plunged. The growth of his character with advancing age and experience is told in a masterly manner. His capacity for hard work and common sense brought him to notice in the First Burmese War; a period of employment in the Revenue Survey gave him a wonderful insight into the Indian mind; a transfer to the Panjab during the First Afghan War showed that he could rule men as few others could.

It must be remembered that the Panjab was at that time an independent state, not very friendly to us. Lawrence found himself, just after the great disaster at Kabul, at Peshawar as liaison officer with some Musalman troops in the Sikh army; the British-Indian troops quartered alongside were in a state of almost open mutiny. Within a few months Lawrence led a detachment of his Sikh troops with Pollock's avenging army to Kabul. There is no better testimony than this to his strength of character, unless it be that, eight months after the First Sikh War, Lawrence, then British Agent at Lahore, led an army of the troops we had just defeated, into Kashmir, and successfully put down an incipient rebellion.

It is with the Panjab that his name will ever be associated, not only because of his skill in pacifying that province, but because of the band of young men—Nicholson, Edwardes, Abbot and others—who, under his brother John, were to save the Panjab, and, through the Panjab, India, by their efforts during the Mutiny.

A memorandum by Lawrence, written in 1843, referring to the weakness of British military dispositions in India, is given in an appendix. Therein he prophesied the Mutiny and described with astonishing prescience what actually happened at Delhi in 1857. The warning fell on deaf ears. But, early in that fatal year, the Governor-General recognized in Lawrence the right man for Lucknow, one of the chief danger-spots. Had he been sent there a year earlier, the Mutiny might have been greatly limited. As it was, Lawrence's exertions during the last three months of his life inspired all and enabled the small garrison to keep the British flag flying over the Residency.

The author has the rare merit in a biographer of frankly recognizing his hero's faults. A very critical spirit regarding the conduct of the military operations in which he took part was one of them, without perhaps realizing that the generals were up against difficulties which he did not know of. Lawrence's battle of Chinhat, just before the investment of the Residency, was a disastrous failure, and it would be only fair to the memory of the military commanders whom Prof. Morison, through views of Lawrence, has condemned, if he had expressed his verdict on Lawrence's failure more forcibly. This, however, is the only serious criticism that can be levelled at the author's treatment of his subject.

The practical Christianity in Lawrence's life was exemplified in the foundation of the Lawrence asylums for the education of British children in a cool climate; the association of his name with the institutions was none of his doing.

The book deserves a better map: there is one unaccountable omission—Lahore—the centre of Lawrence's activities for ten years, and some other towns are badly misplaced. There is a curious misprint on p. 134, "material" for "malarial."

Also, an Indian glossary would be an advantage; especially as many of the vernacular terms, *e.g.*, *burkundauz* and *mahajan*, have gone out of common use.

It is not the fashion nowadays to regard the Victorian Age as having produced great men; all we can say is that we hope that the present age will produce men as great, as good, and as fearless as Henry Lawrence, and we owe a very great debt of gratitude to Prof. Morison for telling us what he did.

F.C.M.

JAMES WOLFE.

By W. T. WAUGH, M.A.

(Manchester University Press. Price 7s. 6d.)

In his preface, the author states that he is fully aware of the rashness in writing this book in view of the numerous books on Wolfe already produced. Would that there were more with his rashness, as he has produced a biography, delightfully written, which fills a very definite gap in the literature of that time, and it is a very human portrait that he paints, of man and soldier.

Born in 1727 of a family of military tradition, Wolfe became a second-lieutenant, at the age of 14, in the regiment of Marines of which his father was Colonel, but was transferred, as a result of family interest, partly because of his terrible proneness to sea-sickness, which was to be such a curse to him in his later life, to the Twelfth Regiment of Foot. At 16, acting Adjutant of his regiment, he was fighting at Dettingen and, by 1744, had been transferred as a Captain to the 4th Foot, thereby missing Fontenoy, where his old regiment was badly cut up.

From then until 1757 we find him at home, fighting in the "45" rebellion and then doing regimental duty both in Scotland and England. He loathed it, and we get a picture, from his letters, of a rather querulous, hyper-critical officer, who might with justice be termed a "grouser." But he was continually ill, with an increasing knowledge that he could not live for many years, and the routine of peace maddened him.

His release came in 1757, when, though only 30, he was chosen as Quartermaster-General for the Rochefort expedition, which not only gave him a further chance of active service but also relieved him from the appointment of Q.M.G. in Ireland, which he had just been forced, reluctantly, to accept.

The story of the fall of Louisbourg—one of the rare examples in those times of the successful co-operation of soldier and sailor—is most graphically told. Then, on February 17th, 1759, he sailed from Portsmouth on his last expedition, which was to bring him real fame. Once again, in Saunders, he found a sailor with whom co-operation seemed assured. As the author says: "The truth is that neither Wolfe "nor Saunders could have achieved anything without the other."

The difficulties and "ups-and-downs" of the campaign are very clearly told, enlivened by entertaining contemporary drawings and caricatures, and a vivid picture is produced of the last "desperate plan" with its culminating scene on the Heights of Abraham.

People had said to George II., "Wolfe is mad," and the old King had replied, "Mad, is he? I wish to God he would bite some of my generals," and that is, perhaps, his best epitaph.

This book cannot be recommended too strongly to the student of war or to the lover of good biography. The author has blended the somewhat sick and querulous man with the vigorous, clear-sighted soldier, so that the reader seems to get a really personal, intimate acquaintance with the subject of the biography.

A remark must be made as to the publishers. The book is very well bound, with exceptionally good print and paper, has many illustrations both in colour and print, and provides excellent plans and maps—the whole at 7s. 6d. May we see many more like it!

T. E. LAWRENCE IN ARABIA AND AFTER.

By LIDDELL-HART.

(Jonathan Cape. Price 15s. net.)

The biography of a man still living is never easy to write. When it is of one who has become, in his lifetime, almost a legend, the task becomes still more difficult, and the author must be congratulated on the general success with which he has carried it out.

It is still difficult to estimate the ultimate effect of Lawrence's campaign in the desert, but its influence was undoubtedly very great, and he did evolve a technique for that type of warfare undreamt of by previous guerrilla or Bedouin leaders. He had previously made a deep study of war in all its aspects, and he had an amazing *flair* for desert war and insight into the mind of the Arab and Turk types.

The author, in his enthusiasms, is always a little inclined to raise the man of whom he is writing above the heads of all others. Lawrence stands high enough on the pedestal of his achievements in the desert war without trying to raise him still higher by comparing Foch and the other leaders of the war most unfavourably with him: and one cannot feel that the author has really strengthened his case by producing arguments from his *The Ghost of Napoleon* to show that Lawrence's conception of war was so immeasurably superior to that of Foch. His comparisons between Bedouin warfare and that of Continental nations seem decidedly far-fetched, and one becomes irritated by remarks such as: "Thus Lawrence's anticipations had "been fulfilled, thanks to nature and to Maulud's skilful adaptation of the Cannæ "model to Arab conditions, on a Torres Vedras basis." One is sorry, too, that the author should have included what were possibly only chance scathing criticisms by Lawrence of other leaders, especially Foch. After all, as the author himself says, "one should remember that Lawrence had only experienced the two extremes of "soldiering, the cesspool of Cairo staff offices and the solitariness of guerrilla war in "the desert."

Apart, however, from this introduction of what has almost become the author's "King Charles' head," the historical account is excellent. He brings out, in the most interesting way, Lawrence's basic idea of the campaign—to keep just sufficient pressure on the Turks to persuade them still to maintain their hold at the end of a very lengthy line of communications, but yet to cause them the maximum of exhaustion. There is little wonder that Lawrence has become a legendary figure when one reads of his almost incredible personal exploits, of the way he held the different warring elements of his force together, and of his power of out-doing the Arabs themselves in all their own special attributes—reconnoitring many miles by day and night, blowing up bridges and railways with his own hands, and with an almost miraculous economy of explosive, settling the whole arrangements of the Bedouin war, and then possibly rushing over to Palestine to deal in no uncertain way with very senior officers.

It is an incredibly dramatic story, told in a crisp, clear way.

The reader gets some slight insight into the troubles of the post-war Lawrence, convinced that we had not honoured our word to the Arabs; and, at the same time one can realize the difficulties of the politicians in dealing with this dynamic idealist. Perhaps it would have been better to leave the story there: Lawrence is a figure of history, Aircraftsman Shaw is a private individual, who probably longs for the life of a private individual. Still, readers may wish to know more of this enigma and, if so, the author has dealt well and tactfully with the subject.

Though military readers may, at times, be irritated by parts of this book, the biography fills a much-needed want, and should certainly be read by any student of war and by any interested in the study of what must certainly be, in many ways, one of the most outstanding personalities in the last war.

PRINCE EUGENE.

By LIEUT.-GENERAL SIR G. MACMUNN.

(Sampson Low. Price 10s. 6d. net.)

Probably, to most people, Eugene is just the "twin soul" to Marlborough, rising to fame in the wars of the Spanish Succession. Yet Eugene was perhaps the most famous soldier on the Continent before Marlborough had begun to make his real name in Europe.

Born in 1663, youngest son of the Count of Soissons, Eugene's parentage seems doubtful. His mother had been the mistress of Louis XIV, and it is possible that Eugene was his son. Louis had cast off the Countess in 1665, and few people in history can have felt more seriously the influence of "a woman scorned." Her life was dedicated to hatred of Louis, and Eugene imbibed this hatred to the full. He had been designed by Louis for the church but, on that King's refusal to change his mind, Eugene fled to the Imperial Court determined to create a military career for himself.

Starting this military career as a Lieut.-Colonel in the Imperial Army, he had his first taste of operations in 1683 against the Turks, who were still almost threatening Vienna, and he served in this war, with considerable success, particularly as a cavalry leader, until the capture of Belgrade in 1688.

From 1689 to 1696, he was employed in various capacities, diplomatic and military, in the fluctuating and somewhat confused fighting in Northern Italy, on the Rhine, and in the Low Country against the French, gradually establishing a reputation, and becoming a Field-Marshal in 1693 at the age of 30.

It was the years 1697–98 that were to make him really famous when, once more, he was opposed to the Turks, this time in command. By the crowning victory of Zenta, with the subsequent Peace of Carlowitz, Eugene became the saviour of Europe from the Turks and the outstanding figure in the military world of the Continent.

The War of the Spanish Succession saw Eugene once more in Northern Italy against Vendome, and it was not until 1704 that he and Marlborough met, when in conjunction they fought at Blenheim. This was the only occasion which seems to have prompted any feeling of jealousy in Eugene's mind. In later years, he felt that all the glory of the success had been ascribed to Marlborough.

1705 saw him back again in Northern Italy where, in 1706, while Marlborough had been successful at Ramillies, he gained the overwhelming victory at Turin; and 1707 saw the failure of the Toulon campaign, one of the greatest strategic conceptions of English history, brought to nothing by the weakness and vacillation of the Emperor. From then onwards, through the great year of Oudenarde and the terrible year of Malplaquet, Eugene was with Marlborough until the latter's dismissal and seldom have two men seen so closely eye to eye or worked in such perfect co-operation.

After Marlborough's recall, Eugene was forced to attempt to continue the struggle, but the Peace of Rastadt brought him respite.

He was only out of military harness, however, until 1716, when again he had to head the Imperial forces against the Turks. Once again he saved the Empire against heavy odds, at the overwhelming battle of Belgrade, which produced the Treaty of Passarowitz.

At last he was allowed some rest from the field to enjoy his newly-built villa and his wonderful art collection. But once more, in 1734, he had to re-don his harness against the French, when he showed that he could fight a waiting, defensive campaign as well as the offensive.

The last few months of his life were spent quietly at his villa, and he died peacefully in April, 1736, at the age of 72½, a great and loyal soldier, a born leader, and a staunch friend.

This book is very interesting but is really more a brief sketch of the whole military

situation in Europe at the time, rather than a study of Eugene himself as a man or a soldier. Students of military history may feel disappointment, the effect of which will be increased by the somewhat inadequate maps which do not even fold out clear of the letterpress. General Macmunn's style, too (accompanied by a maddening punctuation), does not seem to suit this type of work, while proof-reading should not have passed such an historical statement as " Gustavus (Adolphus), only child of Queen Christina, resigned the throne to her cousin, Charles Gustavus, who became Charles X."

ELEMENTARY TACTICS. VOL. II.

(The Art of War, British School.)

By Lieut.-Colonel R. P. Pakenham-Walsh, M.C., R.E., and Major E. E. Dorman-Smith, M.C., Fifth Fusiliers.

(Sifton Praed. Price 10s. 6d.)

The object of this volume is to " demonstrate the application of the principles laid down in the official manuals." With this in view the book consists of a series of schemes.

The narratives and situations are based on one continuous story, and the ground on which the various actions are fought has been selected somewhat fortuitously. The authors in their foreword say they have done this deliberately " not only to give a more human interest to the operations, but also because they feel it is dangerous for teachers of tactics to select ground which affords a typical solution to a problem." As a result they say " it is therefore best to take the ground as we find it."

There are many who will question the soundness of taking ground as we find it when teaching elementary tactics on the ground. In fact, if we turn to the official manual on the subject—*Training and Manœuvre Regs.*—we find :—[Sec. 16 (6) and 17 (2)] " In the preparation of schemes (of this nature) the first essential is to select ground calculated to bring out the required lessons." It goes on to say that an outline scheme should be drawn up from the map, the lessons it is required to emphasize being kept constantly in view. It then explains that solutions to the problems, on the ground, are a necessary part of the preparation in order to test thoroughly the suitability of the ground. Sec. 15 (16) sounds the danger signal of choosing ground, which gives typical or standard solutions by laying down that problems should, as far as possible, admit of at least two reasonable solutions.

The principles to be deduced are that : the first essential is to be clear and definite as to the object and lessons ; the second essential is to choose and test the best available ground to fit these lessons and the final stage is to write up the story with the solutions. *Training Regulations*, 1934, which replaces *T. and M. Regs.*, adheres to these principles. The inference is that we are to be careful in our choice of ground and not to select it fortuitously. The corollary is that even when setting tactical problems from a map we should try to apply these principles and choose the best ground, off the map, in order to bring out the required lessons.

Taking Sec. VIII of the book under review, " River Crossings in face of Opposition " (The forcing of the R. Darent), the authors have not taken the ground as they find it because it does not suit the object and lessons of the problem ; as a result, and presumably in order to keep their story continuous, they were forced to change completely the important topographical features of the R. Darent. As this is an academic study of such an operation off a map little harm is done in altering topography in this particular case. But when teaching the tactics of a river crossing on the ground, a teacher would prefer to take a more suitable river for his purpose and in this case he would not have to look farther than the R. Medway. There are, of course, cases when ground has to be altered, as for example, when no suitable river exists.

But the point is that the essence of teaching elementary tactics is the choice of the best available ground, and we may confuse the issue if we make the choice of ground

dependent on a continuous story. It is often better to have a series of short, crisp and disconnected stories in order to ensure the use of the best ground.

The narratives, situations and solutions are comprehensive; the authors have exemplified very clearly the method of teaching by narrative; administrative problems are not overlooked, and with the addition of good maps and very clear overlay diagrams the book is a masterpiece of thoroughness. It should be included in every military library, and will be of special use for the training of Territorial Army officers. It should be of real value to officers studying for promotion and for the Staff College.

The terrain chosen is in the vicinity of Chatham, and for this reason should be of particular interest to officers of the Royal Engineers.

C.D.M.

FUNDAMENTALS OF INDUSTRIAL ADMINISTRATION.

By E. T. ELBOURNE.

(Macdonald & Evans. Price 12s. 6d. net.)

This very comprehensive work is written as a textbook for students of the newly-developing science of business management. The scheme adopted is to give first a bird's-eye view of the whole field of industry (Part A), followed by a study of the technique of running an industrial concern (Part B). We propose to describe the salient features of each part and finally to give some comments on the book as a whole.

Chapters I to III deal with the history and present state of industrial production. A most interesting account of the historical development of industry in this country is followed by a general view, given by means of a set of statistical tables, very well presented, of present-day production.

Three striking features emerge. First, the extraordinary suddenness of the Industrial Revolution; a very short space of time separates us from, industrially speaking, mediæval times. In 1765 James Watt could not get a cylinder, 2 feet by 6 inches, bored with a smaller difference than three-eighths of an inch between the longest and shortest diameter, and, in spite of wrapping the cylinder "with cork, "oiled rags, tow, old hats, paper and other things," there were still spaces sufficient to let the air in and the steam out! Yet by 1850 mechanical equipment was substantially that of to-day.

Next there is the preponderating part played in that revolution by this country and due to many causes, among them British inventive genius.

Lastly comes the lack of foresight or any national plan or control during the progress of the revolution. This resulted, as regards transport services, in the most haphazard and uneconomical development, and although, in productive industry, free enterprise achieved physical efficiency, yet the complete ignoring of the human and social factors produced most oppressive conditions and led to a certain antagonism between employer and employed which it is now the chief business of efficient management to allay.

Chapters IV to VI deal with commerce and trade. Economics, national and international, are discussed and, as regards commodities, the working of "produce exchanges" is described and a picture given, by well-presented tables, of the imports and exports of the leading countries.

In view, as he says, of the doubts now being cast on so many economic maxims hitherto accepted, the author wisely aims at tracing the development of economic ideas rather than stating laws. In discussing "economic balance," he points out that modern industry appears to result in "much less being produced than could, at suitable prices, be consumed," but he does not suggest a remedy for this situation which is due, he thinks, to the pivot part played, of necessity, by profits in most industrial concerns.

Chapters VII to IX deal mainly with banks, joint stock companies, and "combines." The different ways of obtaining credit and the methods of working of commercial banks on the one hand and central banks on the other are described. The law and practice relating to joint stock companies are clearly explained and a description is given of the many forms of trade associations, working to reduce competition mainly either by price-fixing, or by the restriction of output to definite quotas.

Chapters X to XII deal with Commercial and Industrial Law, and "Industrial Relations." The legal field embraced is a wide one, including the meaning and terms of contracts; patents and copyright; and wages, insurance and factory hygiene.

Under "Industrial Relations" the various methods of payment are fully discussed and it is interesting to note that some fruitful experiments have been made in "collective piecework" which helps to elicit the team spirit. Methods of negotiation between employers and workmen are described—in this country they are still mainly voluntary. "Welfare" is shown now to be a wide branch of activity and the author points out that while efficiency may be directly affected, the success of such activities is to be gauged mainly by the improvement in relations inside and outside the factory.

Passing to Part B (Technique), Chapters XIII to XV deal fully with the physical side of industry under the heads of Production, Distribution, and the combined head of Development and Research; as to the latter the author insists that development, "which is really the application of the results of research," should now be accepted as a "major function in industry."

Such points, among many, are explained as, under "Production," how the most economical size of a batch of machine products can be found by graphs; under "Distribution," the plan of forming subsidiary companies overseas to develop export trade; under "Development and Research," the value of examining, with scientific advice, all operations in a factory; and the use of questionnaires regarding sales—"Who buys? Which brand? Why?"

Chapters XVI to XX are concerned with the financial and accounting side of industry, including the use of charts and statistics. The form and meaning of balance sheets and profit and loss accounts are well explained with a full example. Methods of costing are described, leading on to explanation of how financial control can be exercised by comparing actual costs with "budget formulas"; this explanation, however, could have been made much clearer by a fully worked out example. A scientific method, worth noting, is given, of calculating the comparative financial effects of installing different types of new plant.

The final chapters XXI to XXIV deal with organization and management—office and general. The author believes that much improvement in office work could generally be made if investigation were carried out by a trained and competent person to decide "whether everything is done in the best way, the best place and by the "best available person." He gives useful advice on many office questions such as the use of "routine diagrams" and the management of conferences.

As regards management in general, the author stresses the importance of the human factor. If an undertaking is to succeed, a spirit of willingness and co-operation among all ranks is essential. In large concerns, where personal touch between employer and employed is impossible, he strongly recommends the formation of a special "personnel department" to act as a substitute for that personal touch. This department should deal with such subjects as selection for employment, providing incentives, and circulating information among the personnel. Some sound advice is quoted from Professor Hilton on the initiation and management of Works Councils.

Taking the book as a whole, the author is particularly successful in the descriptive portions, having the gift of selecting and presenting information in such a way as to make every subject touched upon interesting. Theoretical explanations are also

generally clear though in some cases we would have preferred a greater proportion of concrete example to abstract principle.

The appeal of the book will naturally be to those primarily, engaged in, or likely to engage in, industry. For an engineer officer, beyond "tips" to be picked up here and there, it cannot be regarded as specially valuable technically, because the requirements and methods of civil industry differ so much, of necessity, from those of military engineering. On the other hand, industry now enters so much into almost every department of life that there are, especially in Part A, many points of interest and value for everyone, and particularly for those likely to reach positions of influence, whether in the service or outside.

It remains to say that the general arrangement and "get up" of the book are admirable and it has an excellent index.

R.H.

MODERN COLD ASPHALTS.

(The Road Emulsion and Cold Bituminous Roads Association, Ltd. Price 2s. 2d., post free.)

Cold asphalt road-surfacing is nowadays common, but somewhat complicated at first sight, owing to the large variety of processes covered by the recent British Standard Specifications for such work (Nos. 510 and 511 of 1933). In this pamphlet the various processes are classified in accordance with the grading of aggregate employed and the method of mixing the aggregate and bitumen. Each class of surfacing is described in detail and a table is given showing to which class a number of modern British cold asphalt materials belong. Road engineers should find the pamphlet most useful when dealing with this type of surfacing.

C.M.S.

KNOTS, SPLICES, AND FANCY WORK.

By CHAS. L. SPENCER.

(Brown, Son & Ferguson, Ltd., Glasgow. 1934. Price 5s.)

In his preface to this excellent book the author points out that though the art of fancy knotting probably reached its height on board the sperm-whalers in the middle of last century, the art has so declined since the advent of steam that much of it may be lost altogether. "The book," he states, "is an effort to preserve it."

That the author has succeeded in his task is apparent after a short perusal of the book. The whole work is admirably arranged and indexed, so that it may serve either as a textbook for the beginner in the art of splicing or as a reference book for an expert in boatswain's work who wishes to do some fancy work of which he has hitherto had no knowledge.

The construction of ropes is first dealt with, from which the author passes on to the making of knots, some common, others less known. Wall knots, crown knots and many others more complicated, but for the same purpose, are then described. Splices are then fully described, and the remainder of the book is taken up chiefly with the more elaborate forms of fancy work, with the exception of a few pages at the end on wire splicing. The description of square sennit is interesting, as few other books, if any, give a description which may clearly be understood by the reader. Each stage of every piece of work, besides being described, is illustrated by admirably clear drawings.

The author, Colonel Spencer, who is the Rear Commodore of the Clyde Cruising Club, is also an associate member of the R.E.Y.C. and owner of the 29-ton auxiliary ketch *Ron*.

In conclusion, another passage from Colonel Spencer's preface may be quoted: "In yachts . . . of late years a false standard of smartness seems to have been set up. It consists in scrubbing decks and polishing brasswork. These are all very well but are jobs that can be done by anyone. Good ropework is a sailor's job."

L.R.E.F.

MAGAZINES.

REVUE MILITAIRE SUISSE.

(*January*, 1934.)—1. *Le VIe concours hippique international de Genève.*

An account of the last international horse show held at Geneva.

2. *Instruction générale sur le tir de l'artillerie.*

General Rouquerol begins his article with a few comments on the recently-issued French official instructions on artillery fire. He next deals with the latest German war plans. Powerful air squadrons will be sent out, by surprise, to fly over a selected portion of enemy territory, in which they will destroy everything of value and will ruin the defences. This action will be followed by an invasion of motorized troops, who will exploit the results gained by the air force before the surviving defenders have had time to recover and organize themselves. Here there is a difference between the German and Italian ideas. The Italian idea is to achieve finality with the air force alone.

3. *Préparation de la jeunesse italienne.*

Major Perret reviews two articles that appeared in the *Rivista Militare Italiana*: "The Organization of Fascist Youth and Our Military Preparation," by Lieut.-Colonel Carboni, and "Pre-military Formations and the Army," by Major Scalise.

The Italians have copied the ancient Greeks and Romans in training their young men, and they now have a large body of youths, prepared for military service, ready to serve in the army and militia when required. The writer regrets that the Swiss do not possess an organization on similar lines.

4. *Soldats ivres.*

The editor deplores that, although conditions in this respect have greatly improved in recent years, drunkenness amongst soldiers in public is not unknown. Switzerland is the only country in Europe in which the soldier goes on leave and rejoins his unit in uniform and with arms and equipment. It is more common to meet soldiers travelling alone in Switzerland than in other countries.

Various means are suggested for reducing the opportunities a soldier may have for over-indulgence in alcohol. In peace-time drunkenness gives a soldier a bad name, in wartime it may mean disaster.

(*February*, 1934.)—1. *Un voyage d'études à Ethe et à Virton.*

Colonel Grasset has made a study of the actions that took place in Belgian Luxembourg in the latter half of August, 1914. In a previous paper he has dealt with the disaster that befell the 3rd French Colonial Division at Rossignol on the 22nd August. We are concerned with the 5th French Army alone.

The encounter between seven infantry divisions and one cavalry division, on the German side, and seven infantry divisions and a brigade, on the French side, led to the following results. At Rossignol the French met with disaster; at Bellefontaine they carried out a victorious resistance; at Virton, where the French had numerical superiority, the fight was indecisive; at Ethe, with inferior numbers, they broke up a German attack for a whole day.

One of the main features that the writer criticizes is the doctrine, so prevalent in the French Army, of attacking the enemy blindly wherever he might happen to be. He does not lay the blame too much on the staff; they knew their job, as was proved later; but they behaved as if they were on grand manœuvres, and hardly gave the enemy a serious thought. Information about the enemy was defective, cavalry reconnaissance was hampered by the wooded nature of the country and by the fog. The march of the troops was delayed by heat.

The hours of departure fixed by the higher command were not adhered to. Colonel Grasset tells us what would have happened if the movements had been correctly timed. At Rossignol no blame attaches to the 3rd Colonial Division. They were up to time, but blundered into the 12th German Division, whose presence had not been dreamed of. At Bellefontaine, the advance guard of the 2nd Corps only reached the place at 8.30, whereas they should have been at Tintigny—several miles farther on—at 6. Had they been up to time and seized the bridge at Tintigny, the Rossignol disaster would probably have been averted. At Virton the 8th Division was 1½ hours late. Here—the moral is a bad one—its unpunctuality saved it from disaster.

The four engagements are an interesting study and afford valuable lessons. The neglect of these lessons caused a loss to the French of 50,000 in killed and wounded.

2. *Le VIe concours hippique international de Genève.*

Colonel Poudret here concludes his article on the last international horse show at Geneva.

3. *L'échec de la conférence du désarmement.*

The editor does not blame the League of Nations for the failure of the Disarmament Conference: it is the nations themselves on whom the blame rests for failing to come to an agreement. If the great powers have shown more hypocrisy than the small ones, it is because they have greater interests to safeguard. Placed in the same position, the small powers would have acted similarly.

The attitude of France and Poland is quite understandable. Flanked, as they are, by potential enemies, they have no wish to weaken their own powers of defence. France and Germany are the countries who are chiefly interested in establishing a permanent peace, but they cannot see eye to eye with one another.

Great Britain and Italy have tried to exercise a favourable influence, but they are not entirely disinterested and, in any case, they do not wish to be alone in pulling the chestnuts out of the fire. A future war is not likely to remain localized, but will spread like wild-fire over the whole of Europe.

The conclusion arrived at is that, in the present state of human mentality, no nation can afford to neglect its defence.

(*March*, 1934.)—1. *Les éxigences et les disciplines actuelles du haut enseignement militaire.*

This is the first part of a lecture delivered by General Duffour, commanding the 5th Infantry Division of the French Army, to the Swiss Society of Officers. He deals first with the general object and the necessity for higher military training, next with the fundamental methods of this training and, finally, with the actual organization of the higher military training in France. He describes the system of promotion and selection in vogue, and the selection and training of officers for staff duties. Candidates for the Staff College are admitted by examination between the ages of 30 and 40.

General Duffour contrasts the working of the staff in France with that in Germany, where the staff takes complete control, and is allowed to usurp the powers of the commander. Most of the officers who held high posts in France during the war were Staff College graduates.

2. *Quelques mots à propos du recrutement.*

Colonel Verrey gives an account of the experiences of a recruiting officer. Recruits who come from large towns are inferior in physique to those who come from medium-sized or small towns. The effect of sport is not always good. Strong men are apt to overstrain themselves and ruin their health: weaklings may, with care, develop their physique and do better work than the strong.

Some branches of the service are more popular than others. There is considerable competition for the post of mechanic in a tractor battery: the air force is also in favour: there is no difficulty in finding recruits for the engineers; although, in the trades, masons are plentiful, and carpenters, saddlers, shoe-makers and tailors are scarce. Some recruits apply for a special branch of the service, but their wishes

cannot always be met. Conscientious-objectors appear to prefer the medical services.

3. *L'escadron motorisé dans le groupe de reconnaissance divisionnaire.* By X.Y.Z.

In the scheme of reorganization of the Swiss Army "exploration groups" are being formed as part of a division, and consist of cavalry, cyclists and motorized machine-guns. In motorized divisions the cyclist squadron will be mounted on motor-cycles instead of ordinary bicycles.

A motorized squadron was employed in the manœuvres of 1932. Its equipment consisted of 1 motor-car, 62 motor-cycles with side-cars, 3 lorries and 1 kitchen trailer. The drawback to the motor-cycles is that they are tied to the roads, they are noisy (although it is hoped to equip them with efficient silencers), and they have two formidable enemies, the machine-gun, and an obstacle combined with an ambuscade. For work in the mountains, motor-cycles are greatly preferable to lorries, but side-cars have their drawbacks, especially when sharp curves are encountered. In such country ordinary motor-cycles are preferable.

A.S.H.

RIVISTA DI ARTIGLIERIA E GENIO.

(*January*, 1934.)—1. *Concetti di impiego dell' artiglieria controaerei.*

Colonel Castagna gives his views on the employment of anti-aircraft artillery. It is only possible here to mention a few of the points that he raises. He distinguishes between the technical object—that of bringing down an aeroplane, and the tactical object—that of preventing it from attaining its objective.

To calculate the number of guns required to protect the area occupied by a division, for instance, the diameter of such an area is assumed to be 12 to 15 km., and the time required for aircraft to cover this distance is about 200 seconds. In order to bring down a single aeroplane, it must be possible to fire 1,500 rounds at it in this time. This is based on the experience of the Great War, in which it was found that 3,000 rounds were fired, on an average, for every plane shot down. The number of batteries (of four guns) works out to twelve. For flights of aeroplanes, 1,000 rounds are assumed to be necessary for each plane shot down.

Anti-aircraft guns must be in constant readiness: observation must be carried out, if possible, up to a distance of 15 to 20 km. from the batteries. At night, illumination should be provided over a distance of 6 km., that is, for a period of two minutes, on flying aircraft. In conclusion, the writer would assign armament as follows:—

To divisions: Automatic rifles and machine-guns against low-flying aircraft.

To corps: Groups of 75-mm. guns on the lines of probable flight of enemy aircraft.

To armies: Guns of heavier calibre (100 to 120 mm.).

2. *L'esercito inglese ed il problema della meccanizzazione.*

The anonymous writer of this article has made a careful study of the progress of mechanization in the British Army. In addition to the long list of books quoted at the end of the article, the writer has made use of the information given by the military correspondents of *The Times*, *Morning Post* and *Daily Telegraph*. Six photographs taken from these papers illustrate the text.

The first part of the article deals with the organization of the British Army, the purposes for which it is maintained, the supply of officers, and regimental life generally. Whilst the organization is suited to the British temperament and character, there are points about it that surprise and mystify the Latin mind.

With regard to mechanization, the British feel a certain amount of justifiable pride from the fact that, in this respect, they are giving a lead to the rest of the world. But a truly British characteristic comes out here, that of compromise.

In the first post-war period, 1919–23, an attempt was made to organize the tanks that remained over from the war in battalions. In the second period, from 1923 to

1926, the idea was to form mobile units of cavalry, motor-drawn artillery, infantry in lorries, armoured cars and tanks. In the third period of evolution, the idea was developed of forming a completely mechanized force capable of entirely replacing cavalry, artillery and infantry. It was found necessary to reduce the number of types of vehicles to a minimum.

The article ends with the conclusions the writer has reached on the problem of mechanization as it affects the British Army as well as foreign armies.

3. *Idee francesi sull'impiego dell'artiglieria in montagna.*

Under this heading the editor has written a note on a French publication: *Instruction provisoire sur les opérations des grandes unités en montagne.*

A *grande unité* specialized for mountain warfare is an infantry division of two brigades, each consisting of two regiments, with a mixed train, partly carried on pack-animals, and partly horse-drawn or mechanically propelled. The artillery of such a division consists usually of a regiment of pack-artillery and a regiment of horse-drawn howitzers.

There are three types of mountain guns in France: the 65-mm. (1906 pattern), forming 4 mule-loads, the 75-mm. Schneider (1919 pattern), forming 7 loads, and the 105-mm. Schneider (1919 pattern), forming 7 loads.

It would be an advantage if a single type of pack-saddle for all loads could be introduced, as in the case of the Skoda 75. Mountain artillery should be capable of firing at high angles of elevation (60° to 70°), and the gun should have a variety of charges to enable it to fire with a very reduced charge at short range. The ballistic problem at high elevations becomes a complicated one, since wind, temperature and pressure are liable to very sudden changes.

4. *L'organizzazione della protezione collettiva antigas.*

Lieut.-Colonel Biagioli describes types of shelters against gas attacks, which he divides into two classes:—

(i) Those hermetically sealed, which provide protection for the inmates by excluding air from outside.

(ii) Filtering shelters, in which air is admitted from the outside after the noxious gases have been rendered harmless by some absorbent material.

The former are intended only for short occupation; the latter for occupation for longer periods. Companies of sappers and miners are provided, in their engineer park, with material and apparatus for protection against gas attacks.

5. *Motori a idrogeno.*

Lieut.-Colonel de Braud has derived the information that he gives in this article from an article in *Motor Transport* and from a paper read before the "Institute of Fuel," of London, in March last, by Messrs. R. Erren and W. Hastings Campbell. The use of hydrogen in internal-combustion engines offers considerable possibilities. It may be used by itself, mixed with air, or mixed with oxygen. It may also be added to a poor mixture of petrol and air with satisfactory results.

The hydrogen engine combines the characteristics of the petrol and steam engine. Hydrogen is introduced into the cylinders through a special valve and burns like an explosive, as in an internal-combustion engine, producing water in the form of superheated steam, which does additional work by expanding as in a steam engine. The result is the absence, in the cycle, of the short period of intense pressure which is the cause of knocking in petrol engines.

In Italy hydrogen could be produced by the electrolysis of water: the current being furnished by water-power during the periods when there is least demand for it for other purposes. To obtain hydrogen cheaply it is, of course, necessary to find a market for the oxygen which is produced at the same time.

6. *Mobilità e potenza delle artiglierie in terreno di montagna.*

Colonel Pavari discusses the merits of different types of guns suitable for mountain

warfare, and comes to the conclusion that there are only two suitable types: long-range guns with mechanical traction, and pack-artillery.

7. *Il proiettore sul campo di battaglia.*

Captain Paoli devotes a long article to the employment of searchlights on the field of battle. He begins with a description of the searchlight, the angle of depression of the beam, its range, etc. Next, he deals with the location of the searchlight and the position of the observer. Other points mentioned are the use of the projector in the approach, in organizing the attack, in preparing and carrying out the attack, and in the defence. An instance is quoted, in the passage of the Isonzo in May, 1917, when twenty searchlights were used by the 24th Corps to confuse the Austrians as to the points selected for crossing. Finally, we come to the use of searchlights in anti-aircraft defence. Here the writer makes certain specific recommendations.

(*February*, 1934.)—1. *Fanteria, truppe celeri e genio.*

This is a prize essay by Major Cappucini on the relationship between infantry, mounted troops and engineers. After a brief historical survey, the writer quotes the pre-war regulations laying down what the relations were. At the outbreak of the war, all countries found that their armies' supply of engineers was hopelessly inadequate, and that the regulations defining the duties of the engineers were anything but clear. Not only were the engineers insufficient in numbers and inadequately equipped, but engineer stores were too few and badly arranged, and means of communication were defective.

During the war there were many examples of the flagrant misuse of engineers, mostly on tasks that should have been carried out by the infantry. This occurred in every belligerent army.

During the war great changes took place. Those that took place in the Italian Army and other armies are described at some length. Many specialized units were formed; infantry were given their own detachments of pioneers, detachments of signallers were attached to infantry units, and some armies, notably the British and American, organized a Corps of Signals independent of the engineers. The amount of technical equipment was increased many times over.

The writer gives a detail of the organization of divisional engineers in nine of the principal armies. He discusses, at considerable length, the duties of engineers in relation with other troops, and what these duties will be in the future.

2. *Le artiglierie divisionali nell'avvicinamento.*

In Lieut.-Colonel Bravo's article, a comparison is made between the French and Italian official regulations dealing with the action of artillery in the approach to an enemy position.

3. *Modalità e mezzi d'addestramento della radiotelegrafia pratica.* By Lieut.-Colonel Supino.

A detailed account of the course of instruction for radio signallers.

4. *Le corazzature dei carri armati e le armi anticarro.* By Lieut.-Colonel Caracciolo.

There are two schools of thought with regard to the design and armour of tanks: (1) those who believe in high speed and light armour, which is, roughly, the British system, (2) those who believe thick armour to be a primary consideration, involving a diminution of speed, which may be taken as the French system, although, as a matter of fact, the French possess all conceivable different types.

Lieut.-Colonel Caracciolo quotes German, French and Polish writers on the subject of tanks and anti-tank weapons, also the British regulations for a mixed battalion of tanks in the attack.

The conclusion he arrives at is that, for repelling an attack of mixed tanks, a gun is required of a calibre of 40 to 50 mm., with a muzzle velocity of 550 to 600 m/s. (1,900 ft./sec.), whilst for light tanks, with 9 to 10 mm. of armour, a light weapon

with a calibre of 12 to 15 mm. and a velocity of 800 to 820 m/s. (2,700 ft./sec.) is most suitable.

The writer concludes with an example, in which he assumes an attack carried out on a 400-metre front, held by a battalion, by two companies of tanks (one of 16 light, and one of 16 medium tanks) His calculations show that three guns of 40 to 50 mm. would be required to put the medium tanks out of action and that, similarly, three machine-guns of 12 to 13 mm. would be required to deal with the light tanks. In both cases the number of anti-tank weapons is greatly in excess of what is likely to be available.

5. *Motori a idrogeno.*

Lieut.-Colonel de Braud concludes his article on hydrogen motors.

The success of the "Erren" engine depends upon a cheap supply of hydrogen. Hydrogen can be obtained cheaply by means of the "Noeggerath" electrolytic cell, working under pressure. Not only is this method cheaper than the ordinary method of electrolysis—the consumption of current being less—but the gases themselves are produced under pressure and are collected in metal cylinders. Expensive compression plant is thus eliminated.

The efficiency of the hydrogen engine is proved by the fact that the engines converted to this system in the "Erren" works in Berlin were of obsolete type and in bad condition and, even so, they gave good results with hydrogen. There is a decided increase in efficiency and power over the petrol engine.

The "Erren" works are now represented in England by the Erren Motors Co., Albion Works, 17, Grayling Road, Stoke Newington.

(*March*, 1934.—*Technical Supplement.*)—1. *Un nuovo metodo di calcolo della traiettoria per archi successivi.* By Lieut.-Colonel Bruno. A new method of calculating trajectories of guns.

2. *Il traffico radio campale.* By Colonel Sacco.

A technical appendix to an article that appeared in the December number.

3. *Qualche considerazione sulla precisione dei telemetri monostatici.* By Brig.-General Calichiopulo.

A discussion on the accuracy of range-finders, with special reference to the Zeiss stereo-telemeter.

4. *Sulla deformazione dei cilindretti di metallo malleabile impiegati per valutare la potenza degli esplosivi.* By General Marrullier.

The theory of experiments on soft-metal cylinders to determine the force of explosives.

5. *Su alcune formule generali di balistica interna.* By Major Argan.

6. *Il cambio Wilson.* By Major Marziani.

An article on the Wilson gear-changing mechanism, and its application to military vehicles, with thirty illustrations.

A.S.H.

REVUE DU GENIE MILITAIRE.

(*January–February*, 1934.)—1. *Note au sujet de la fortification permanente.*

Colonel Didio has written an interesting note on permanent fortification based on the experiences gained during the war in the Verdun forts. The note should be read in its entirety; it is only possible here to allude to a few of the points mentioned.

The rapid fall of the Belgian forts, under a bombardment of heavy guns, led to a belief that permanent fortification was doomed. This idea was, fortunately, disproved when the Verdun forts were reorganized under General Pétain as *points d'appui* of the field of battle. The forts became the breakwater on which the waves of the German attack broke up. It must be remembered, too, that it was the

existence of the French forts, Belfort, Epinal, Toul and Verdun, that led the Germans to violate Belgian neutrality, and so brought Great Britain into the war.

In designing a fort, it should be spread out over a considerable area. For practical reasons, only a few portions, such as gun-shelters, observation posts, etc., can be made proof against shells of heavy calibre. Other places, such as machine-gun emplacements, etc., should be kept at a distance from the gun-shelters, so as to be safe from shells intended for the latter.

The armament of a fort should consist of guns of 155 mm. (6-in.) calibre for long-range fire, and 75 to 90 mm. calibre for shorter ranges. There should also be small-bore guns and machine-guns. Guns should have disappearing mountings, and not merely revolving turrets. As regards infantry weapons, all should be under cover. It is absolutely impossible to man the parapets of a fort during an attack.

Precautions should be taken against gas attacks, and proper ventilation should be provided; by no means an easy matter. There should be an ample supply of provisions. Once it is completely isolated, no fort is likely to hold out more than a fortnight, but it should be borne in mind that re-provisioning a fort, even if not isolated, is a difficult job, and it is advisable to provide supplies for several weeks, if not months.

As regards water supply, a well is essential, even if it has to be sunk to a great depth. Cisterns cannot be relied upon: they are apt to be damaged by shells, or the water may be poisoned by infiltrations after a bombardment.

Constructional alterations or repairs often have to be carried out during a battle. An ample supply of building material (*e.g.*, cement, sand, steel bars, etc.) pneumatic drills, sheet piling, and tools of all kinds, are necessary. Detailed plans of the fort should be available, showing thicknesses of concrete and other important information. The absence of such information was the cause of much unnecessary work in some of the Verdun forts.

2. *Travaux d'interêt général exécutés par les troupes du Génie en* 1932.

This is an account of the construction of some bridges by the Corps of Engineers during 1932. It is fully illustrated by photographs. The works described are the following:—

A foot-bridge, with a clear span of 18 m., constructed for the municipality of Arneville.

A wooden pile bridge, with a waterway of 21 m., for the commune of Recologne.

Three bridges erected in Morocco on newly-constructed roads. One of these, across the Oued Asfalou, was described in this review for the months of November-December, 1933. The other two bridges are those of Aghembou and of Tahar es Souk. The former is a single-span bridge of the Pigeaud steel-girder type, with a span of 37·50 m., and concrete abutments. The Tahar es Souk bridge has three spans of the same type, each of 32·50 m. The piers and one abutment are founded on reinforced concrete wells. In the case of the other abutment, it was found necessary to drive piles.

3. *L'inauguration du monûment au Général Ferrié.*

Speeches made at the inauguration of a memorial to General Ferrié, on the 15th November, 1933. General Ferrié was Director of Wireless Telegraphy during the Great War and a leading international authority in that branch of science.

4. *Note sur une méthode d'étude et d'enseignement des noeuds et brélages.*

Commdt. Violette shows a method of explanation, or self-instruction, of knots and lashings, for intelligent students who are not quick with their hands.

5. *Exercice sur la carte (sapeurs-mineurs). Emploi du génie à l'échelon armée.*

A scheme (to be discussed in the next number) for employment of engineers in a situation similar to that in which the French Army found itself at the beginning of September, 1914; assuming, however, that the right wing of the German Army had continued its march to the south-west according to the G.H.Q. plan. A.S.H.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(*January*, 1934.)—1. *Pages d'histoire de l'armée belge au cours de la guerre* 1914-18. *Reconnaissances et patrouilles de cavalerie.*

These are three reports written by cavalry subalterns who were sent, in command of detachments, to the Belgo-German front at the end of July, 1914, to report if and when the German troops crossed the frontier. Their reports were sent in by carrier pigeons. Lieut. Selliers eventually found his retreat cut off by the Germans and, going north, got into Dutch territory and was interned. Lieut. Istasse was more fortunate, and got back to Huy, which was not yet occupied by the Germans.

The arrangements made are criticized. Each officer was in command of 24 men. Since he had orders not to fight, it would have been better to have reduced each command to five or six men, and so have given them a better chance of concealment and escape.

2. *Transports par automobiles.* By Major Gilbert and Captain Colette.

A scheme, worked out with the help of two maps and two tabulated statements, for the transport of an army corps by motor-lorries under war conditions.

3. *Histoire militaire des Belges.*

Lieut.-Colonel Bouha gives us extracts from a work by the Vicomte Terlinden, *Histoire Militaire des Belges.*

Going back to the times of Cæsar, who chose Belgians to form his personal guard, the Belgians have always maintained their reputation as brave soldiers. Although, in more modern times, Belgium has been under foreign domination for long periods, its people have always managed to retain their internal autonomy. They have kept up their fundamental laws, customs, and traditions: they have retained a body of really national troops under the orders of Belgian chiefs.

Modern Belgium may be said to have been constituted in 1430, when the states of Brabant (*i.e.*, Brabant, Limbourg, Luxembourg and Hainault) were united under Philip the Good, Count of Flanders. In this first article, the writer takes us in succession through the periods of Spanish and Austrian rule up to the middle of the eighteenth century. In the sixteenth century the name of Walloons was given to all Belgian troops, wherever recruited, to distinguish them from Spanish, Italian and German troops in the service of the Emperor. It was during the Thirty Years' War that the Walloons made their reputation in Germany, and Tilly (a Belgian by birth) made his name as a great commander.

4. *Méthode de résolution des problèmes de tir indirect aux distances reduites.* By Serjt. Dieuaide.

5. *La ventilation des écuries.*

Vet.-Major Meugens discusses the problem of the ventilation of stables. Each horse requires 60 cubic metres of fresh air per hour: a good system of ventilation allows for the renewal of the air in a building three times an hour. The general conclusions arrived at are:—

The purpose of windows is that of giving light, and they are not necessarily required for ventilation. If windows are fixed in their frames, breakages will be reduced. In the winter foul air can be extracted by flues placed in the ceiling, fresh air being admitted through inlets in the walls at a height of two metres from the floor. In the summer the upper halves of the doors on opposite sides of the stables can be kept open, to allow of a through draught.

(*February*, 1934.)—1. *Pages d'histoire de l'armée belge au cours de la guerre* 1914-18. *Reconnaissances et patrouilles de cavalerie.*

These are accounts, illustrated by maps, of four reconnaissances carried out by cavalry subalterns, during August and September, 1914. Some of the reconnoitring parties had narrow escapes of being cut off, but all managed to obtain some useful information, which was sent in either by cyclists or carrier-pigeons.

A point of interest, in connection with these reconnaissances, was that the Germans

were so sure of their own overwhelming strength that they kept entirely to the main roads, and did not trouble to employ flank guards.

2. *Histoire militaire des Belges.*

Lieut.-Colonel Bouha completes his article in this number with a sketch of the history of the Belgian Army from the eighteenth century up to the present day.

After Ramillies (1705) Belgian troops fought for Spain from 1706 to 1792. Many Belgians attained to posts of high distinction. At the time of the French Revolution the French occupied Belgium, and 112,000 Belgians served in the Napoleonic armies between 1792 and 1814. At the same time many others were loyal to their original engagements and served under Austria. The treaty of Fontainebleau, in 1814, released the Belgian troops from service in France, and in the following year we find the Belgo-Dutch army fighting under Wellington at Waterloo.

Between 1815 and 1830, under the union with Holland in the kingdom of the Netherlands, the Belgian Army, as such, practically ceased to exist. A good deal of space is devoted to the Belgian revolution of 1830, and the ten-day campaign of 1831.

During the period of Belgian independence, from 1831 onwards, Belgian troops saw service in various parts of the world, but mainly in their African colonies. In 1870, the army was 100,000 strong, a number sufficient to guarantee the neutrality of the country during the Franco-German War. Unfortunately, the numbers were not kept up in proportion to the increasing strength of the neighbouring countries, and, although compulsory service was introduced at the end of 1912, it was too late to prevent the tragedy of 1914. What the Belgian Army accomplished during the years of the Great War is largely due to its Commander-in-Chief, King Albert.

3. *L'observation.*

In this article Major Adam limits his remarks to the observation of infantry and of the higher command. He deals with the duties of infantry observers, the points on which information is required, and the methods of transmitting it.

4. *L'artillerie de forteresse au service de l'armée de campagne.*

Captain Gérard discusses the employment of fortress artillery in co-operation with the units of a field army. Fortress guns will, of course, fire from fixed emplacements, and the range of every prominent point to their front will be accurately known. The writer deals with the relations between the fortress artillery commander and the commanders of the larger units of the field army.

5. *L'entretien du soldat dans les armées romaines.*

Captain Avaert has collected information with regard to the pay, clothing, equipment and rations issued to the Roman soldier, and his terms of service. Up to the time of the Roman republic the soldier received no pay. Pay was first issued in the year 347 of the Roman era. It amounted to 2 asses (about 32 centimes gold) per day for the infantryman, 4 asses for the centurion, 6 asses for the cavalryman. Cæsar doubled the pay, Donatian added to it three gold pieces every year. Octavius introduced rules for pay and rewards, leave rules, and pension rules for veterans.

The writer gives a description of the method of collecting supplies for an army, and of the clothing and equipment in general use.

(*March*, 1934.)—This number contains brief notices, with portraits, of the late King Albert and of King Leopold III.

1. *Pages d'histoire de l'armée belge au cours de la guerre* 1914–18. *Reconnaissances et patrouilles de cavalerie* (1914–18).

Here are three further reports of reconnaissances by cavalry subalterns. One was carried out by Lieut. Count d'Oultrement between the 3rd and 10th October, 1914. The other two were carried out by Lieut. Bonvalet on the 17th October, 1918, and by Lieut. de Troyer from the 30th October to the 3rd November, 1918. On the latter two occasions, the role of the cavalry was to keep touch with the enemy in his retirement.

2. *Aide-mémoire à l'usage du chef de section de mi.* (1) *La section de mi. dans la défensive.*

Lieut. Mélon has written an *aide-mémoire* explaining the duties of the commander of a section of machine-guns, in the various situations that might occur in the defensive.

3. *Description et mode d'emploi de l'abaque "Dieuaide" pour la résolution des problèmes de tir indirect des mitrailleuses.*

Serjt. Dieuaide has designed a calculating table on squared paper, with scales, to simplify the working out of the various problems in connection with the indirect fire of machine-guns. By a simple modification of the dimensions the table could be used for artillery fire.

4. *Appréciation des distances à la vue.*

Lieut.-General Grade describes three methods of judging distances :—

(1) By comparing the distance with that of one or more known points.
(2) By the use of type distances.
(3) By the silhouette method.

As regards the second method, the ordinary rifleman will not usually fire at distances exceeding 400 metres, and every man should be trained to estimate a range of 400 metres as accurately as possible. Machine-gunners should be trained to judge distances of multiples of 400 metres, up to 1,200 metres. The silhouette method is limited to distances not exceeding 500 metres.

The writer adds a series of exercises that he recommends for judging distances.

5. *La formule de la victoire.*

Captain Callens here reproduces the gist of an article in the *Militär Wochenblatt* of the 11th and 25th September, 1933. The writer compares the trend of military opinion in various countries. Both Italy and Great Britain have gone in for an independent air force. France has hitherto been opposed to this arrangement, but is now coming round to it.

The problem of defence against aerial attack is one of supreme importance. In crowded cities defence against explosive bombs is almost impossible, but the main danger is from incendiary bombs. Protection against gas is more easily provided. But, while there are alarmists who predict the most unspeakable horrors from an aerial attack, others, whose opinions are entitled to respect, think that no country would undertake the bombardment of towns except as a desperate measure, and that such an event would be unlikely to occur at the beginning of a war.

The questions of motorization and mechanization are discussed. France is now inclined to follow the lead of Great Britain in this respect, but has no intention of having an entirely mechanized army. With regard to tanks, the continual struggle between guns and armour, that the Navy has known so long, must necessarily end in a victory for the anti-tank gun, since the weight of a tank and its armour is limited to what roads, railways and bridges can carry.

Other points discussed are the relative merits of a small professional army, as against a nation in arms; a ministry of defence, combining sea, land and air forces; questions of blockade, contraband and freedom of the seas.

A.S.H.

REVUE MILITAIRE FRANÇAISE.

(*October*, 1933.)—Général Loizeau begins a most interesting article entitled *La stratégie allemande en* 1918. This instalment deals with Ludendorff's general plan for 1918, which he considered at the end of 1917, the direction of his attack and the means available. Ludendorff saw clearly that an offensive must be pushed through to the last extreme before the Americans came over in numbers and also that it was necessary to beat the English rather than the French. Therefore his idea of attacking generally north of the Somme in a north-westerly direction, with a view of separating

the French and the English, was thoroughly sound. Where he went wrong was in his idea of one single attack which would carry all before it. The instalment finishes by considering an alternative scheme put forward by Colonel Wetzell, by which a number of attacks were suggested culminating in a final blow towards Hazebrouck.

Colonel Bernis finishes *Essai sur le renseignement à la guerre* in this number. He considers how the various commanders of different branches, infantry, artillery, cavalry, etc., and the heads of services should consider information and how it is produced. There are many examples of lack of information at the critical time, and also many of the production of information for commanders like Hannibal, Napoleon, etc., when they required it mostly. Colonel Bernis finishes by saying that information must be correct, otherwise a commander is not in a position to " risk the life of his country."

Chef de bataillon Gras also finishes *L'offensive sur Colmar en* 1914 in this number. The description is too detailed to be of much interest to an Englishman who never fought in Alsace, but the writer's conclusion makes one wonder whether there was not considerable value in the fighting on this distant part of the front. The writer considers that much was gained from the valour with which the French fought against the Germans from Bavaria, and though the French had to retreat towards the crest of the Vosges, the Germans lost many men and were unable to carry out their plan of driving the French in here as well as on other parts of the front.

Intendant Coanet begins *Contribution à l'étude du rôle colonial de l'armée.* He first runs briefly through the various empires that the French have held; but while the British are naturally interested in the empires of the eighteenth century which were taken away from the French, the writer considers at far greater length the present-day empire which was gradually built up during the last seventy years or so. The value of this empire to the French Army has been clear for some time, and as Intendant Coanet points out, Gallieni's principle of " civilizing without destroying ancient institutions and customs " has been used throughout.

Général Meynier begins the second part of *La guerre sainte des Senoussya* in this number. It is an interesting article, as the writer took a prominent part on the side of the Allies both before and during the Great War. In this instalment the Italians were driven back in Libya and Cyrenaica by the vigorous onslaught of the Senussi under the general order of the Sultan of Turkey, and General Meynier found the situation grave enough in French Algiers as a result. It is impossible to go into details in such a short review, but the article is worth reading.

(*November*, 1933.)—Lieut.-Colonel Larcher has an interesting article entitled *La Direction de la guerre des Empires Centraux. Falkenhayn* (1914–1916). He describes Falkenhayn's efforts to bring the war to a successful conclusion after taking over from Moltke, who was a poor successor to the Moltke of 1870–1871. Falkenhayn's chief difficulty was to combine with Conrad, the Austrian Commander-in-Chief, and it was really through his being unable to do so that he was superseded by Hindenburg, after the Rumanians entered the war, in 1916. As the writer points out, Falkenhayn was sound but lacked the touch of genius which was necessary, and it was owing to this lack that, although what he carried out was generally quite successful, he never achieved an outstanding victory.

Les fabrications de guerre, by Colonel Menu, describes how much the provision of shells affected France in the Great War and how the Allied command depended on this provision in deciding what attacks it was to make at different periods. It took no less than thirty-one months to build up a sufficient provision after trench warfare started in September, 1914, and it was not till the summer of 1917 that the Allies could carry on in the field without thinking of munitions which were coming up. Colonel Menu shows clearly how the various French commanders called for more and more munitions and points out that in the future the difficulty of providing them should not occur again if the organization of the country is taken up by the Government from the start.

Général Boucherie has an interesting article entitled *La cavalerie moderne et son évolution* in this number. It is divided into three sections, 1914–1925, 1925–1930, 1930–1933. We all know how the old type of cavalry was only able to carry out reconnaissance as cavalry during the Great War; it was incapable of fighting with any degree of force owing to its lack of guns or machine-guns. It was realized that fire was necessary to a greater extent for the cavalry to fight and after 1925 the horse was combined with mechanized vehicles so that cavalry could carry out its proper role of fighting as well as reconnaissance. After 1930 this was still further developed and while the horse was realized as being still necessary for the eyes of a force of cavalry, more powerful mechanized vehicles of various kinds have been also provided, so that now a cavalry formation is of real fighting as well as reconnoitring value.

Général Armengaud, who has been director of the Centre of Aeronautic Studies, has an article entitled *Les idées directrices de l'organisation de l'armée de l'air*. He begins by describing how the air force should have been in action at the different stages of the Great War, provided that it had the necessary machines and personnel. This, however, was always the trouble, to find everything that was required. The writer then considers how it can be done in the future and how France should be able to counter efforts by any future enemy to attack her from the air as well as from the ground. General Armengaud naturally knows his subject thoroughly and his article is of considerable interest.

(*December*, 1933.)—Général Loizeau continues *La stratégie allemande en* 1918 with a detailed discussion of the various plans considered by Ludendorff and with his final orders. Various attacks, Michel, Mars (on the heights south of the Scarpe,) Archangel (on the left bank of the Oise) and St. Georges (towards Hazebrouck), were all gone into and eventually Michel was decided on. We all know how this attack proceeded, but General Loizeau explains clearly how this attack already had lost some of Ludendorff's original idea of defeating the British. One single operation, successful against the Russians and the Italians, was not to be completely successful. The next instalment will consider the execution.

La guerre sainte des Senoussya is continued in this number by Général Meynier. The Italians were fighting the Senussi early in 1915 before they came into the Great War, and Colonel Miani was severely defeated in April. His force had to retreat with considerable losses to the port of Syrte. After the Italians entered the Great War her troops and those of the French in Northern Africa came into closer contact and acted together without any difficulty, but the situation was still none too easy for either country. General Meynier was in command of the French forces, but shortly after he moved towards St. Oued he received telegrams stating that the Khalifa ben Asker had begun his attack on Southern Tunis. This is where the instalment ends. A map would help a reader of the article.

Intendant militaire Coanet completes *Etude du rôle colonial de l'armée* in this number. He describes how the French leaders in the colonies have carried out colonization in the proper way and how the army has both done its work and formed itself into a further protection for the mother country. Engineering, medical services, etc., have all done their part, and the writer devotes a special chapter to the supply service which has done a great deal in the colonies. There is no doubt that in Africa, France has both developed a first-class empire and provided many troops who will come to help her should the occasion arise.

Colonel Baills and Capitaine Gazin begin *Franchissement des cours d'eau en periode de mouvement. La bataille de la Meuse* (25 *au* 28 *août*, 1914). The German 4th Army had orders to cross the Meuse in the neighbourhood of Sedan, while the French 4th Army were to defend the crossing. The Germans did not have accurate information regarding the French, and General de Langle found that his right wing had put him in a position to attack strongly the right-hand corps of the German Army, which will be described in the next instalment. There is a good sketch map as well as ordinary maps on this action.

Dr. Ferdinand Stoller has an article entitled *Le Siège de Vienne par les Turcs en* 1683. The defeat of the Turks is one of the greatest actions of past history and it is interesting to read an account by Dr. Stoller, who is able to produce documents, maps and photos from the Austrian capital. There is no space here to give any details as to how Kara Mustapha was defeated and the efforts of Sobieski and the other Imperial commanders. Unfortunately writers of different nationalities have different views as to the value of the various commanders, and Dr. Stoller does not consider that Sobieski is of such great importance as other writers. The article is nevertheless well worth reading.

(*January*, 1934.)—*Un exemple caractéristique de la direction de la guerre par l'Entente en* 1914–1918. *L'expédition de Salonique*, by Lieut.-Colonel Larcher, follows the recent article on the difficulties of the Central Powers published in the *Revue Militaire Française*. The Allies had the same, or even greater difficulties, to overcome, and these appeared probably more at Salonica than on any other part of the front. When the expedition to Gallipoli failed twenty-three divisions in all were established at Salonica, but it took between two and three years for the French, British and Italians all to work in the same direction. At first General Sarrail was in command but really very little was done and the Serbs in the meantime were driven out of their own country. It was not till 1918, with Foch as supreme commander-in-Chief, with Franchet d'Espérey at Salonica, that the Allied forces delivered a real attack which put the Bulgarians out of the war and restored Serbia to her own people. Unfortunately this cannot be regarded as purely on account of the better organization of the command in general, as the Bulgarians had become weaker, the Austrians were in a similar state and the Allies at last seemed about to win through-out.

Colonel Morin has an article entitled *Etude sur la défense des côtes et régions fortifiées* in this number. He begins with a description of men-of-war of the various sea-powers of Europe and then considers the type of fortification required. A good deal of the article is very detailed, but he gives a good description of the difficulties met by the British at Gallipoli, where the Turkish defences were hardly of the highest class. After describing the type of defence which can be provided, at any rate in France, for the future, Colonel Morin concludes by saying that at any rate Nelson's statement remains true that "Every man-of-war who attacks a fortification is mad."

La mobilisation économique à l'étranger, by Lieut.-Colonel de Gaulle, is an interesting article on the means to be ensured in the future by the United States, Italy and Belgium, so that the whole country will go to war if necessary, and not only the army. The three countries are so different that a comparison shows clearly how there is more than one way for every factory to "do its bit." In the U.S.A. the President depends considerably on Congress; Italy, on the other hand, is governed by Mussolini as a despot; while in Belgium the Government is democratic to a considerable extent. There is no space here to go into how the work is to be done in war, but the article is well worth reading.

Général Lemoine has an article entitled *Rencontres d'armées* in this number. He selects Eckmühl in 1809, the Tcha-Ho in 1904, the Ardennes and the Marne in 1914, as examples. In each of these actions neither side knew, to start with, what the other side was doing and yet in each case one commander was distinctly victorious over the other. Napoleon admitted that he had hardly any plan to begin with and yet he was successful. Oyama directed his troops on a straightforward attack and was successful at the Tcha-Ho. During the Great War the problems were considerably more difficult, yet the Germans drove the French right out of the Ardennes while Joffre won what was really a decisive battle at the Marne. The great difficulty is to get the necessary information; when this is obtained then the commander is able to decide and act firmly.

(*February*, 1934.)—Général Loizeau continues *La stratégie allemande en* 1918 by

describing and still criticizing Ludendorff's action with its variations after the attack of March 21st. The writer's view is that Ludendorff's original strategy was sound, but that it depended on the British being easier to defeat than he thought. After the original attack he achieved a great tactical success where the British and the French joined and this diverted him from the idea of driving the British away from the French. He then continued with great tactical successes, but any strategical success vanished as soon as he started to change his plan at each tactical triumph. General Loizeau's view is of considerable interest, and his sketch maps give a very good idea of the German attacks becoming more and more eccentric during less than a month following 21st March, 1918.

Another instalment of *La guerre sainte des Senoussya*, by Général Meynier and Commandant Filio, appears in this number. After Italy joined the Allies, all the tribes in both French as well as Italian Northern Africa became more and more restive and an expedition was prepared to deal with them. In the meantime, Khalifa ben Asker, one of the tribal chiefs, made a great effort to take Oum Sonigh. This was gallantly defended and eventually relieved by the French, Millérand, the Minister of War, congratulating the defenders. The writers describe various other operations and the instalment ends with the armistice in Europe. This article is of interest provided the reader has his own map and can follow the outlandish names which abound.

Colonel Bailly and Capitaine Gazin continue *Franchissement des cours d'eau en période de mouvement. La bataille de la Meuse* (*25 au 28 août*, 1914). This article is too detailed for a reader to gain much from glancing through it, it requires careful study. Details of the German technical resources for crossing the River Meuse are given, and also the French dispositions are described. As usual, no proper arrangements were made to destroy the various bridges and the Germans were able to use certain of them. This does not apply, needless to say, to only this part of the front; the difficulty of destruction at the outbreak of a war has always been a hard problem.

Chef d'Escadrons de Bardies-Montfa has an interesting *Etude sur la cavalerie dans l'exploration* in this number. He begins by describing what General Sordet was told to find out at the beginning of the Great War and how far he was successful. As all students of this part of the war will remember, General Sordet covered a great deal of ground without finding out what was really wanted. The article then goes on with a description of what is now being done for the cavalry and how necessary they still are for reconnaissance. General Boucheric has just had a more detailed article on the same subject and both are well worth reading.

Notions sur l'armée suisse, by Colonel Aublet, describes the method of organization of the Swiss Army. This army consists of a form of militia, not of the normal regular soldiers, and for this reason alone the article is of value. No details can be given here of the details provided by the writer, but he describes incidentally how units are formed and how they mobilize in the event of war.

(*March*, 1934.)—Général Loizeau's fourth instalment of *La stratégie allemande en* 1918 discusses the actions on the Chemin des Dames and east of Rheims. Here Ludendorff found he was up against a difficult problem, what to do and how to do it quickly. He decided first to make a holding attack against the French followed by an attack *à bout* against the British. The holding attack was made on the Chemin des Dames and was a great success, so much so that he decided to push it on; in the meantime the attack against the British was given up for the time being; General Loizeau agrees with Ludendorff's strategical idea, but here again his tactical success obscured the strategical objective. It is pointed out that extension to the flanks was not used by the Germans as it was by the Allies later, and this was one of their greatest mistakes.

Général Meynier completes the second part of *La guerre sainte des Senoussya* in this number. Here he turns to the British campaign against the Senussi and gives an interesting description as to how the campaign was carried out and how the Senussi

were finally defeated. The British had a good deal of trouble in locating the Senussi forces moving in the desert, but when they did locate them they succeeded eventually in defeating entirely their threat to the Nile. This article is of interest, anyway, to the British.

Franchissement des cours d'eau en période de mouvement. La bataille de la Meuse (25 *au* 28 *août*, 1914), by Général Baills and Chef d'escadron Gazin, is continued in this number. Here the German crossing of the Meuse and Chiers rivers is described, but the description is considerably too detailed to mean much to a casual reader. The complete attitude of the German attackers and French defenders is given to start with, followed by the actual attack. A good sketch map is provided.

Capitaine X. . . . has an interesting article entitled *L'organisation et le fonctionnement de la Garde Nationale des Etats-Unis*. He describes the National Guard of the United States throughout from its original history, organization, training, etc. As the United States fear no foe from close by, as do France and other European nations, their protection is naturally much more fluid; it is interesting to see how it is drawn up and how it is capable of coming into action in the event of war. He finishes with the situation of the National Guard in 1932 and shows how many went to camp that year.

H.A.J.P.

MILITAERWISSENSCHAFTLICHE MITTEILUNGEN.

(*January*, 1934.)—An editorial claims that the bold decision to issue the magazine monthly instead of every second month has been a complete success. This change, involving a great change of character, was made, in view of forthcoming important military developments, in order to keep the magazine's readers in closer touch with military affairs, and more up to date as regards both the international situation and progress in their own and other armies. The editor quotes a recent utterance of General Schönburg-Hartenstein, the first holder of the new post of Secretary of State for National Defence: "The diversity of our profession demands not only of all leaders zealous study of the military sciences but, above all, on the part of all ranks practical work with the troops."

The *M.M.'s* endeavour, in its new monthly form, will be to foster both of these desiderata. It announces, as a new feature, a prize essay, and more articles to be devoted to training questions and practical work.

The Austro-Hungarian Army Cavalry in 1914. This article by Colonel von Dragoni is by way of being an answer to "The Advance of the Cavalry," by Dr. Leppa, which appeared in *Wissen und Wehr*, 1932, and which dealt with the advance, deployment and use of the army cavalries of the Central Powers, *i.e.*, in the East as well as in the West. Colonel von Dragoni points out the great difference between the two theatres, viz., that of the Austro-Hungarian cavalry, hemmed in between the frontier of Rumania and the Vistula, could only advance directly against the front of the oncoming Russian armies, whereas on the German right wing, on the flank of the great wheel through Belgium and France, there was a splendid field of activity for a very strong army cavalry, always providing that it had been specially equipped for its task.

Certain failures of the Austro-Hungarian cavalry, as also of the German cavalry, the author attributes to the impossibility of improving the staffs of higher formations. When in the field formations are taken from various sources for a specific purpose, usually one of two things happens. Either the senior amongst the commanders is given command of the whole, and has to carry on with his original staff attempting a dual role, *e.g.*, running a corps and a division at the same time; or, the gathering together of the formations under one command is omitted entirely—and this has always had the worst results.

In the first case, delegation is sometimes attempted, but this is no remedy, since

it only passes the trouble on to the headquarters of a lower formation. Congestion will be worse with the smaller staff, and the troops will have to suffer the more.

Of the second case, Colonel von Dragoni gives as a classic example the battle of the Marne, when the circumstances of command in the gap between the German 1st and 2nd Armies led to the German retirement, and perhaps decided the whole war. He looks upon the German forces in this gap, two cavalry corps, six rifle battalions, and finally an infantry battalion, with six batteries, as having been frittered away. No attempt was made to unite these, as might have been done under General von der Marwitz, or what would have been better still, to put in for that purpose a complete corps staff which the 2nd Army happened to have spare, viz., the VIIth Corps H.Q. under General von Einem. The latter is the view of the German Official History. The author's opinion is that four cavalry divisions, one infantry division and nearly 90 guns, wielded by one man, would never have allowed the enemy, feeling their way carefully over the Marne on the 9th of September, to cross that river. The moral would appear to be that if detachments have to be taken under the stress of circumstances from various sources, G.H.Q. must have in reserve, and be able to produce at a moment's notice, a staff to command them, complete with signals and all other headquarter troops.

As regards failures of the army cavalries due to other causes, Colonel von Dragoni repudiates General Groener's judgment, in his excellent *Count Schlieffen's Testament*, that the German cavalry did not find the leaders capable of handling them in wide movements against the enemy's rear. He says that Germans and Austrians alike had leaders of the right type who could have done what was required of them, if only their cavalry had been equipped for such undertakings.

A Brigade Headquarters near Luck in the Spring of 1916, by Major-General Steinitz. A somewhat intimate record of impressions, considerations, joys and sorrows, as experienced at a brigade headquarters during important happenings. It covers the successful defence of a trench position, unmolested withdrawal, and successful defence of the new line until stabilization. Time and place refer to the great Brussilow offensive. The experiences given are those of an Austrian brigade north of the gap where the Russians broke through, pushing back the Austro-Hungarian 4th and 1st Armies, the former to the north and the latter to the south, and making a breach 30 km. wide. The arrival of six German divisions enabled the closing of this gap after fourteen days. Reasons for the failure of the Russian cavalry to utilize the great opportunity offered them are referred to in *The R.E. Journal*, June, 1933, p. 372, and may be correlated with the cavalry failures dealt with in the preceding article.

General Steinitz's brigade believed in making the troops as comfortable and as happy as possible, and we are given a picture of the amenities of life on a *cushy* front in position warfare, when troops are undisturbed for months by reliefs. The reason given for not destroying on retirement their huts, recreation-rooms, gardens, baths and delousing station must be unique in the annals of war, " so that the Russians might learn what our higher culture had been able to create." *Quid postea ?*

Australia and the World Powers. General Wiesinger manages to compress into 14 pages a vast amount of information about Australia, its constitution, features, climate, agricultural products, distribution of population, capacity for new settlers (estimated at 130 millions), trade figures, mining, etc. To this is added an account of Australia's relationships with Great Britain, the United States and Japan, together with comparative tables of the naval strengths of those powers, of their air force strengths, and of their coast defence artilleries.

The article marshals the above evidence in order to present a picture of the forces at work in the face of the opposition of Australia and Great Britain, and probably of the U.S.A., and to give some idea of the present struggle, both political and in competition of armaments, between the Pacific powers. It leads up to the dicta :

Necessity knows no law. The years of peaceful seclusion for this continent are numbered. A new era knocks at Australia's door.

Review of International Politics. Major-General Paschek's notes fulfil a dual purpose—they serve as a review and a reminder to many, and they keep up to date the reader who has not always time for the daily Press. In either case they classify and collate. Under heading A the Disarmament Conference crisis is dealt with under three sub-heads, proceedings in the autumn, the question of increased armaments, and progress in defence organization and training. Sub-head 1 treats in turn of Henderson's mission, the pourparlers of the Great Powers, the League of Nations' general meeting, activity within and without the Conference up to Germany's leaving both Conference and League, the effects of Germany's withdrawal up to the German general election of November 12th, the results of the latter.

Heading B and heading C deal with two more crises. The crisis of the League of Nations falls into sub-heads—Japan and Germany leave the League, the Four-Power Pact, and meetings, general and council.

The world's economic crisis is similarly dealt with under—the London Conference; the American Experiment; and other attempted solutions, viz., the Russian Second Five Years' Plan, the politico-economic possibilities of the Danube States, and Coudenhove-Kalergi's Pan-Europa Economic Conference in Vienna; the unemployment question; and progress in communications, air routes and combined networks of railway and motor routes in North Italy and in Germany.

General Paschek finds that the fear of the national socialist state has increased immeasurably among those favoured by the Treaty of Versailles. He says that the democratic nations behind their front of encirclement are working, even with the Bolsheviks, against the rise of the " Unified Christian-National " state.

X Day, being an Account of the Great Battle in France, 21st March–5th April, 1918, by Gustav Goes, published by Wilhelm Kolk, Berlin, with 1 map and 16 photographs, price 3 marks 50, paper covers. The following extract from an Austrian review of this work is remarkable since it shows to what an extent the desirable objectivity is attainable even in a popular account of a war event: " The 64 divisions of the armies of Below, von der Marwitz, and Hutier, assembled on a 75-km. front, are confident. The sight of battery on battery, and gun to gun, inspires courage and the assurance of victory. On the enemy's side all is quiet. They appear to have noticed nothing. And nevertheless the threatening storm is suspected. Enemy newspapers have spoken of it for some time. There remains only the great problem of ' When ? ' This problem is solved on the 19th of March, when two deserters from the German trench mortar personnel carry the solution across.

" The main attack falls on the British 3rd and 5th Armies. In spite of the fearfu hurricane of fire and the superb dash of the attackers the British soldiers do not lose their nerve for a moment. They cause the Germans terrible losses so that nowhere can the first day's objectives be gained. Even in the direction of the main thrust the attack is pinned after an advance of from 3 to 4 km. Only to the south certain portions of Hutier's army succeed in reaching the third and last position. Consequently the battle takes a turn not in accordance with the intentions of its leaders' —and so on.

This is by no means history for nit-wits: it appears to be history as demanded by a generation nourished on newspaper headlines and cinema captions. Though its style may not attract there is something soldierly about its simplicity, while its impartiality is much to be praised.

(*February*, 1934.)—This number starts with obituary notices of two great soldiers, a gunner and a sapper, Field-Marshal Krobatin and General Potiorek, both outstanding figures in the final history of the Austro-Hungarian Empire. The latter found his way to the General Staff early, was head of the Operations Branch before he was 40, and finished up as C.-in-C. in Bosnia. The former was an artillery teacher

for years, head of A Branch at the W.O. on mobilization, and commanded the army in Corinthia in 1918 when Austro-Hungary collapsed.

Wallenstein. The leading Austrian military periodical cannot omit to notice the tercentenary of the death of one of the two greatest European soldiers of his time, not only on account of the victories he won for Austrian arms, but because, on the authority of Ranke, he is to be regarded as the chief founder of the Austrian Army. The task of reviewing Wallenstein's life and character is made the more difficult by his tragic end, and the treachery of which he was accused and which led to his assassination. Modern public opinion, led by the historical accounts, is generally content to label Wallenstein as a traitor and to leave it at that. Schiller, having first treated the subject historically, proceeded to treat it dramatically and, in the style of Greek tragedy, represented Wallenstein as a great character struggling against an inexorable fate.

If this article cannot altogether aim at rehabilitation, it certainly shows that there is a good deal to be said on the other side, and thus to suggest that Wallenstein may have been far less black than he has been painted. When he treated with the Swedes for peace without the Emperor's knowledge, he may well have judged that a final victory in the field was not possible, and therefore that he was acting in the best interests of the Empire. When a few months after his assassination the Swedes were heavily defeated at Nördlingen, and as a result the Electors of Brandenburg and of Saxony joined the Imperialists, it certainly appeared as if Wallenstein was wrong, and his murder thus, so to speak, justified. But Wallenstein may also have foreseen that France would never permit too great an increase of the Emperor's power, and the peace by negotiation with the Swedes which he was trying to bring about might have saved the German-Roman Empire from being bled white and finally defeated after thirteen more years of devastating warfare.

The Plan of Attack from the S. Tyrol in May, 1916. The article on this subject in the July number (*vide R.E. Journal*, December, 1933, p. 697) has called forth some remarks from General von Horsetzky, who commanded one of the four divisions which carried out the main offensive. His remarks are intended to complete the picture, but they go also to show that the failure to carry the last Italian positions was not due to lack of co-operation in the offensive of the 15th of May. The two centre corps, separated by the Val d'Astico, the IIIrd on the Lavarone plateau, and the XXth on the Folgaria plateau, worked on a systematic scheme and afforded each other support either directly or by counter-battery work. These corps both belonged to the 11th Army. The dividing up of the main plateaux between the 3rd and 11th Armies to which General Dankl attributes the petering out of the offensive, and which was in opposition to F.M. Conrad's Plan, took place two days later.

At the Zenith of the Great War. Under this title Major-General Kerchnawe continues his notes on the last published parts of Vol. IV of the Austrian Official Military History. According to this, Germany and Austria passed their zenith during the first half of 1916. The writer condemns the general headquarters of both Central Powers as guilty at that time of " a sin against the holy spirit of the conduct of war," in that they did not apply their whole strength at the decisive point, an application all the more necessary since from the very beginning they had possessed no decisive superiority. The same conclusion is reached by Colonel Kiszling in the final chapter which is entitled " Problems of the Conduct of War in the First Six Months of 1916." Another important chapter is " Considerations about the Brussilow Offensive." The greatest space, however, is devoted to much minor fighting in Volkynia and in Eastern Galicia, all bearing the stamp of improvisation.

General Kerchnawe's opinion of the importance of the great Russian offensive is a high one, as the following quotation shows : " It remains Brussilow's incontestable merit, albeit his own country did not reap the advantage, of having dealt the old Imperial Army this heaviest of wounds, a wound from which, although it still had

before it great deeds, it was never able quite to recover. Confidence in the final victory of the Central Powers either disappeared altogether, or in most places was so severely shaken that it could no longer stand severe trial. Thus Brussilow, the greatest leader of the Czar's army, became to a certain extent a Winkelried for the final victory of the Western powers. Without Brussilow and the hecatombs of Russians who fell in his great offensive the Western powers would never have made their opponents waver." To substantiate this opinion some striking figures are produced. At the beginning of June the total strength of the Austro-Hungarian Army had risen to its maximum of three and a half millions. After the battles of Luck and Czernowitz it could not, even by the utmost exertions, be brought above 3,171,000; the deficiency in front-line troops being 227,000. On the fighting front, between the 4th June and the end of July, out of 650,000 men armed with rifle or carbine the Austro-Hungarian Army had 475,000 casualties, or a permanent loss of 300,000.

The account covers the first large-scale gas attack, viz., that against the Italians on the Doberdo plateau. The result, as at Ypres, was a complete surprise, and the Italian divisions attacked suffered casualties up to 25% of their strength. As at Ypres also very little provision was made for exploiting the success.

General Kerchnawe says that as each volume of the Official History appears it turns out in completeness, as in several other respects, to be an advance on its predecessors.

Introduction to Co-operation between Arms by training at the Cadet School. This article refers principally to the important question of improving the co-operation of artillery with infantry, and Major-General Kainz refers with appreciation to articles on the same subject which appeared in *The Times* last summer. His solution is to demand for all cadets up to the point when they decide upon infantry, cavalry, artillery or engineers, a common education lasting 2½ years. Having elected for, and been selected for, their particular branches they will be separated only during their last year of cadet-training. The most important part of this education in common is not mentioned by General Kainz, perhaps as being too obvious. It is not that the future infantryman learns more of artillery, and the future gunner more of infantry work. These could both be arranged for without amalgamating the military colleges. It is because having had the same education, each will know how the other's mind works and what the other will expect of him. Many a sapper, taking up a difficult case before a new G.O.C. or a new G.1 knows the relief accompanying the thought, "Thank heavens he was at the Shop."

Horse-Power, by Major Baron Kirchbach. Thoughts which tend to show that mechanical and physical horse-power are not mutually exclusive but complementary. When these considerations end, however, with: "The field army of the future will be able to do without mechanized and motorized troops as little as it will be able to dispense with a cavalry with modern training and armament, and to the highest degree capable from the point of view of horsemanship," then the boot is indeed on the other leg. One seems to hear again, as in England when the cavalry is threatened, "the spurs clanking down the House of Lords."

The Thompson Sub-Machine-gun, by Major Wettendorfer. This is a close-range hand-firearm fired from the shoulder or from the hip. It is a product of the Automatic Ordnance Corporation in New York, and is used among others by the U.S. Army, Navy, coast-guards and police. During recent fighting in Nicaragua the American marines were equipped with it on a scale of one to every ten rifles, and it is said to have been a great success. It can be used to fire single rounds, or for series fire half-automatic, or fully automatic. It has a Cutts compensator fitted to the muzzle to counteract the property of throwing high, common to all automatics.

The pattern 28AC costs 25 dollars, including Cutts compensator, and a 20-cartridge magazine. Including the time taken in changing magazines 100 aimed rounds can be fired in a minute, half-automatic; and full automatic, 300. Other patterns are

21AC, firing up to 800 rounds per minute, with 100-round drums; and 27AC, which is only for single rounds, and half-automatic.

The cartridge used is that of the ordinary automatic pistol, 11·5 mm. calibre.

The Thompson sub-machine-gun may be said to fill a gap between the automatic rifle and the machine-gun. Within its range limitations it gives one man the fire-power of the m.g.

The mechanism is not described, but there is a sheet of photographs, a section with numbered parts, and a table of data.

(*March*, 1934.)—A Radetzky number. Except for notices of new books on the last few pages, it was intended that this issue of the magazine should be entirely given up to one who was for Austria at least what Moltke was for Prussia, "not only a successful general in the field and a bringer of fresh life into the State, but unsurpassable as a preceptor, an example of the best soldier and civil virtues." At the last moment, however, and quite unexpectedly, this intention was foiled, and although 140 pages of the March number are devoted to an account of the career of Field-Marshal Radetzky, pride of place had to be given to the Austrian War Office official account of the military doings in the recent revolution.

The Overthrow of the Insurrection, 12th–15th February, 1934. This account brings out clearly that the lion's share in quelling this attempted revolution fell to the army. It will be remembered that so far from this being the case on the occasion of the last armed rising in Vienna, when the Socialists burnt the Law Courts in July, 1925, the police with great skill and gallantry restored order in a few hours without calling for military aid. Without detracting in any way from that achievement by the police, the whole affair differed in nature and size from what took place in February; and especially a new factor played a part, viz., that the Socialists had, with good military foresight, taken advantage of their many years' rule in Vienna to build—with public money—under the guise of workmen's dwellings, large concrete structures of warlike intent. These buildings were designed for machine-gun defence, and occupied tactically commanding points. They were amply stocked with rifles, ordinary and automatic, machine-guns and ammunition. That the police could not tackle this new factor without military aid was certain, as also that the soldiers would hardly have succeeded without the introduction into street-fighting of a more powerful weapon, viz., the field howitzer. Credit for the use of field artillery against buildings occupied by rebels must, however, be given to the Irish Republican Army for their effort thirteen years earlier on the Dublin quays against Rory O'Connor and his friends. Of the many fortified buildings captured by the troops in Linz and in Steyr, in Upper Austria, as well as in the capital, only one, the Reumannhof in Vienna, had to be taken without artillery assistance. The heavy casualties in this case give an idea of what the whole operation would have cost without the help of the guns, even assuming that the troops could have won through with infantry weapons only.

Of the greatest importance to the Government in defeating the rebellion was information received as to the Socialists' intentions, and especially that the signal for a general strike was to be the stoppage of all electric trams by a strike at the Electricity Works. When the trams stopped running at 11.30 a.m. on the 12th February, the Government answered immediately by occupying the City Hall by means of the 4th Cyclist Battalion of Field Rifles. It was this prompt action which determined the whole course of events, for it deprived the Socialists of their head-quarters and all central direction, stifled all concerted attacks, and broke the whole operations up into a series of separate fights.

No mention is made of the number of troops who took part in the fighting, which lasted three days, but the official account mentions twenty battalions by name and at least five batteries. The troops and police both used armoured-cars, and, for the capture of the Workmen's Home and railway station of Floridsdorf, also armoured-trains. The engineers are mentioned as having particularly distinguished themselves.

in destroying barricades, in trench-fighting, and in leading assaults with hand-grenades.

The total casualties were 300 killed and 800 wounded, almost equally divided between the Government forces and the rebels. Two officers and 27 O.R. was the army's share of the killed, and the compiler of the official account has managed to get together the necessary twenty-nine photographs here reproduced.

Field-Marshal Radetzky, by Colonel Baron Wolf-Schneider. The name Radetzky has survived the thrills of a century. Here and there the Austrian is reminded of this great man and great general by a memorial, the name of a street, of a bridge, or of a barracks, and still the number of people diminishes who know who and what he was. Five years ago, on the seventieth anniversary of his death, a Hamburg paper reproduced his portrait with the text, " The Austrian Field-Marshal Count Radetzky, known through Johann Strauss' composition ' The Radetzky March,' " —a fine example of *sic transit gloria mundi*, which shows at the same time how in these days of broadcasting a great composer can help to keep a memory green.

For Radetzky's significance General Kerchnawe may be quoted: " Radetzky is the very essence of that Old Austria with its great historical mission, which was never more clearly recognizable than at the present day—of that Old Austria, which ensured to its many peoples not only the enjoyment of their daily bit of bread, but respect in the eyes of all the world, and a rare degree of freedom in the development of their special characteristics. This Old Austria, already beginning to disintegrate, Radetzky's insight, determination, and his strong arm held together in 1848–49 once again, and for the last time. The present Austria, naturally influenced by its latest lines of development and hence prejudiced, may judge as it pleases. Radetzky saved *his* Austria from the irremediable disorder which convulses our days. He was the saviour of Austria, but also the guardian angel of Europe, as General Cavaignac, the French War Minister in 1848, wrote to the French ambassador in Vienna."

The references in the foregoing are to Radetzky's services in preserving for Austria her provinces of Lombardy and Venice when, in the cause of the unification of Italy and taking advantage of the revolution in Vienna, the King of Sardinia declared war on Austria, and called upon Austria's Italian subjects to throw off her yoke. Although the Field-Marshal was over eighty years of age he conducted two lively campaigns, won all his battles against odds, and restored order in the provinces, before it was even restored in the capital. General von Schönhals, in his *Reminiscences of a Veteran*, says that Parliament would not pass a vote of thanks to the Commander and his successful army, and that the thirteen standards captured from the enemy had to be smuggled into Vienna and hidden there, for fear of their being confiscated and returned to the Italians. These two items throw an illuminating light, and give some indication of the difficulties over which " Father " Radetzky (as his troops called him) triumphed.

F.A.I.

WEHR UND WAFFEN.

(*January*, 1934.)—*Reduction of the Number of Ordnance Types and the Use of Gas.* Major Schneider makes out a good case for replacing the ordinary field-gun by the 10·5 cm. gun, and for simplifying matters by abolishing the 6-in. in favour of the same gun. It is fundamental to his proposals that the 7·5 or 7·7 c.m. has long been found unequal to requirements, therefore it must be replaced by a heavier gun, or, for A.T. defence against modern fast tanks, by a heavy machine-gun. Further, that the performance of the 10·5 cm. against troops under cover in the field could hardly be surpassed even by a 15-cm. howitzer. The 10·5-cm. gun has the special recommendation of being the best of all calibres for gas. Upon which point the author's remarks are very wise: " For though the use of poison gas in a future war

is said to be excluded by international agreements and treaties, there can be no doubt that such arrangements will not be observed, for they simply *cannot* be observed. The indispensable condition of success of every attack is the beating down of the defender's artillery. By reason of the latter's distribution in breadth and depth, this cannot be achieved by explosive but only by gas-shell. No commander will expose his troops to destruction by neglecting to use their means to victory. The conclusion of such agreements, of the impracticability of which the leading military experts of the contracting states cannot for a moment be in doubt, is thus from the outset a dishonourable measure, intended to counterfeit for public opinion humanitarian strivings, which really do not exist." Major Schneider then shows how much more humane gas is than explosives.

The United States Coast Defence Artillery. This branch has been completely re-modelled since the war. To the coast batteries and mine-fields have been added railway-guns, motor-guns, A.A. guns and machine-guns. The Coast Defence Artillery has taken over all anti-aircraft defence artillery work, and all C.D. artillery personnel is trained equally in both branches.

Major Blümner gives here a detail of the armament for both purposes, and a short account of the organization, from which it appears that San Pedro, San Francisco, the Panama Canal, the Sandwich Islands, and the Philippines alone are occupied at full strength, all other harbours having only cadres, guards and cleaning personnel. At home there are 28 batteries actually present, and 97 still to be completed.

Bridge Demolition by the British in their Retirement in 1914. Extracts with sketches from the late General Buckland's account in *The R.E. Journal*, March, 1932, but with the narrative largely re-written. Almost the only comment is that the lattice-girder bridge over the Oise, at Beautor, was completely destroyed with only two-thirds the amount of explosive necessary according to German formula, while the 2-lb. charges on the road-bearers were one-third of what the Germans would have used.

Theory of Musketry, by Major Mouths. In 1927 Major Dänicker, of the Swiss General Staff, an instructor at the Swiss School of Musketry and well known as the author of many technical articles, produced *An Introduction to the Theory of Musketry*. This he has now followed up with *The Principles of the Theory of Infantry Fire*, published by E. S. Mittler and Son, Berlin, with 127 diagrams. Major Mouths compares this work with the German *Musketry Manual*. Both treat of the rifle first, followed by the light machine-gun, the pistol and the hand-grenade. So far the *Manual*; Major Dänicker further includes the rifle-grenade, the heavy machine-gun, and the light trench-mortar; the latter to a certain extent considered as an infantry accompanying gun. One might almost say that in this work the machine-guns play the chief role, and hence that Major Dänicker's new book marks the transition from rifle to m.g. as principal infantry weapon.

The 20-mm. Machine-Cannon Breda by Major Dänicker. Most patterns of machine-cannon are recoil-loaders. Only certain firms, notably Hotchkiss and Scotti, who construct m.g's as gas-pressure loaders, have also built machine-cannon on the same principle. It is of interest to note that Breda, of Milan, whose machine-guns are recoil-loaders, have taken a step in the other direction by going over to gas-pressure loading, both with their super-heavy 13·2-mm. machine-gun, and also with their 20-mm. machine-cannon.

The latter is here fully described with photographs. Its proper task is anti-aircraft, for which it fires from a tripod and up to 80° of elevation. For anti-tank use it can be regarded only as an auxiliary weapon.

Progress in the Construction of Horse-drawn Vehicles, by Lieut.-Colonel Giesecke. This month's contribution to the subject of the rationalization of horse-draft is confined to the wheel, *i.e.*, to a comparison of the effects of ordinary and rubber-tyred wheels. Since all modern armies appear to have answered the question, "Horse *v.* Motor?" by "Both," the modern spirit demands that rationalization be

now applied to horse-transport, both to horse and vehicle. The best stamp of horse must be discovered and bred: the best type and size of vehicle must be worked out. The first thing to test out in the vehicle was the wheel, and to this end exhaustive trials have been made over a long period by the "Special Committee for the Improvement of Means of Transport" appointed by the German Agricultural Society. Their report is entirely favourable to the use of rubber tyres for all forms of country horse-drawn vehicles, exceeding 3½ tons useful load. Applied to military purposes, this rules out first-line transport, but it opens up a wide field in the transport columns, with savings in horseflesh, column length, personnel and wear on roads.—(*To be continued.*)

Notes on Foreign Armies deals this month with (1) the artillery of the Italian Army, its organization, establishments and armament, compiled from the *Rivista di Artigleria*, the *Rivista Militare Italiana*, etc., and (2) the present position of the infantry gun question in the British Army, the introduction for this purpose of the 3·7-in. mountain howitzer, advantages and disadvantages of its motorization.

(*February*, 1934.)—*The Early History of Trench-mortars*, by Major Mouths. There is a widespread idea that the introduction of trench-mortars was due to experiences in the siege of Port Arthur thirty years ago. In the present sense of the word this may be correct, but in the general sense of the word, especially as regards light and medium, the trench-mortar had its forerunners not only centuries back, but also in the trials made at the end of the last century for the introduction of the light field howitzer.

Krupp's, either at the request of foreign customers, or on their own initiative, conducted such trials to arrive at a very mobile high-angle fire weapon of fair range with low muzzle velocity, permitting the shortest of ranges, instead of the light field howitzer hitherto demanded, having as great range as possible. These trials resulted in the production of the so-called Austrian 12-cm. field mortar, 1897 pattern, which bore the stamp of a light field howitzer, and, with its muzzle velocity variable between 60 and 146 m/sec., covered ranges from 300 to 3,300 metres.

Apart from its maximum range, which was more than twice as great, and regarding only the weight of its projectile, 16½ kilos, this field-mortar stood half-way between the light and the medium trench-mortars of the Great War.

Observation of Fire at the Longest Ranges. In spite of the known ballistic disadvantages of fire at the longest ranges, and in spite of constructional difficulties of gun and ammunition connected therewith, it is astonishing what maximum ranges are being demanded, striven for, and even obtained by all the artilleries in the world. The permanent arrangements of stationary warfare facilitated all observation even at the greatest ranges, but how is such observation to be obtained in the war of the future when mobile warfare is the rule and stationary warfare the unwelcome exception? Harassing fire may be left out of account; a hit is then only blind chance; but for effective fire observation of some sort is imperative. Without it in mobile warfare there can be no artillery success, and no excessive expenditure of ammunition at the longest ranges can make up for the want of it. Neither observation from the air nor the work of the field survey sections can be relied upon exclusively, the artillery must learn how to help itself. This must be done by using the most capable and boldest artillery officers for forward observation in cross-country motor vehicles with radio-telephony sets. They must be as mobile as cavalry patrols, accompanying the advance guard as far forward as possible, moving quickly from one point of advantage to the next, reporting targets and correcting fire. It is not likely that quite young officers would be suitable for this work, as it needs trained observers and experienced fire leaders.

The writer hopes to stir up comment. He will.

Multiple Gun Turrets. Traces the rise from the twin-gun turret almost general on battleships and cruisers before the war, through the three-gun turret introduced even then in the U.S.A. *Tennessee* class, the Italian *Cavour* class and the Austrian

Viribus Unitis class to the four-gun turret designed for the *Normandie* class, and now existing in the *Dunkerque*. The advantages and disadvantages of placing guns together in turrets are such as to balance out in the case of a pair, but under limitations of space and conditions of weight the ship-constructor has forced the naval gunner to accept the three- and four-gun turret. In the *Dunkerque* already mentioned there are two four-gun turrets, containing eight 13-in. guns, both forward and close together, one being super-elevated. The idea, as with our *Rodney* and *Nelson*, is to go straight for any enemy, relying on their armour, and at the greatest possible range to bring as many guns to bear as possible. This form of construction is thus a definite abandonment of the old pre-war principle of locating guns so as to be able to distribute their fire equally around the horizon. Logically this new principle, if a ship should be built to avoid engagement, would lead to her gun turrets being placed aft. A proposal to this effect has actually been made by a Danish naval officer in the case of a ship sanctioned for the Danish Navy, viz., a single turret with two 15-mm. guns forward, and four 24-cm. guns in two turrets aft.—(*To be concluded.*)

Bridge Demolition by the British in their Retirement in 1914. The narrative continues with maps and sketches taken from *The R.E. Journal*, June, 1932. Comment is confined almost exclusively to pointing out ambiguity in orders, and instances of order and counter-order.

Progress in the Construction of Horse-drawn Vehicles (continued). Under the German Agricultural Society the Experimental Farm at Bornim has tried out rubber tyres for horse-drawn vehicles for three years, as regards the effect of sun and rain, standing in the open in manure, travelling over all sorts of ground from rough, rocky ground to sand; subjecting them, in fact, to such treatment as the ordinary wheels of farm wagons have to stand. The results of these tests have been entirely favourable to the rubber tyre. Even the dreaded puncture is far less frequent than was expected, as nails work but slowly through the tyres when the vehicle moves at the rate of a horse's walk.

The farmers have discovered that the best way to profit by the report on the Bornim trials is to buy up an old chassis and let a carpenter build up on it the required body. With new wheels the whole vehicle (a four-tonner) can be got thus for about £23, or a saving of 40% against the old type. The farmers are going over so readily to the rubber tyre, that there is already a rise in price, and a threatened shortage, of old chassis.

Through the rubber-tyred horse-drawn vehicle the horse's power of competing with motor transport is so considerably raised that the report lays down, "As long as it is a question of distances which a horse can cover there and back in one day, the motor-lorry nowadays does not pay either in farming or in transport generally."

Further trials of agricultural wagons have included two more types, viz., with steel wheels, and with caterpillar-track and steel front wheels. Comparisons are given on different surfaces, and all three new types show great increase of useful load. A novelty, too, in agriculture is the all-steel wagon made by Welger of Wolfenbüttel. This is made in three sizes known as Wolfenbüttel 1, 2, 3 and carrying about 2, 3 and 4 tons respectively. The constructor's ideas were: to make the wagon as strong as possible, to raise considerably its travelling power, to place its centre of gravity more favourably, to facilitate loading and unloading, and to make its lubrication more effective and lasting. Also it should be suitable for and simply attachable as a trailer. All these points have been realized. Of the Wolfenbüttel wagons only No. 1 (1½ to 2½ tons) can be compared with a military light wagon. It takes twice the load of the latter, thus saving in horses, drivers, fodder and rations, it shortens the length of the column, is weather-proof, has a longer life, is less liable to damage, requires less repairs, costs only 62½% of the military type, and is suitable for mass production.

The Use of Tanks in Defence in Conjunction with Field Fortification. An article by N. Schmakow in the Russian periodical *Technika i Wooruscheuije* prompts a

writer to ask whether tanks are to be given only tasks of a purely active character, or whether they could not also be used for the defence of definite sectors, and thus secure places of assembly of their own troops, development or retreat. He then works out his suggestion of a passive defence against tanks by means of a row of so-called tank-forts. These tank-forts would be from 2 to 4 km. apart, and behind a passive defence belt 1 km. broad. Each fort should be able to contain at least one tank coy. It is not to be considered as a permanent position, but includes a number of tank positions, and serves as a base from which the tanks issue to take up other prepared positions, as the situation demands. The belt, 1 km. broad, in front, consists of (1) tank obstacles, (2) infantry obstacles, and (3) firing positions for tanks, chosen for command of the foreground, at tactically suitable places, concealed from the enemy. Behind the belt and between the tank-forts themselves there must be strong obstacles provided in the shape of ditches, mine-fields or artificial inundations. Amongst these obstacles alternative tank positions are to be prepared. Such an employment of tanks in defence is based upon the assumption that one tank in position is equal in fire-effect to three tanks in motion.—(*To be concluded.*)

Notes on Foreign Armies.—The Artillery of Czecho-Slovakia. The nuclei of the Czech Army were formed during the Great War out of the numerous deserters of Czech nationality from the Austrian Army to the Russians, Italians and French, and were collected into the Czech Legion on the side of the Entente. At the end of 1917, at the request of Masaryk, now the veteran President of the Republic, these troops were collected from the various fronts to form a separate Czecho-Slovakian Army. Thus when peace was made and the Czecho-Slovakian State was formed, it found itself in the happy possession of a ready-made army. The French Military Mission at once formed this into 4 divisions, and later into 4 military commands, covering the whole country and producing 12 divisions and 4 cavalry brigades. There are no corps. Lists are given, compiled from various sources, showing the organization of the artillery, and of its equipment with full particulars.

The International Automobile and Motor-cycle Exhibition, Berlin, 1934. This exhibition, intended by the trade to take place at the end of the year, was brought forward to March at the request of the Chancellor. The main idea of the change was to assist those responsible for finding work for the unemployed.

Review of International Politics. General Paschek concludes his *résumé* of the events of 1933, and his review, by discussing the nations and their grouping, under the headings (A) the struggle for a new configuration in Europe, and (B) outside Europe. The three main groups under (A) are the French group; the widened sphere of the Eastern (non-aggression) pacts; and the group for treaty revision, viz., the Central Powers and Italy. The British Empire gets pride of place under heading (B).

Thoughts on Defence. Under this title Lieut.-General von Cochenhausen has collected and issued (Hanseatic Publishing Institution, Hamburg; price 5 marks) over a dozen articles by military experts, dealing with national defence. Amongst the essays most praised by the reviewer, Major-General Steinitz, are "The Armies of the North American War of Secession," and "The Decision of War." In the former, Dr. Daniels says: "When 1914 came, both the Germans and their enemies took the field with only a passing knowledge of the fact that fifty years before in the ancient forests of the new world forms of the art of war had struggled to the light, the study of which would have been of the greatest practical use to them." General Steinitz refers to a later instance of neglected lessons: "The teachings of the war in Manchuria were considered as not applicable to a European theatre. Prophetic voices, like that of Colonel Csicserico, were lost." The explanation of this neglect in that officer's own words appears in *The R.E. Journal,* March, 1931, p. 186.

In "The Decision of War," Dr. Linnebach champions the thesis that the happenings of the Great War have been misunderstood and wrongly turned to account. Contrary to the general opinion, he considers that the battle, the decision by arms,

in fact military warfare, is and will in future remain the means by which decisions are compelled. He looks upon economic warfare as no more than an aid. Only—the mass of the hostile armies must be overthrown and not, as in the Great War, merely portions of them General Steinitz, in support, points to the fact that the decisive battle of the war and the end of the war may be far separated in time. "The Great War was really lost by the Central Powers already in 1914 on the Marne."

Amongst the other articles are: "Fighting against Odds," by the editor, "The Nature of the State and the Nature of its Defence," by Colonel von Oertzen, "Naval Warfare and its Significance for Great Political Decisions," "Signals in Modern Warfare," in which Colonel Pfleger shows how much the lack of telephonic communication between German G.H.Q. and the armies of the right wing contributed to the wrecking of Schlieffen's clever plan, and "The Development of the Chemical Weapon since the War," by Dr. Hanslian, the gas expert, whose *Chemical Warfare* was reviewed in *The R.E. Journal*, March, 1928, p. 152.

Austro-Hungary's Army in the Great War, by T. von Schäfer, and *The Austrian Soldier in the Great War*, by O. Gallian. It is so much the custom in Germany to cry down everything Austrian that the simultaneous appearance of complimentary articles in *Wissen und Wehr* and in the *Militär-Wochenblatt*, a recognition long overdue, must be as welcome to the Austrians as it is surprising.

Sound-rangers and Flash-spotters. In Austria, where the army is small, it is sometimes maintained that sound-ranging and flash-spotting are luxuries which are only justifiable in large armies. Field-Marshal Gerabek points out that the size of an army is not one of the determining factors, since the object of sound-ranging and of flash-spotting is, by increasing the effectiveness of one's own artillery fire, to prevent waste of ammunition. He welcomes, as filling a hitherto empty space in war books, an account of the *51st Sound-ranging Section*, by M. Bochow, Union German Publishing Co., Stuttgart, price 2 marks 80 pf., which goes into the composition and work of a sound-ranging section in a manner as clear and convincing as it is entertaining, and "better than any training manual." Special praise is accorded to the photographs and sketches.

(*March*, 1934.)—*Multiple Gun Turrets (continued)*. In distinction from the French Navy, wherein all kinds of turrets are to be found on the different kinds of ships, the choice of turrets in the U.S. Navy has been more unified. Excepting the first two built, all the U.S. 10,000-ton cruisers have three turrets containing 8-in. guns in three's. The exceptions are the *Pensacola* and the *Salt City*, which have a twin and a triplet forward, and the same aft, making ten guns in all, as against nine of the later type. A bird's-eye view photograph of the *Pensacola's* bows shows five guns ready to fire in the ship's line of travel, the turret with pair being forward and the turret with three guns being above and just aft of it.

The British and Italian navies also kept truer to type, in all 10,000 and 6,000-ton cruisers laid down since the war retaining the twin-gun turret. Only in the *Nelson* and *Rodney* are the new 16-in. guns mounted in three's. Experiences of this method of mounting are not favourable. The rate of fire suffers owing to the difficulty of supplying ammunition to the centre gun. Salvoes of all nine guns are not fired, but only of from four to five, *i.e.*, of one to two guns per turret. The same difficulty as regards ammunition supply to the centre gun would not be felt in the case of smaller guns being bunched, like the 6-in., but three-gun turrets have not even been tried in the cruisers. The determining factor with *Nelson* and *Rodney* was to have one more 16-in. gun than the *Colorado* class with eight guns in four turrets. The Italians have likewise kept since the war to the twin-gun turret, although in the *Cavour* class the three-gun principle had been adopted before the war.

The article then deals with methods of mounting the auxiliary armament, discusses the question of casemates *versus* turrets and the differing opinions of Capt. Acworth and Capt. Fiovaranzo. Apart from the fact that the medium armament may have to be used against aircraft the question of how to mount it cannot be considered a

burning one, since the important type, the Washington cruiser, possesses none, A.A. defence has to be undertaken conjointly with the defence against torpedo-boats. Against this the French battle-cruiser *Dunkerque* re-introduces the medium armament, of sixteen 6-in. or 5·6-in. guns in turrets of two and four guns. The author appears not to care for this, as he says: "The good simple mounting of one 5·6-in. gun on a single carriage behind an extended shield, which we see on the British battle-cruiser *Hood*, has been repeated only on the German pocket-battleship *Deutschland*.

On destroyers and destroyer-leaders of 1,500 and 2,500 tons, the choice of the carriage depends upon other circumstances. Machinery-drive is unsuitable, since the guns get very wet in a heavy sea and failures in electrical control cannot be avoided. Also extra machinery means extra weight. On a rolling vessel the gun must be laid by hand, hence the best arrangement is single guns behind light weather shields, two guns forward, one higher than the other, the same aft, and one midships. The Italians, on the other hand, prefer the twin-mounting for its advantages of reduced top-hamper, *i.e.*, better stability and lessened profile. The French are following the Italians experimentally in two destroyers that are building, while the Japanese in their *Fubuki* class of destroyer-leaders have also gone in for pairs, in this case in light turrets.

Man and Technics in Modern Armies, by Dr. Hänert, instructor at the Naval Academy at Flensburg, and ex-captain of artillery. The questions Dr. Hänert sets himself to answer are: Have technical occupation and technical skill an influence upon the soldier's chief quality, viz., his personal courage, expressed principally in combativeness and daring? Does a training more or less directed upon technics, do scientific inclination and gifts have any effect upon the qualities of military leadership, *e.g.*, upon the power to form quick and bold decisions? Hence, is the technical soldier suitable for specially daring attacks? And, has the technically-trained officer still the necessary moral qualities of a leader?

Cockshies are sometimes erected for the purpose of being knocked down, and certainly Dr. Hänert has little difficulty in disposing of this lot. A simple argument he uses is to point to the deeds of the German military engineers in the Great War. The men who made the first hand-grenades out of provision tins were the first to assault the enemy with them. What the engineers did in the front line, in destroying wire, in bridging, etc., under fire, everybody knows. The technical ability of the troops and the technical gifts of their officers in no way prejudiced their personal bravery and their spirit of attack. Rather the other way about. Dr. Hänert's excuse for asking these questions lies in an article in *Deutsche Wehr*, in which Dr. Simoneit attempts to find a scientific explanation for a popular idea that science unfits a man for war. Dr. Hänert points out that such a search is itself not in accordance with scientific method and cannot serve science since true science works without prejudice, endeavouring only to explain facts.

As an example of leadership utterly unspoilt by scientific labours, the author picks the Russian Admiral Makarow, who, before he took over the command of the Port Arthur Squadron, had been long employed on the constructional side and had become known as the inventor of a modern ice-breaker. Makarow in a short time was able to animate the beaten and disheartened Russians so as to be able by powerful and far-seeing operations to keep the superior Japanese forces at bay. The Czar said of him, "This man was worth more than a whole fleet."

The summing up is: Technical occupation, technical inclination and gifts have no prejudicial effect on the basic moral quality of the fighting soldier, nor do they harm the indispensable qualities of the leader. Whether a man is suitable for a soldier, or for a leader, depends far more upon his character than upon the nature of his studies.

The Use of Tanks in Defence in Conjunction with Field Fortification (continued). On the assumption that, in the almost entire absence of infantry, tanks might be called upon to occupy a defensive line, the concluding instalment of this article

describes with sketches tank-nests, tank-ditches, a tank cover-trench for several tanks, and the design of a tank-fort (say 1,000 metres × 700 metres) or repair and rallying-point, with all that it might contain.

Bridge Demolition by the British in their Retirement in 1914. Lieut.-Colonel Wabnitz concludes his most careful investigation, based upon General Buckland's narrative, with the doings of the 3rd and 4th September, and with Major Playfair's comments. In his own comments he says: Between the Condé Canal and the Marne—as far as the foregoing account permits of accurate calculation—the British destroyed only two-thirds of the bridges attempted, while in about one-third the desired object was not attained. The blame for this does not attach to the British Engineers engaged in carrying out the work, who performed prodigies (*die ganz Ausserordentliches geleistet haben*), but is chiefly to be found in an issuing of orders which leaves much to be desired both as regards time and content, and to a smaller extent in insufficient establishments of explosive, fuse and exploders. Of such an operation generally as fell to the lot of the Field Companies of the B.E.F. during a fortnight's retirement the author writes: "The success of barring a hostile advance by destroying artificial structures depends quite especially upon the most careful preparation. This, however, in addition to well-trained personnel, demands sufficient time. Such time must be gained, and will be at our disposal only by the exercise of forethought, systematic arrangement, and the early and prompt issue of orders."

The German Earth-oil Question, by Capt. Bornemann. Deals principally with the actual and possible German sources of supply, the chief of which at Pechelbronn was lost to France with Alsace, and with methods of obtaining the petroleum, especially the rotary-borer, first used in Texas in 1901 and now employed for 75% of all borings in the United States.—(*To be continued.*)

The International Automobile and Motor-cycle Exhibition, Berlin, 1934. A natural result of this exhibition, intended for November, having been advanced eight months—at the request of the Chancellor, in the interests of the unemployed—is that there is a dearth of entirely new constructions. A characteristic note is that the public is being tempted with cars reasonably cheap, and yet with good travelling properties and comfort. The era of the smallest h.p. appears to be over. The coming motor-railways appear to be affecting ordinary car design as regards stream-line types. For cars the petrol engine remains unchanged, but there are a number of improvements as regards mixing, ignition, lubrication, etc. For lorries the Diesel engine, notwithstanding its short time of development, has proved absolutely reliable, and holds the field without opposition. Air-cooling has made great progress. Details of the exhibition and a criticism from a military standpoint are promised.—(*To be continued.*) F.A.I.

THE INDIAN FORESTER.

(*January,* 1934.)—With this number, *The Indian Forester* enters upon its sixtieth year. It begins with a message of congratulation from the Viceroy, and, not unnaturally, devotes a large space to its past history, and to hopes and fears for the future.

If the White Paper in its present form is implemented, the Forest Service in India will be "provincialized," that is to say, that there will be a dozen services, each with its own cadres and rules of working, instead of one, or at most three (Bombay and Burma are, at the present time, to a large extent independent of the central authority). Old hands cannot but regard this decentralization with misgiving, as they must also the progressive Indianization of the service.

The extent to which the Indian Forest Service has been the father and mother of many of our overseas organizations is little realized outside that service itself. The number under review relates how much the services in New Zealand, Nyassaland, Malaya and Trinidad owe to India; in some cases the local service was inaugurated

by officers seconded from India and Burma. The service in this country itself which, it will surprise most readers to learn, did not come into being until after the Great War, owes much in its inception to the advice of an ex-Indian forester, Sir William Schlich.

It is interesting to learn that teak has been successfully started in Trinidad, from seed imported from India; and that two other trees, well known to R.E. officers who have served in India, the deodar and kail, are now being grown in New Zealand. Another forest denizen, the *sambur* deer, has also been introduced there from India, but is unfortunately proving a bit of a pest.

There are three articles in this number of the magazine of special interest to the R.E. *qua* engineers. The first deals with the subject of joints in timber framing, and is itself a review of a publication by the Forest Products Laboratory of the U.S.A. *The Indian Forester* contains diagrams and descriptions of some novel joints, which are claimed to be very much stronger than those in general use; but the reviewer is careful to add that such joints may not be suitable for all constructional timbers in use in India. It is interesting to learn that an auditorium with seating capacity for 75,000 persons, bridges more than 1,000 feet long, and a radio tower 460 feet high, have been constructed of wood, the magnitude of the dimensions being solely due to the use of novel timber connectors. It is claimed, in connection with 330-foot radio towers at Stuttgart in Germany, that a much greater radio efficiency is obtained by the use of timber, when brass bolts and oak dowels are used to the exclusion of steel and iron connectors. The joints described, however, seem to necessitate the use of finer instruments and more accurate measuring appliances than are likely to be available in the field.

Another article, "Control Measures for Termites," may be usefully read as a supplement to Lieut.-Colonel Hyland's interesting article in the December, 1933, *R.E. Journal*. Reference is made to experiments at Dehra Dun regarding the resistance of various timbers to white-ant attack, and it will surprise most Sappers who have served in India to learn that teak is placed in a comparatively low category, viz., "timber whose heartwood is durable but liable to slight attack in three to four years," while the highest class, with apparently absolute immunity from attack, includes rosewood, *shisham*, *padauk* and others. But, as the author explains, species of termites differ in their tastes, and in consequence, in Ceylon, teak occupies first place, presumably owing to the absence there of the species that are so voracious at Dehra Dun. A few recipes, additional to those in Colonel Hyland's article, for destroying nests are given. As regards protection of buildings, the author's principal recommendations are anti-termite shields, consisting of metal strips projecting downwards just below plinth level, and projecting concrete courses similarly situated.

Thirdly, some experiments on the strengths of various timbers are described and the results plotted on a chart. From these results, the author has deduced a curve (actually a straight line) connecting weight per cu. ft. with safe working stresses. (Some connection, it should be noted, between weight per unit and safe working stress is given in *Military Engineering*, Part III, but there are some building timbers which will not fit into any formula, while the specific gravity for any species is by no means a fixed quantity, diminishing considerably as the specimen seasons.) It should be noted that there is a very large scatter among the various results, some being 33% above, and others 40% below, standard. The author does not place too much reliance on such an empirical formula. A much smaller factor of safety is recommended than we are accustomed to use.

May we take this opportunity, on the beginning of its sixtieth year, of congratulating *The Indian Forester* on its continued excellence, and of wishing it the best for the future. Its technical articles should be of great help to the M.E.S. in India, while its sporting tales should find it a place in R.E. and S. & M. messes.

F.C.M.

CORRESPONDENCE.

THE DIARY OF AN R.E. SUBALTERN.

To the Editor, *The R.E. Journal.*

Royal Military Academy, Woolwich, S.E.18,
14*th May*, 1934.

DEAR SIR,

Since the publication of "The Diary of an R.E. Subaltern with the B.E.F. in 1914," in the December, 1933, issue of *The R.E. Journal*, I have frequently been asked questions about the blowing up of Compiegne Bridge (pages 554-559). On page 558 I stated that Brig.-Gen. Fowke was present to the very end, accompanied by some other Staff Officer. So as to clear up any possible misconception on this point I have written to General Sir George Fowke, and he has very kindly replied, giving me liberty to use his letter.

The following extracts from General Fowke's letter will, I think, be of general interest :—

"The Staff Officer was Major-General W. F. L. Lindsay, C.B., D.S.O., late R.H.A., subsequently Sir Walter Lindsay, K.C.B. He was my opposite number in the R.A. at G.H.Q.; he was Artillery Adviser and I was Engineer Adviser; I think it was under these rather odd titles that we started the war." . . .

"I got instructions from French verbally to blow up the bridge, and after I had seen the bridge I told French that the blowing up would have a very small delaying effect on the Germans, as there was such an easy bridging site near the permanent bridge. French agreed with me but said that it was by Joffre's orders." . . .

"Newcombe's presence is explained by the fact that he rolled up at G.H.Q. a couple of days before as a railway expert!"

"When French told me about the bridge I seized hold of him as the only Sapper at G.H.Q. with the exception of my clerk. I daresay you remember how he worked, I can see him now going down the first chamber with his trousers off and his shirt tails fluttering in the breeze." . . .

"(With Lindsay) the only three at the blowing up were Newcombe, yourself and myself, and the only other people I visualize plainly are the begoggled Frenchman in his car over the charge when the exploder failed, and later on the village idiot and I told you to light the safety fuze and not mind him." . . .

"You are at full liberty to send Lindsay's name to *The R.E. Journal*, and my corroboration."

I feel it would be impossible to get any better corroboration of my description of the demolition of Compiegne Bridge than the above, coming as it does from one who was not only Engineer-in-Chief to the B.E.F. but was also present throughout the operations on the bridge.

Yours truly, B. K. YOUNG.