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The End of the First Hundred Years.

The Six-Inch Survey of Scotland and the North of England.—At the end of the year 1837 the general situation was the following:—Three-quarters of the one-inch map of England and Wales had been finished; the six-inch survey of Ireland was approaching completion; but nothing had been done for Scotland, except the original sketch map of 1747-55, and an incomplete triangulation on which work had been stopped in 1825. It was clearly the turn of Scotland, and influential corporations and individuals moved the Government to approve of the execution of a six-inch map of that country. Thus, in 1837, the Town Council of Edinburgh presented to the Treasury a memorial, from which the following extracts are taken:—

"The form and position of headlands, and even of considerable islands, not only in Arrowsmith's map, but in our best charts, are erroneously given, and sometimes dangerous rocks are totally omitted. For example, the distant rocks of the Stack and the Skerry, off the northern coast of Sutherlandshire, are left out by Arrowsmith, while the important islands of Barra and Rona are misplaced both in latitude and longitude. In some books and charts the nearest distance of the large island of Arran is stated or laid down as four miles from Bute, and in others as three miles from that island. Pladda Island Light is placed as 16 north of Ailsa Craig; whereas its true distance is only 10.20! . . .

"Your Memorialists are informed, that of the great triangulation of Scotland, by which the positions of the principal objects are ascertained, the greater part was executed nearly twenty years ago, though the results have not yet been published; and that the remaining part can be soon accomplished at a small expense."

They also pressed for the general Survey of Scotland to be proceeded with. Other addresses and memorials on the subject were submitted to the Government by various public bodies in Scotland.

The question was brought to the notice of Parliament, and a motion for the production of memorials on the subject was brought forward by Sir R. Musgrave. The upshot was that a six-inch survey of Scotland and of the six northern counties of England was approved by the Government.

Sir Henry James, then Director of the Survey, writes in 1859 :—

"The survey of Ireland was completed on the six-inch scale; and though it is to be regretted that it was not made in the first instance on a much larger scale, still it was found to be of such immense benefit as compared with the one-inch, that, when we resumed the survey of Great Britain in the North of England and South of Scotland, we were ordered to proceed upon the six-inch scale as we had done in Ireland; and we completed the whole of Yorkshire and Lancashire, and several small counties in the South of Scotland on that scale."

The triangulation of Great Britain was taken up again in 1838. In July and August of that year we find Colby, with Lt.-Colonel Robe and Lt. Robinson, on the summit of Ben Hutig (or Hutich), on the north coast of Sutherland. From this year until 1852, when it was finished, the work proceeded steadily. The observers for the first three or four years were Lt.-Col. Robe, Captains Robinson, Pipon and Hornby and Lieut. Da Costa.

A change of custom took place in 1840-41. Until then, all the observations of the principal angles were made by officers, as is still the case on the Survey of India. But in 1840, Corporal Donelan, R.S.M., observed some angles with the 12-inch theodolite in Ireland; and, in 1841, Corporal Steel, R.S.M., observed some angles with the 18-inch theodolite in Yorkshire. Thereafter, it became increasingly common to employ non-commissioned officers on this duty, and by the time the triangulation was completed it might be said that three-quarters of the total number of the angles had been observed by them. The observers most to be remembered, in this connection, are—giving them their later ranks—Sergt.-Major Steel, Colour-Sergeants Donelan and Winzer, Sergeants Bay and Jenkins, and Corporal Stewart; between them they observed at no fewer than 149 principal stations, out of a total of 228 in the British Isles.

The Completion of the Original Six-Inch Survey of Ireland.— The original object of the six-inch survey of Ireland, at its commencement in 1825, was the accurate delineation of the boundaries of counties, baronies, parishes and townlands. Later, however, it became necessary to show all the detail that could be drawn on the scale. Larcom writes :—

"At this time (1843) another circumstance had arisen. The early northern counties had not been surveyed with the degree of detail which had been attained in the south. . . The tenement valuation, now introduced for the Poor Law, required this detail. Accordingly, on the memorials of the northern counties, the Government allowed the maps to be revised."

Sir Henry James, writing in 1859, thus describes the matter :—

"We commenced first in the North of Ireland, I myself taking part in the survey. To obtain accurately the acreage of the townlands, which was at first supposed would be all that would be required, it was decided that the scale should be six inches to the mile; and then commenced that series of mistakes which has interfered with our proceedings up to the present day. For no sooner had we completed the survey of four counties, according to our instructions, than it was found that the skeleton plan, containing the mere boundary of the townlands and the principal roads and rivers, was altogether insufficient; and that every field and garden must be surveyed to enable the tenement valuation to be made. We consequently had again to proceed to the north and complete the survey. . . Our parties are now finishing it—they are in Armagh. . . . And when that is finished I trust it will close the six-inch survey of Ireland."

The revision, so described, was not finally completed and published until 1863; but the original survey was finished in 1846, just before Colby retired. This original survey was complete as regards the southern counties, but in the north was only in skeleton—as laid down by the Select Committee. We have seen that the maps of the first county to be finished, namely Londonderry, were submitted by Colby to King William IV. in 1833.

So far we have dealt principally with a horizontal survey which made no attempt to show vertical relief. In the thirties this latter question came to the fore, and the advent of railways made the matter a practical one.

Levelling and Mean Sea Level.—The first lines of spirit-levelling undertaken by the Survey were those run in the year 1837, in the north of Ireland, to connect the larger lakes with the sea. These observations and those carried out between Axmouth and Portishead, by a committee of the British Association, under the direction of Whewell, in 1837-38, showed that much greater accuracy was obtained by levelling than by the observation of vertical angles. In 1839 levelling was definitely adopted in the Survey of Ireland for the purpose of fixing altitudes. The first levelling of Ireland was finished in 1843. The datum for Ireland was fixed as the level of a low water spring tide, observed at Poolbeg Lighthouse, in Dublin Bay, on the 8th April, 1837. If we compare the values based on this datum with those based on mean sea level, we shall find that all the heights on Irish maps are about 8-ft. too great.

In 1840 the original primary levelling of Great Britain was commenced; this was not completed until 1860.

The question now arose as to what datum should be chosen for Great Britain, and, after consultation with Airy, Colby caused to be carried out a series of tidal observations at 22 stations round the coast of Ireland, in June, July and August, 1842. The observations were taken on a tide-pole every five minutes, for one complete tide a day. The results confirmed the opinion that mean sea level would form the best datum. To obtain this datum for Great

Britain, tidal observations were made at the Victoria Dock, Liverpool, in 1844, taking the mean of high and low water. These observations were made at five-minute intervals, extending over about an hour around high and low water, and lasted from the 7th to the 16th March. Owing to the short period during which observations lasted, the old Liverpool datum was not minutely accurate; but it served its purpose well for nearly eighty years. It is now superseded by the new datum, which is mean sea level at Newlyn, in Cornwall, "as derived from the mean of the hourly readings recorded by the automatic tide gauge there for the period of six years from 1st May, 1915, to 30th April, 1921." It is of some interest to note that the mean of six years' readings differs from the mean of 10 years' readings (up to April, 1925) by less than a tenth of an inch, and that the probable variation of one year's mean from the mean of the ten years is about half an inch. This amount is about the same as the probable annual fluctuation found at nine tidal stations in India, which is 0.6 inch. The next step, after having settled the datum and the method of determining the heights of the level net-work, was to devise a suitable system of showing the ground-forms.

Contours.—A contour has been defined as "the outline of the intersection of a gravitational equipotential with the irregularities of the earth's surface"; but even this somewhat formidable definition is not quite correct, having in mind the actual method in use. The *Oxford Dictionary* defines a contour line as "a line representing the horizontal contour of the earth's surface at a given elevation," and this description, though not minutely exact, will do for most purposes. The same Dictionary quotes *Ansted*, who, in his *Geology* of 1844, remarks on "the laying down on the map a system of what are called contour-lines; by which is meant lines of equal altitude above a certain standard level." According to Colonel Berthaut:

"La première idée des courbes de niveau remonte, en réalité à 1729. A cette époque déjà, l'arpenteur hollandais Cruquius avait imaginé de définir le lit de la Merwède à l'aide de courbes d'égale sonde. En 1737 Philippe Buache représenta de même le fond de la Manche. Mais, comme le faisait remarquer la Commission de 1802, c'est le Corps de Génie qui le premier, et bien avant les ingénieurs géographes, sut définer les accidents du sol par des courbes de niveau. . . . Le chef de bataillon du génie Haxo, dans ses projets de 1801 pour Rocca d'Aufo, employa le premier régulièrement les sections horizontales, à l'échelle de 500e."*

To this account may be added that Buache, above mentioned, "published a contoured map of the English Channel, but did not

* *La Carte de France.* Colonel Berthaut, Service Géographique de l'Armée, 1898. Vol. I., p. 139.

touch the land, 1752. Ducarla is said in 1771 to have developed the idea practically, not knowing of Buache's work."†

We have seen that, in 1777, Dr. Charles Hutton, F.R.S., for the purpose of determining the attraction of Schiehallien on the plumb-bob, "fell upon" the method of "connecting together by a faint line all the points which were of the same relative altitude."‡ Hutton's idea was evidently quite independent of those quoted above, and Hutton's appears to be the first application of the idea to the land surface. But, however that may be, it was forgotten.

With regard to the date of the first use of contouring in this country, Larcom, in a letter to *The Civil Engineer and Architects' Journal* of November, 1843, states that contours have been applied to the representation of ground "for more than half a century (*i.e.*, before 1793), especially to military plans, where the relative command of ground is of great importance; for which purpose all officers of engineers are instructed in contouring."

In the Ordnance Survey Library, at Southampton, there are four volumes of manuscripts, bound together by Sir Thomas Larcom, dealing chiefly with contouring and levelling. In three of the volumes there are prefaces in Larcom's handwriting. These volumes give a very clear history of the adoption of contouring by the Ordnance Survey, especially in Ireland. In the introduction to the first volume, which has the title, *Contouring*, 1841-45, Larcom writes:—

"A general map on the scale of one-inch to the mile was an original portion of the Irish Survey ordered by the House of Commons, but it was properly deferred until the outline survey on the larger scale of six inches to the mile was sufficiently advanced to furnish the reduced outline in readiness for the delineation of the ground upon it. In 1831 it was so, and the best and most experienced officer on the English Survey was transferred to Ireland to take charge of it (Lieut. Dawson). He was stationed at Londonderry, around which the six-inch work was already completed. I had myself been employed on the English Survey and was very familiar with the general map of that country. But my subsequent experience on the Irish Survey had led me to the conviction that the more perfect outline obtained by the Content Survey in Ireland required that the hills also should be inserted by a more rigorous process than the sketching used in England. This could, I thought, be obtained in no way so well as by the introduction of lines of equal altitude, in the French mode, which Mr. Dawson (the father of Lieut. Dawson) had taught to the cadets by the name of contouring, but which had never been practically used in England for the maps. For this purpose I was anxious that Lieut. Dawson should adopt contouring, and I was allowed to supply him with outline maps and proper instruments. It did not

† From a note by Colonel H. G. Lyons, D.SC., F.R.S.

‡ *Philosophical Transactions*, 1778.

then succeed, because Dawson was soon called away to a succession of temporary duties in England . . . till, in 1838, he was permanently withdrawn to a civil situation."

It will be noted that Larcom attributes to the elder Dawson the introduction of the word "Contouring." This would, perhaps, be about 1800.

In 1841 Larcom was sent

"A young officer of no experience whatever, who had never been employed on the Survey at all, he was forced upon me by Colby, but was so entirely unsuited to the work that it became necessary in 1843 to relieve him. Thus more valuable time was lost. But during the 12 years which had elapsed since 1831, practical science had greatly advanced and the value of correct topography had become more and more appreciated. Railways alone, which during that time had become introduced, were sufficient to enforce the necessity for correct altitudes and differences of level; and contours had therefore assumed yet greater and more general importance. They had now become a necessary adjunct to the six-inch plans themselves. The Ordnance, however, remained opaque, and it required a Parliamentary Commission (Sir J. Young's, 1843) and the representation of scientific and local bodies to impress on that heavy Board the necessity of allowing us to keep pace with the advancing knowledge of the age. Gradually, however, even this was accomplished, and when Lieut. Leach succeeded to the duty in 1843, the field was nearly clear for him to move freely. The contouring had been begun at Londonderry, and been dropped. Then, on a whim of Colby's, moved to south; then to Kilkenny, with, in that case, a good object, viz., an effort to produce the contours in sufficient time to insert on the six-inch sheets, then in process of engraving . . . the young officer . . . was succeeded by an admirable man (Lieut. Leach), but too late to overtake the six-inch work. . . Leach began systematically to carry on the two duties together (revision and contouring), and he did both satisfactorily. Much energy, in spite of many checks, gradually succeeded, and all continued to go on well till 1846, when I left the Survey."

In Larcom's second volume of letters he says that this part of the story

"Begins with the movement at the British Association in favour of contouring, at the Cork meeting in 1843. Next, the desire for more accurate knowledge of levels in aid of the sanitary improvement of large towns in England in 1844—for which our (Irish) contoured sheets were produced as examples. Then, the movement of the Northern Irish Counties for revision as well as contouring. The value of contouring had, in fact, become fully recognised, and the Ordnance could no longer withhold their assent."

The volume also contains some correspondence relating to the proposal to have the cadets at Woolwich instructed in contouring; nothing effective being done till Captain Stotherd, who had been trained on the Irish Survey, became Professor. "It was then combined with Surveying, and continued (1839 to 1843)."

But, perhaps the most unexpected contents of the volume are the accounts of the various experiments made by the elder Dawson, Larcom and others, and show hill features on a map. The examples bound up in this book date between 1824 and 1847. We have first an inked-in field sketch by T. Budgen, as practised on the first one-inch Survey of England; then essays in light and shade by Larcom in 1824; then some brush and pencil drawings by Dawson and a fine bit of chalk lithography; horizontal hachures; close contours; layer shading of County Kilkenny; and layer shading with the relief emphasised, of 1843—we might have had layered Ordnance maps as early as that year; hills in plastic low relief; and a curious, but effective, example of contours as fine raised lines. These experiments are worth study and almost deserve a monograph to themselves. They show that our predecessors were much alive to the importance of the subject, and that eighty or ninety years ago there were no methods, which we practice now, with which they were not acquainted, and that they had also tried others which we have forgotten.

In Great Britain contouring was begun about the same time as in Ireland. "Contour parties" first appear in the returns in 1843.

In the midst of all this technical activity there came an administrative change which was to affect the future of the Survey very materially. This change, the removal of the headquarters from the Tower to Southampton, came about chiefly as a result of a fire in the Tower. And this must now be described.

The Fire in the Tower of London.—The offices of the Ordnance Survey, the drawing room and the stores, were housed in some buildings touching the upper old storehouse and to the east of it, in the Tower of London. This storehouse was to the north of the White Tower, that is, on the far side from the river. The upper old storehouse is so described in a map drawn about 1685; later it was known as the Grand Storehouse. It was, in fact, an Armoury which had been begun by James II and completed by William III. This Armoury was destroyed by a fire which broke out on the 30th October, 1841. The following extract from the *Times* describes the circumstances:—*

"1st November. On Saturday night last at 10.30 p.m. fire broke out at the Round, or Bowyer, Tower to the north of the Stores.

"11 p.m. The fire reached the Armoury or Store House.

"11.20 p.m. The roof fell in.

"12.30 p.m. Heat was so great between the Armoury and the White Tower that some of the engines were burnt.

"1 a.m. All attention was directed to save the White Tower and St. Peter's Church. The lead on the White Tower was melted. 'By this time a plentiful supply of water had been obtained.'

* The writer is indebted to Major C. J. ffoulkes, B.LIT., F.S.A., Curator of the Armouries, for this reference.

"2 a.m. Some signs of abating. 'Prior to this a new cause of alarm arose in the Map Office. This was in very great danger, which was averted by the exertions of the firemen, and the very efficient assistance of the troops.'

"3rd November. Brick Tower totally destroyed.

"5th November. At 10 o'clock last night the fire was still raging in the west wing of the building.

"6th November. 'The Map Office, which occupies the north-east corner of the Quadrangle, and which has suffered very materially from the action of the fire, is now quite deserted. It had long been the wish of the Officers of the Survey Department to remove their headquarters to Southampton, and many of the presses and fittings, having been seriously injured by hasty removal on the night of the fire, the Board of Ordnance have directed that suitable apartments shall be immediately prepared for them at the above port.' The Board of Ordnance Meeting: Colonel Peel in the Chair.

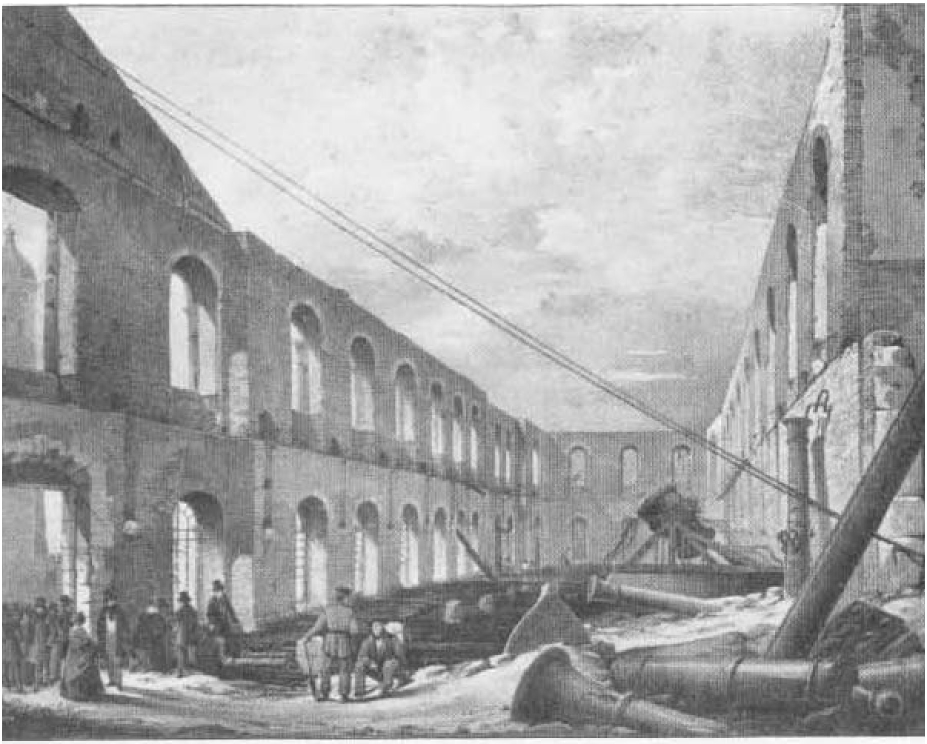
"9th November. Wet blankets were hung over the north face of the White Tower to prevent the flames cracking the stone work.'

The chief loss which the Survey suffered was the destruction of Ramsden's Zenith Sector. The standard bars were saved; the four theodolites, the 3-ft. R.S., the 3-ft. B.O., the 2-ft. by Troughton and Simms, and the 18-in. by Ramsden, were all in the field. The "long room," where Drummond's light was first tried, which occupied the upper floor of the Armoury, was, of course, destroyed.

A small point arises as to the want of water with which to fight the flames when the fire first broke out at 10.30 p.m., on the 30th October. In the Fire Officer's report it is stated that no water was supplied by the Water Company's mains, and water could only be drawn from tanks, from the moat or from the Thames. It appears, from information kindly furnished by the Hydrographer, that it was high water about 1.45, that is, about three hours after the outbreak was discovered.

"*The Annual Register*,† describing 'the Awful Conflagration at the Tower' of London, states that: A sentinel fired his musket to give the alarm, the troops turned out, the tower engines, 9 in number, started to play, or rather, to work, and engines of the Fire Brigade hurried up from all over the metropolis. Unfortunately the tide was out and the tanks under the Tower afforded but an inadequate supply of water. By 11 o'clock the destruction of the Round Tower was complete, the Armoury was involved, there were fears for the Jewel Tower and its contents, especially when it was remembered that the keys to the cases were in the possession of the Lord Chamberlain. However, they were broken into and the 'regalia, crowns, sceptres and other valuables of Royalty' were carried to the Governor's residence. 'A new cause of alarm arose in the Map Office, which contains some very valuable maps, records, etc., catching fire. That, however, was soon got under, and all the property placed in safety.'"

It was supposed that the fire originated in the armourer's forge



VIEW OF THE RUINS OF THE GRAND STOREHOUSE IN
TOWER OF LONDON.

After the Fire which broke out on 30th October, 1841.

Reproduced from a Sketch preserved in the Tower, by permissi
of the Curator of the Armouries.

TOWER OF LONDON

in the Round Tower. It would appear that all the Survey maps, stores and documents were saved, except Ramsden's Zenith Sector.

The Ordnance Survey moves to Southampton.—In the extract from the *Times*, above quoted, it is stated that "it had long been the wish of the Officers of the Survey Department to remove their headquarters to Southampton;" but this desire was certainly not the official reason for the move. In the *Minutes of Evidence taken before the Select Committee on Army and Ordnance Expenditure*, 1849, occur these passages :—†

"Major-General Charles R. Fox [Surveyor-General of the Ordnance] called in; and examined.

"Sir J. Graham: You have heard the evidence which has just been given; have you formed any opinion upon the subject of that evidence? —Yes, the Map Office, which has been lately transferred to Southampton might, I think, in the event of these rooms being vacated, be brought back to the Tower, thereby saving the constant journeys which take place to and from Southampton, and a good deal of postage.

"Do you think it would be more convenient, considering the growing importance of the surveying establishment, that it should be in the metropolis, and not at Southampton?—I am not so competent to give an answer upon that as many others might be, but I think it would be preferable.

"Mr. V. Smith: Is the Map Office now at Southampton in public premises?—It was an old barrack.

"Sir J. Graham: Why was Southampton selected?—On account of having this vacant place, I believe.

"Therefore, it was not that Southampton was the most convenient place for this particular duty, but because it was the only place where accommodation could be found at the time?—Certainly.

"In your opinion, if accommodation could be found in the metropolis, for every purpose of rapid communication and central position, it would be an advantage?—I should say decidedly so.

Major-General Charles R. Fox was perfectly right. It was not for the benefit of the national survey, nor for the good of the public, that the headquarter offices were moved to Southampton. The Ordnance Survey affords a rare example of the administration of a great survey being carried on in a provincial town. The only other case of the kind that readily comes to mind is that of Italy, which has its Istituto Geografico Militare in Florence, and not in Rome. But France, Germany, Spain, Belgium, India, the United States, and hosts of other countries, have their national surveys properly housed in the national capitals. The result of having had the administrative offices fixed at Southampton during the past eighty-four years has been to give the Survey a certain extra degree of independence, at the cost of its getting

† The writer is indebted to Mr. F. J. Hudleston, of the War Office, or this reference.

somewhat out of touch with the great offices of the Government and with the scientific and business activities of the nation. Certainly, from 1842 onwards, there comes a difference in Colby's relations with the Honourable Board; he is no longer able to go in and out in the old way, and discuss matters as they arise. No longer is he able to dine at Airy's hospitable table on Sundays, or to meet the astronomers, or engineers, or geologists, or geographers as frequently as he used to meet them in the past. But the change was not wholly for the worse. There was more room at Southampton than there ever could be in the Tower, and the various technical departments were now more free to develop. But the choice of Southampton was clearly a kind of accident, whether the Survey Officers wished to go there or not; and the ideal solution would have been to build an establishment in the outskirts of London, say at Kensington.

The history of the "old barrack" at Southampton is the following: Sometime about the end of the eighteenth century, probably, cavalry barracks were built on the ground now occupied by the Survey buildings. These barracks were, in 1816, taken over by the Duke of York's Royal Military School, then called the Royal Military Asylum. This well-known institution is a military school, founded for the training of the sons (and formerly, also, daughters) of soldiers. It was opened at Chelsea in 1803. "The Peninsula War was followed by such a great increase in the number of pupils of the School at Chelsea, that branch establishments were opened at Southampton, and one for infants at Parkhurst, Isle of Wight. . . The alterations at Southampton were commenced on the 24th June, 1816, and finished in the following year. The expense of altering a cavalry barracks to a school for children, including additions to building, and the purchase of ground, from 1816 to December 31st, 1830, amounted to £15,955 17s. 2d. The boys and girls occupied the school from 1817 to 1823, when all the boys, except the infants, were transferred to Chelsea, the girls at the latter place going to Southampton. The number of pupils at Southampton during the years 1817-1823 was 400. After the girls were transferred to Southampton their number was gradually reduced. . . . The year 1840 saw the end of our branch at Southampton."*

The open space at the foot of the Avenue, outside the Survey Office, is still known as Asylum Green, and thus perpetuates the memory of the twenty-three years of the existence of the Royal Military Asylum at Southampton. It must be repeated that the occupation of this old converted barrack school by the Survey was not due to any motives of policy, and was not approved because

* From a memorandum by Mr. Lewis C. Rudd, of the British Museum, an Old Boy of the Duke of York's School.

SIR GEORGE AIRY DCI LLD FRS 1801 - 1802

Southampton was a specially suitable place for the Survey headquarters, but came about chiefly " because it was the only place where accommodation could be found at the time."

The change of headquarters put the Survey, as has been said, a little out of touch with the scientific societies and scientific men of the metropolis. Amongst those scientific men one should specially mention Airy, who took the place that Dr. Charles Hutton filled in early years, in that he was frequently consulted by the officers of the Survey and the Board of Ordnance. Airy had so much to do with the geodesy of the operations that it seems desirable to give a brief account of his work, in so far as it affected the survey.

Airy.—Airy was born in 1801, and after holding the appointments of Lucasian Professor of Mathematics, and Plumian Professor of Astronomy, at Cambridge, was, in 1835, appointed Astronomer Royal, in succession to John Pond. His influence on the Ordnance Survey was very marked. He was always accessible to Colby and to others, like Yolland, who were concerned with the scientific aspects of the work. He remained Astronomer Royal for forty-six years, that is, until 1881; but it was chiefly in the early part of his long tenure of that appointment that his influence was felt in the Survey. Airy's *Figure of the Earth* was adopted by the Survey shortly after 1830, when it was published in the *Encyclopædia Metropolitana*. As the maps of the Survey are still plotted on this figure, and as the *Encyclopædia Metropolitana* of 1830 is not very accessible, it is, perhaps, desirable to explain how Airy arrived at his figure.

At that date it would have been possible to use 14 arcs of meridian and four longitudinal arcs. Airy rejected the latter, no doubt wisely. As to the meridional arcs, he noted that the greatest discordances occurred when observations in mountainous countries were made use of; it was, of course, well known in those days that mountainous masses attract the plumb-bob. He, therefore, rejected the arcs, such as the Arc of Peru, measured in mountainous regions, and he was left with eight arcs from which to derive his figure. These eight arcs were: two French arcs, the American arc (Mason and Dixon), the English arc from Dunnose to Burleigh Moor, two Indian arcs, Gauss's Hanoverian arc, and Struve's Russian Arc; the two longest being the French arc of 12° from Formentera to Dunkirk, and Lambton's and Everest's arc of 16° measured in India. Airy refused to adopt the method of least squares, and used only the terminal latitude of each arc; in fact, his method of calculation was arbitrary and differs widely from modern practice. The elements of Airy's figure are:—

a (semi-axis major) in international metres, 6,377,542

c the compression, or $\frac{a-b}{a}$ where b is the semi-axis minor, $\frac{1}{299.3}$

This may be compared with Hayford's Figure, which, in 1924, was recommended by the International Union of Geodesy and Geophysics. In this Figure,

$$a = 6{,}378{,}388 \text{ international metres,}$$

$$c = \frac{1}{297}$$

As compared with the most recent Figure, Airy's has, thus, a semi-axis major which is 846 metres too short, and it has somewhat too small a compression. But the effect of those differences on the maps of the British Isles is negligible: no practical or theoretical purpose would be served by recomputing the geographical positions on the map, and it is unlikely that any figure other than Airy's will ever be used for the Ordnance Survey of these Islands.

Mr. H. L. P. Jolly has shown that the adoption of Hayford's figure, in place of Airy's, would alter the latitude of Cape Wrath by about 3½ seconds, and would alter the longitude of Achill Island (off the coast of Mayo) about 5½ seconds of arc; in each case assuming Greenwich to be the origin of the computation. If the changes were made, there would be no difference in the linear accuracy of the maps, but the latitude and longitudes round the margins would be shifted slightly. It is, clearly, not worth doing.

The question may be asked, Why does the Survey require to use any figure of the earth? The answer is, that for such a small portion of the earth's surface as is covered by Great Britain, or by Ireland, a figure is not necessary for the construction of the maps themselves. The original six-inch maps of Ireland were, for instance, constructed without reference to any figure, no latitude or longitudes being marked on these sheets. The whole of Ireland could have been mapped on one meridian, and the whole of Scotland, without reference to the real shape of the earth. England, which stretches some 160 miles east and west of the central meridian of 2° W., would have required two meridians, but no accurate knowledge of the real shape of the earth would have been wanted for the large scale maps. Of course, when we come to map the British Isles as a whole, we must fix on some definite projection and have at least an approximate notion of the true shape of the earth. But the real necessity for the adoption of a figure becomes apparent when we consider that latitudes and longitudes must be shown on nautical charts of all descriptions, and that the accurate delineation of the shores of these islands on such charts is taken from the Ordnance Survey.

Airy's calculation of a figure was, then, necessary for the use of the Survey. It was by no means his only service to the Department. In the autumn of 1841 Colby consulted him as to the design of a Zenith Sector for the observation of latitudes. The instrument was to be more portable than Ramsden's, and to be of such a nature that good results could be got from the work even of a single night. "The Astronomer Royal, with his usual readiness to oblige, gave the subject his immediate attention, and accordingly proposed, and subsequently superintended, the construction of the instrument." It differed from Ramsden's instrument chiefly in the substitution of spirit levels for a plumb-line, and in the solidity yet portability of the few parts comprising it. It was used, between the years 1842 and 1850, for determining the latitudes of five stations in Ireland and of twenty-two in Great Britain.

Another matter, affecting the Survey, which occupied Airy, was the question of tides and the level of the sea. We have seen that in the early days of the work "the low water mark" was taken as the datum for heights. Whewell remarked, in 1838, that surveyors and naval men are in the habit of assuming the surface of *low water* to represent the level of the sea, whereas it is not even approximately a level surface at all. Whewell recommended *mean water*, "the means of low and high water." Mean water is not quite the same thing as mean sea level, but it is not very different. The latter is now universally recognised as the proper datum.

Airy also, in 1844, determined the longitude of the trigonometrical point Feaghmaan, that point on the Island of Valentia, off the south-west coast of Ireland, which is the westerly termination of the great European Arc of parallel along 52° north; this he did by the transport of chronometers from Greenwich. This longitude was re-determined by telegraph in 1862.

Airy was also much interested in pendulum determinations of the density of the earth. In 1826, and again in 1828, he carried out experiments at the bottom of Dolcoath mine in Cornwall; and again, in 1854, at the bottom of Harton Colliery, 1,260 feet below sea level, he swung pendulums for the same purpose.

But enough has been said to show how considerable was Airy's activity in scientific matters affecting the Ordnance Survey, and what a fortunate thing it was that, for a long series of years, he should have occupied, as it were, the position of official scientific adviser to Colby and his successors. Airy resigned his position as Astronomer Royal in 1881, being then eighty years old; he died in 1892. In the *Dictionary of National Biography* his son is quoted as summing up his father's scientific character in these words: "His nature was eminently practical, and his dislike of mere theoretical problems and investigations was proportionately great." No doubt he found in the work of the Survey just those practical applications of science which most attracted him.

A few letters from Airy to Colby have been preserved. Amongst them, perhaps the most interesting is the following, written in 1850, after Colby had retired. The latter had evidently been asking for Airy's views on education:—

"About the education of your sons, I cannot help you much in regard to treatises. I never expect very much from education; I think, perhaps, not so much as you do. Taking, for instance, the general subject of mathematics, with the view to its ulterior application to the business of science that may turn up in life, it appears to me that all that can be done is this: First, to give a perfect habitual familiarity with the machinery of mathematics, for example, with the general process of algebra and with the principal properties of circles and squares, etc. Secondly, to give what may be called a mathematical drill, to enable the mind to appreciate demonstration, and to see, in many cases, towards what conclusions the premises must lead without following them completely. But as to preparing the mind (otherwise than in this general way) for more than a very small fraction of the wants that will occur, I consider it desperate. For the second of the purposes that I mention, I think the modern school of mathematics (employing differential calculus, etc., when geometrical considerations will do as well) much inferior *in general* to the geometrical school: and so, I think, do most persons who have attended carefully to the results of academical education. Pray give Mrs. Airy's remembrances and mine to Mrs. Colby and believe me, my dear sir,

Yours truly,
G. B. AIRY.

Two more letters to Colby:—

Royal Observatory, Greenwich.

MY DEAR SIR, 1841, October 4th.

To-morrow (Tuesday) between two and three will be perfectly convenient to me. I shall, therefore, expect you, Yolland and Simms, about that time: dinner will be ready between three and four, and you then will be pleased to dine with us. This order being issued by Mrs. Airy there is no escape from it. You will notify accordingly to Yolland: I am just writing to Simms.

Yours very truly,
G. B. AIRY.

MY DEAR SIR, 1842, January 10th.

I am much concerned to find that you are laid up by illness. But as it *has* come, I hope you will indulge it well. Your life has been one of most incessant activity, and I think that Nature is giving you a hint that a little quiet, especially in a severe season, is not only comfortable, but also necessary. . . . ."

Yolland.—All who have had occasion to study the geodesy of the British Isles will remember that we owe a great deal, in this connection, to Captain William Yolland. In 1842 Yolland wrote the account of the *Astronomical Observations* made with Ramsden's Zenith Sector; this account discusses the latitudes of 10 stations, determined with Ramsden's instrument, between the years 1802 and 1818, with the addition of some observations at Greenwich in 1836. In 1847 he published an admirable work on the *Measure-*

ment of the Lough Foyle Base, a measurement which had been carried out some twenty years earlier. And in 1852 he published a bulky and elaborate report upon the *Astronomical Observations* made with Airy's Zenith Sector, at 27 stations, during the years 1842 to 1850. These three works are the standard authorities on the observations with which they deal, and are written in an admirably scientific spirit.

The writer of these books, so important in the scientific history of the Survey, was born in 1810, was commissioned as a Second-Lieutenant in the Royal Engineers in 1828, and became a Second Captain in 1843. He was posted to the Ordnance Survey in 1838, about the time that Colby left Ireland, and when the question of the six-inch Survey of Scotland was being settled. Yolland was greatly trusted by Colby, who, in 1842, placed him in charge of the operations at the headquarter offices at Southampton. Late in 1846, Colby, having made up his mind to retire, recommended Yolland as his successor. But Colby had reckoned without the Board of Ordnance; and, indeed, it does not appear that he had taken any adequate steps to pave the way and to secure the concurrence of the Board. The removal of the headquarters of the Survey from the Tower to Southampton had put Colby a little out of touch with the authorities in London, and Burgoyne's appointment as Inspector-General of Fortifications seems to have had the effect of still further hindering Colby's approach to the Master-General. Things were very different from what they had been in the twenties in that respect. However that may be, Yolland was not the senior of those serving under Colby; there were two captains senior to him, and from a military point of view it is difficult to see how the appointment could have been made. Colby had not taken early measures to ensure his being succeeded by an officer of sufficient competence and seniority. In making the recommendation he writes Sir John Burgoyne that,

"An objection may arise to the appointment of so young an officer as Captain Yolland; the continuance of peace has made promotion slow, but he is about the same age (37 years), and has about the same length of service (19 years), which I had, when I succeeded the late Major-General Mudge in charge of the Survey in 1820: and I have upwards of eight years' personal observation of his close attention to the various duties, and of the results of his management, to warrant me in proposing his name."

Apart from seniority, and assuming that Portlock was not available, Yolland was without doubt the right man. In a letter to him, dated 19th March, 1847, from Douglas Galton, there occurs this passage:—

"The high and deserved praise of the present state of the Survey makes me the more regret that the new Superintendent has been appointed. I was talking about it to Harness the other day. He says

Matson asked him his opinión as to who should succeed Colby, and he says that it never occurred to him that any one except yourself could be named to it, that everyone who knew anything about the Survey knew that all improvements of late years had been introduced at your suggestion, and that although it is quite fair that General Colby should have praise due to those improvements, because he placed you in that situation, yet it is not fair that on his retirement a fresh person knowing nothing of the subject should be brought in to gain credit from your brains."

However, Sir John Burgoyne either would not, or could not, overcome the difficulty of Yolland's want of seniority, and a complete outsider was appointed. Yolland remained on the Survey for seven years more; but there was inevitable friction with his new chief, and in 1852 he was transferred from Southampton to the Irish Survey. In 1854 he left the Survey for good—but not for the good of the Survey—and was appointed an Inspector of Railways under the Board of Trade. In 1856 he was a member of the Commission appointed to consider the training of cadets for the scientific corps of the army. In 1859 he was elected a Fellow of the Royal Society. In 1877 he became the Chief Inspector of Railways, a post which he retained until his death in 1885.

Yolland was an able and popular officer. The testimony of men like Galton, Harness and Colby, and the good opinion held of him by Airy, are conclusive as to his ability; and as to his popularity, it is to be noted that, when he left Southampton for Ireland, in November, 1852, the Mayor and Corporation presented him with an address in acknowledgment of the interest which he had taken in the welfare of the town.*

Colby's Successor.—Sir John Burgoyne, apparently on his own initiative, and in spite of Colby's strong protest, recommended to the Board of Ordnance that Colby should be succeeded by Lieut.-Colonel L. A. Hall, R.E., and this officer became Superintendent of the Ordnance Survey, as the title then was, in April, 1847. Lt.-Col. Hall had had no previous acquaintance with survey matters. In a letter dated 16th March, 1847, Colby remarks that the official documents on the case "will show most distinctly that neither Sir John Burgoyne nor Lord Anglesey have any notion that the charge of a great national survey requires any experience of the nature of such a duty."

No doubt Hall had some good qualities which made him acceptable to the Board. His appointment was, however, something like a confession of failure on the part of the authorities, for it was known to all that he would have to rely upon Yolland. And for five-and-a-half years he did rely upon Yolland, who, in difficult circumstances, maintained the reputation of the Department, under

* *Dictionary of National Biography. Art. Yolland.*

a chief who was a mere administrator. It was Yolland, for instance, whose evidence was sought by commissions and parliamentary committees. The experiment was not a very happy one, and was drastically terminated by the Board after a few years' trial.

Colby was furious at Hall's appointment, and by letter and in personal interviews expressed himself with much freedom to the authorities in London. But Hall remained Superintendent until a year or two after Colby's death. It is, perhaps, significant that Colby having died in October, 1852, Hall sent Yolland to Ireland the *month after*; no doubt the strain had become rather more than either could bear. The Survey was then left without anyone at headquarters who understood the trigonometrical or astronomical work, until young Clarke joined in 1854. This appointment of Clarke is, by the way, very much to Hall's credit, and the scientific tradition was maintained, with the slight break mentioned, until 1881.

Some Miscellaneous Letters.—From Charles Macintosh to Colby:—

Red Bull Wharf, Upper Thames St.,
15th February, 1826.

"I now send you a specimen of muslin; as I believe, in all respects properly water proofed; and capable of resisting any test. I fear the colour is too dark for doing maps upon; but think, with care, that evil may also be remedied. . . ."

From Sir George Everest, shortly to be Surveyor-General of India, to Colby:—

Oriental Club, Hanover Square,
27th June, 1829.

"I am induced by the kindness of your offer when I last had the pleasure of seeing you to take a journey to Ireland this summer to witness the working of the machinery of your beautiful system in the field. I am too late, I fear, for anything connected with the base line measurement, but there will still be a great deal to interest me, I feel persuaded. . ."

From the same, dated November 23rd, 1829, describing two sections of the Indian arc, and ending:—

"Now I want your similar data to compare with. Give me all you have and all my data are at your service. . . P.S. The Court of Directors have made me Surveyor-General of India—tell this to Robert Boyd."

From the Secretary to the Birmingham and London Rail Road Company to the Board of Ordnance, 69, Cornhill, 23rd May, 1831:—

"The Company formed for the purpose of establishing a railroad communication between London and Birmingham, to which I am Secretary, have derived so much benefit from the published Ordnance Surveys in the course of the examination which they are making of the intermediate country, that I am anxious to obtain for our Surveyors the additional advantage of access to the documents which are not before the public."

From Henry Raper, author of the celebrated treatise on *The Practice of Navigation*, to Colby, 12, Milton Street, Dorset Square, April 29th, 1839:—

"MY DEAR SIR,

"I take the liberty of enclosing you a prospectus or two of a work which is now printing, and on which I think I have mentioned to you I have been for some time employed.

"The prospectus contains an account of the first volume, which I call *practice*, in order that the public may not feel themselves obliged to buy two volumes when one contains all that they want. I need not trouble you with further remarks on the first volume or part, than to observe that I have omitted Surveying altogether as not belonging to the place of the spectator on the surface of the earth; besides which, it is trifling both with the reader and the subject to pretend that surveying is to be learnt in three pages and a half. . . .

"I would not have occupied your time with these details, but that as your opinion will be of great consequence to the character of my work, I am anxious that you should be prepared to expect not merely a *technical* but an *educational* object in the composition; for I cannot but think that the only way to promote precision and clearness of ideas in our merely practical men is to place before them the matters they have to deal with, already digested with every attention to unity and purity of design, and the utmost distinctness of arrangement, and further, that this precision of ideas is more likely to become, insensibly, a habit, than to be inculcated by any precepts.

"The plan that I have adhered to involves the principle that practice should come *before* theory, as it appears to me rather inconsequent that a man should learn theory first—for the word theory implies specific knowledge of an end or fact which theory is to explain. In fact, if for 'stargazing' you read 'walking' the absurdity of saying 'study the doctrine of equilibrium in order to be able to walk,' becomes absurd enough. . . . Believe me,

My dear Sir,

Yours very sincerely,

H. RAPER.

Raper's *Practice of Navigation* was published in 1840, and he was awarded a gold medal by the Royal Geographical Society for this work. The projected second volume on "Theory" was never published.

From Colby to Captain Henry James (afterwards Director of the Ordnance Survey), 7th May, 1845:—

"When I undertook to direct the Survey of Ireland I considered that it was the first essential measure for the pacification and improvement of the country, and I gave very strict orders to prevent any political or sectarian interference in the survey duty. The selection of the persons to be employed was solely guided by their supposed fitness for the work they were to do, and their advancement or removal depended upon their fitness or unfitness for their work, as proven by trial. I never allowed any enquiry as to their religious creeds, or for whom or against whom they had voted at any election. But I certainly did prohibit those employed from attending political meetings, to prevent, as far as my influence would go, any party politics from continuing to disturb the peace of the country. I believe that these instructions are pretty generally known in Ireland, and I have not been aware that Captain Larcom has deviated from them. . ."

The following remarks, which are in Colby's handwriting, seem to be part of the draft of a farewell order :—

. . . "After the decease of my much esteemed predecessor, the late Major-General Mudge, the Duke of Wellington did me the honour of placing the Ordnance Survey under my direction.

"And when the House of Commons ordered a Survey of Ireland on a scale of six inches to one mile, as the basis for a new valuation of the land in that country, His Grace also confided to me the direction of that Survey. The entire Survey of a large country, with the *minutiæ* of detail and accuracy required for a valuation of land, had no precedent of any similar work to guide its arrangements. I, therefore, devised new methods which I proposed for His Grace's sanction. I had learned from Major-General Sir Charles Pasley, the skill and intelligence which the Royal Sappers and Miners evinced in the acquirement of his course of instruction. And I proposed a military system with officers of Royal Engineers, soldiers of Royal Sappers and Miners, and assistants. From His Grace the Duke of Wellington, his Secretary, the Lord FitzRoy Somerset, and Viscount Hardinge, then Clerk of the Ordnance, I obtained every requisite authority and much valuable aid. It is, therefore, highly gratifying to my feelings to have an opportunity of expressing my gratitude for their early aid in enabling me to produce the present prosperous state of the Survey."

Let us, then, glance at the state of the Survey during Colby's last year of office.

The State of the Survey in 1846.—In 1846 the Survey was almost exactly one thousand strong, including all officials, both in Great Britain and in Ireland. The strength of the Survey of Ireland had come down with a run after 1840, when there were nearly 2,000 men employed in that country. The reason for this was that the original six-inch survey was approaching completion; the field work was finished in 1844 and all the maps were engraved by 1846. Only a small staff of about 250 men was left, after that year, to carry on the revision.

The original six-inch Survey of Ireland had taken rather more than 20 years to execute, and had cost about £800,000.

It should be noted that, in 1851, Captain William Yolland gave evidence before the Select Committee on the Ordnance Survey of Scotland, that the six-inch survey of that country "could be done in 15 years at a cost of about £750,000," including the contouring.

In January, 1846, there were 735 persons employed upon the Ordnance Survey in Great Britain and 132 of this total were stationed at Southampton. The offices of the detail survey were at Dumfries, Liverpool, Preston, Wakefield and York. The main work was the original six-inch survey; this was published in "full" sheets, each 36 inches from east to west, and 24 inches from north to south. The sheets were engraved on copper. Work was going on chiefly in Kirkcudbrightshire, Lancashire and Yorkshire.

There was that innovation, a contouring department, thirty-five strong, and this was occupied in contouring Lancashire. Great attention was paid to the correct delineation of county and other administrative boundaries.

There were also the "5 Feet" plans in hand, that is, plans on a scale of 1:1056; and a few one-inch sheets were being engraved. But the main energies of the Survey were directed to the revision of the six-inch map of Ireland, and the execution of the original six-inch maps of Scotland and of the northern counties of England.

Colonel William Yolland gave evidence before the Registration and Conveyancing Commission to the following effect: "The orders under which the Survey proceeds at present contemplate the completion of the six northern counties of England and the whole of Scotland on the six-inch scale, with maps of the towns on the 60-inch scale, this part of the country not having been previously surveyed." . . . "When I say 'towns,' I mean towns having a population exceeding 4,000 inhabitants."

In studying the reports and returns of these years, one gets the impression of a carefully organized department, carrying out its duties methodically, by means of a well-considered system of division of labour, controlled by an efficient headquarter office. In fact, Colby's large-scale map-making machine was working well.

The End of the First Hundred Years.—Colby's machine was working well, and in that state we will take leave of it, when, in March, 1847, he retired from the Army and the Survey. The machine was working so well that it underwent but little change for a generation, or more, to come. We have attempted to trace, for the first hundred years, the growth of this survey, the finest of all national surveys in its completeness and usefulness. And we will end with the picture of old Roy, in his house in Argyll Street, urging in his last paper, written just before he died in July, 1790, that the trigonometrical operation so successfully begun should be extended over the whole country; and, as we may suppose, casting his thoughts back to his share in those early explorations of the Highlands, which were to lead at last, though not in his lifetime, to the creation of the Ordnance Survey.

SOME NOTES ON FRENCH ARMY TRAINING.

By LIEUTENANT H. B. HARRISON, R.E.

WHILE most officers will be fairly familiar with the salient features of the French Army training, yet it is probable that the details of the life and training in peace time of the officers, N.C.O.'s and men are not quite so well known.

The following few brief notes may be of general interest. They were collected during a two months' attachment to a French infantry battalion, followed by one month with a sapper regiment. The battalion in question was the 6e bataillon (Alpin) de Chasseurs à Pied, stationed at Grenoble, while the sapper regiment, also at Grenoble, was the 4e Regiment du Génie, a regiment of sappers and miners.

The Chasseurs à Pied may be said to be the élite of the French infantry and are organised in 31 battalions spread out along the N.E. and E. frontiers, which they hold in an emergency pending the mobilization of the field armies. Those battalions stationed opposite the Italian frontier at such places as Grenoble, Barcelonette, and Nice, are called " alpin," for obvious reasons, and enlist a very hardy type of hillman not unlike the Gurkha in build.

The following notes on the Officers cover generally all branches of the Army :—

OFFICERS.

With national service there are, of course, two distinct types :— 1, Regular (*officier actif*), 2, Reserve (*officier de réserve*).

1. *The Regular Officer*.—A regular commission can be obtained in three ways :—

(*a*) By direct entry into the Army through either St. Cyr or l'Ecole Polytechnique. In each case there is a competitive examination followed by a residence of two years. The two schools correspond approximately to our Sandhurst and Woolwich respectively, although l'Ecole Polytechnique is not essentially a military establishment, a large number of the students, on passing out, entering civil life as engineers.

(*b*) Through the ranks. A young man wishing for a commission by this means writes to the nearest *Bureau de Recruitement* to be enlisted in the regiment of his choice. He is sent to that regiment as a private, and on arrival is put into a special platoon kept for the purpose in every regiment. After four months, with good conduct, he is made a "caporal," which is a stage between private and N.C.O., and now enters the special platoon for budding N.C.O.'s. After a further five months, with good conduct, he becomes a sergeant and is now an N.C.O. Having served two years as a sergeant, he can take a competitive examination for entrance into whichever of the following schools he may choose:—

St. Maixent, for infantry and tanks.
Fontainebleau, for artillery.
Vincennes, for administrative services.
Versailles, for engineers.

He does a year at one of these schools and, after a passing-out examination, leaves as a 2nd lieutenant, becoming a lieutenant after two years' service.

(*c*) Only a few officers receive their commission by the third means, which is direct promotion from the rank of "adjutant" to that of 2nd lieutenant, after at least 15 years' service. The "adjutant" corresponds approximately to our warrant officer, and there is one per infantry company.

There are no promotion examinations for French officers corresponding to those we have in England.

To pass from the rank of lieutenant to captain and to each successive grade up to General, every officer has to attend for a three months' course at a special school at Versailles. An officer attends when nominated to do so by the French War Office, which is guided by the length of service and by the biennial confidential reports of each officer.

Thus, although the normal service for a captaincy is about 12 years, by being specially recommended by his Commanding Officer for accelerated promotion, it is quite common for a lieutenant to attend his three months' course at Versailles after, say, seven or eight years' service. The same applies from captain to major and so on.

2. *The Reserve Officer.*—He does the usual 18 months' compulsory service at the age of 20.

This service is divided up into three periods of six months each.

1. Preliminary period of six months.
2. Six months at St. Maixent or St. Cyr.
3. Six months with a regiment.

There are two alternative methods of carrying out the preliminary period :—

(*a*) If at a university he can undergo what is called a "préparation militaire supérieure," which consists in attending lectures on military subjects given by officers specially told off for the purpose, and in carrying out certain military exercises.

(*b*) Those who do not undergo the "préparation militaire supérieure" must enlist for six months, when they are put in a special platoon, one of which is kept for this purpose in each "corps d'armée."

In either case, (*a*) or (*b*), the would-be officer has to pass an examination at the end of six months in order to enter either St. Maixent or St. Cyr.

Students for certain professions, such as doctors, lawyers, etc., are permitted, on application, to do their 18 months' service several years after they reach the age of 20, so as to prevent their studies being interrupted at a critical period.

Having completed his compulsory service and been liberated, the reserve officer returns to civil life and comes up again for so many weeks' training every other year according to the existing regulations. He does this training when he chooses, but not necessarily in the same unit as the one in which he did his original service, although he naturally keeps to the same branch.

There is no system of officers' messes in France, and consequently no accommodation for single officers in barracks. All the unmarried officers of a battalion, etc., live in lodgings in the town and foregather for the two meals of the day, at noon and in the evening, in one of the local restaurants, where they arrange to pay by the month. Naturally there is no mess kit for the evening meal, mufti or service dress being worn.

There being no messes, the system of calling is different from what it is in England. An unmarried officer arriving in a station calls only on his own commanding officer—as I discovered after an attempt to call on the gunners in the garrison, when I spent a considerable time at their barracks in a fruitless attempt to explain the reason for my visit.

Most garrison towns have a "cercle militaire," or officers' club, consisting of a restaurant, reading room, library, etc.; and where, during the winter, weekly or fortnightly dances are held, the officers of the garrison bringing their partners.

Riding, fencing, bridge playing in the cafés, dancing in the local casino or its equivalent, and the theatre or opera if there happens to be one in the station, constitute the main relaxations for the average officer.

INFANTRY TRAINING.

The recruits come up for their 18 months' service at the age of 20, joining the battalion to which they have been posted in the middle of November.

The Chasseurs enlist men suitable for the arduous hill work of the frontier, men who have usually been born and brought up in the hills. The principle worked upon is to send a man whose home is, say, in the south, to do his service in the north, and vice versa, a man thus becoming familiar with as large a stretch of the frontier as possible. For example, a native of Nice will be sent to a Chasseur battalion at, say, Grenoble or Albertville. Thus, in the 6e *bataillon* there were a number of Alsatians.

Composition of a Battalion :—

- *Bataillon* (*Commandant*)
  - *Compagnie* (*Capitaine*)
  - *Compagnie*
    - *Section* (*lieutenant*)
    - *Section*
      - *Groupe* (*sous-officier*)
      - *Groupe*
        - *Equipe grenadier* (*caporal*)
        - *Equipe fusil-mitrailleur*
      - *Groupe*
    - *Section*
    - *Section*
  - *Compagnie*
  - *Compagnie Mitrailleuse*
    - 4 sections each of 4 machine-guns.

Each battalion possesses one small gun (*canon de* 37) and one Stokes mortar.

Such importance is attached during the recruit's training to the "Groupe," which is the miniature fighting unit in the company, that it is worth while studying a detail of its composition.

Composition of a "Groupe."

Composition.		Arm.
1 N.C.O. commanding the *Groupe*		Rifle
1 *équipe* of Light Machine-Gunners	1 "*caporal*" cmdg. *équipe*	Carbine
	1 Firer	M.G. and revolver
	1 Assistant	Revolver
	3 Spare men	Carbines
1 *équipe* of Bombers	1 "*caporal*" cmdg. *équipe*	Rifle
	1 Bomb-thrower	Carbine and revolver
	1 Rifle Bomber	Rifle
	3 Riflemen	Rifle

The training of the recruits, from the date of their joining-up, is on the following lines:—

(1) All the recruits are incorporated in the three ordinary companies and armed with the rifle. They receive individual instruction in the use of the rifle, close order infantry drill and preliminary musketry. Those men who possess a sufficient knowledge of the rifle at the time of their joining up begin firing a course at once, and the rest as soon after as possible.

(2) At the end of the first month, guided by the recommendations of the Company Commanders, the battalion commander details the men, who have been considered suitable, for the Machine Gun Company and for the Gun and Stokes mortar. These men begin a special training accordingly.

At the same time, each Company Commander picks out the men who look like making good N.C.O.'s and these are all collected together in a special platoon—one platoon per battalion—and begin a special training. The embryonic N.C.O.'s are called "élèves-caporaux" and at the end of four months they become, with good conduct, "caporaux," and after a further five months in another special platoon, they are eventually made N.C.O.'s with the rank of sergeant.

(3) During the third month each man is given a definite rôle in his "groupe," and section and company drill is carried out.

4) At the end of the fourth month the recruits are considered ready to take the field if required to do so.

(5) From the beginning of the fifth month onwards the battalion carries out exercises as a unit and prepares itself for the annual manœuvres.

The command is exercised as follows :—

The Battalion Commander gets out a programme for the whole year and receives the recruits at the beginning of the fifth month trained ready for battalion exercises. During the first four months he hands the recruits over to the

Company Commanders, who get out a detailed programme for the four months and receive the recruits at the beginning of the fourth month ready trained for company drill. During the first three months he hands the men over to the

Subalterns, who are responsible that the recruits get a complete knowledge of *groupe* and *section* drill according to the programme of the company commander. They usually content themselves with supervision and hand on the executive work to the

N.C.O.'s, who carry out the actual training of the recruits for the first three months or so.

The following are the main items in the training of the soldier :—

1. The raising of his "moral."
2. Physical training.
3. Musketry, bombing and machine-gunnery.
4. Infantry Drill.
5. Knowledge and use of ground: use of tools and the gas-mask.
6. Recreation.
7. Signalling and specialist work generally.
8. Field exercises and manœuvres.

One of the chief points aimed at is that every soldier should be able to assume any rôle whatsoever, at a moment's notice, in the "groupe." This entails for each man an intimate knowledge of the light machine-gun, the bomb, the rifle-grenade, the rifle and the carbine, and the revolver.

INSTRUCTION OF OFFICERS.

The colonel of a regiment is responsible for the instruction of the officers under him. This instruction comprises :—

1. General instruction.
2. Professional instruction.

1. General instruction aims at ensuring the officer's prestige in the eyes of the N.C.O.'s and men. The following methods are employed :—

(*a*) The institution of regimental libraries.
(*b*) Periodical conferences for regimental officers.
(*c*) Conferences for officers of the garrison.
(*d*) The grouping together of officers for common study and for carrying out definite exercises.

2. Professional instruction consists in :—
(*a*) Complete knowledge of Infantry Regulations (including M.G.'s and Tanks): a working knowledge of other arms, especially Artillery and Air Force.
(*b*) Intimate acquaintance with the manipulation of all weapons used by the Infantry.
(*c*) Ability to command their own and higher units.
(*d*) Perfect knowledge of the neighbouring country by means of reconnaissances, map-reading, etc.

The professional instruction of officers is supervised closely by the Battalion Commander, who assembles his officers periodically, issues programmes of studies, and checks progress made. He reports confidentially, once a year at least, on each officer to the Regimental Commander.

Finally, all officers of dismounted units attend compulsory riding classes twice a week during six months of the year. These classes are held at the riding school of one of the cavalry or artillery units in the garrison.

Sapper Training.

One does not, perhaps, fully realise the difficulties the French have to contend with in training their sappers.

With a service of only 18 months, a raw recruit has to be turned out an efficient fighting-man as well as a technically trained engineer. Moreover, although the compulsory service is theoretically 18 months, yet, what with numerous exemptions on compassionate grounds, sickness, and special duties, the average recruit is lucky if he gets a full year's training.

The following shows briefly how the French sappers are organised on a war footing :—

(1) *Divisional Sappers.*
(*a*) A Commanding Officer (Lieut.-Colonel) and Staff.
(*b*) One Battalion of two Sapper and Miner Companies.
(*c*) One Park Company.

In addition a battalion of territorial Pioneers is nearly always available.

(2) *Corps Sappers.*
(*a*) A Commanding Officer (General or Colonel) and Staff.
(*b*) One Battalion of two Sapper and Miner Companies.
(*c*) One Bridging Company.

(3) *Army Sappers.*

(*a*) A Commanding Officer (General) and Staff.

(*b*) A variable number of Sapper and Miner Companies, either regular or territorial.
Light Bridging Companies.
Heavy Bridging Companies.
Mining Companies.

(*c*) An Officer in command of Works, commanding the following:—
Road Companies.
Forest Companies.
I.W.T. Companies.
Companies of Electricians.
Camp Construction Companies.
Park Companies.

(4) *Organization of a Sapper and Miner Company.*

The Sapper and Miner Company constitutes the tactical unit. It deals with all works (including bridging), which do not require too great a specialised knowledge. It is the unit that finds itself most commonly in contact with the Infantry.

(*a*) Personnel—
5 Officers, including one Captain in Command.
24 N.C.O.'s.
251 Sappers.
33 Horses.
13 Vehicles.

The company is divided into one headquarters section and four sections of equal strength, and possesses a first and second line train.

(*b*) Equipment—The sappers are all armed with the carbine.

(*c*) First line tools:—
52 Picks. 52 Shovels. 32 Axes. 10 Bill-hooks. 8 Wire-cutters, etc.

The first line tools are similar to the tools kept in the Park, but are of a lighter pattern, to render them more portable.

(*d*) First line train comprises six vehicles, namely:—
4 Tool carts (one per section). 1 Bridging Waggon. 1 Explosives Waggon.

(*e*) The company park is its own particular property and serves nobody else but the company. The divisional park, on the contrary, keeps the troops of all arms supplied with tools.

The peace-time organisation of the French Sappers is somewhat different from the foregoing.

In peace it is the regiment that is the standard unit, for the following reasons:—

(*a*) To concentrate command.

(*b*) To concentrate instructional equipment, workshops, and fieldworks ground, so as to economize as much as possible.

(*c*) To centralise and reduce administrative staffs.

Thus the regiment consists of several battalions, each of a varying number of companies. The company is divided into sections and the sections into squads. The strength of a squad varies usually from 12 to 16 men, commanded by an N.C.O.

Instruction of the Sapper and Miner Recruit.

On joining their regiment the recruits are posted to companies. The instruction is divided into two periods:—

(1) First period of six months, at the end of which the recruit must:—

(*a*) Understand his duties as a soldier.

(*b*) Be familiar with the use of the weapons, gas masks, tools, and implements which he may be called upon to use in the field.

(*c*) Be able to march 15 miles in field service equipment.

(*d*) Be perfectly familiar with squad and section drill.

(*e*) Have carried out certain technical exercises.

During this period the instruction is carried on in such a way that the soldier may be ready to take the field, if necessary, at the end of four months.

The "élèves-caporaux" as in the infantry, are picked out and receive a special training.

The training of the recruit is divided into two parts, Theoretical and Practical.

During this first period the proportion is as follows:—

Practical $\frac{1}{3}$ of the first month's programme.
$\frac{1}{2}$ of the second month's programme.
$\frac{3}{4}$ of the third and fourth months' programme.
Whole of the fifth and sixth months' programme.

(2) The second period, lasting until the soldiers are liberated, consists of:—

(*a*) Instruction of N.C.O.'s class.

(*b*) Completing the technical and military training of the recruit.

(*c*) Carrying out technical and military exercises in the field.

(*d*) Annual manœuvres.

This period is essentially mostly practical instruction.

The practical programme for the whole of the recruits' training is allotted as follows:—

(a) Fieldworks—$\frac{1}{8}$ total programme.
(b) Mining and Demolition—$\frac{1}{4}$ total programme.
(c) Light Bridging—$\frac{1}{4}$ total programme.
(d) Pontooning—$\frac{1}{4}$ total programme.
(e) Roads and Communications—$\frac{1}{8}$ total programme.

Specialists and Artificers.

The general instruction given to all recruits does not allow for the training of the specialists and artificers essential to a Sapper and Miner field company. These are trained separately at central training centres, which are drawn on as required by the field units.

Thus each battalion or regiment picks out likely men and sends them to—

Versailles, to be trained as mechanics;
Bourges, to be trained as trade artificers;

and so on, where the men receive special instruction.

Games.

Sport has developed considerably in the French Army since the war. In addition to daily P.T., the men play rugger, soccer or basket-ball two or three times a week. Each battalion, regiment, etc., has its rugger and soccer teams, and garrison tournaments are held regularly.

For hill-work in winter, units stationed along the east frontier are provided with skis for a definite proportion of their total strength, and, when the snow is suitable, ski-ing is a favourite pastime amongst both officers and men.

Rugger and soccer, especially the former, have also made great strides among the civilian population, and every town of any importance has its representative team.

That the Frenchman wishes to introduce the correct spirit into his games is shewn by the following notice that one sees frequently pasted up at football grounds:—

Au Public.

"Le vrai sportif est toujours maître de ses nerfs, se réjouit dans la victoire, accepte loyalement la défaite.

L'arbitre n'étant qu'un homme peut ne pas tout voir, peut même se tromper.

Les arbitres n'étant pas payés sont droits au plus grand respect.

Injurier un arbitre ou un joueur n'est pas digne du vrai sportif."

NOTES ON MILITARY RAILWAYS.

By MAJOR E. ST. G. KIRKE, D.S.O.

R.E. OFFICERS are sometimes called upon to construct or maintain military railways at short notice, and it is not always possible readily to obtain the necessary information. In such cases the following notes based on the construction of several hundred miles in different parts of the world may be of some small value.

Military railways differ from those built for civil purposes in that if they are wanted at all they are wanted in a great hurry. A certain amount of experience of railway construction under active service conditions is necessary to decide in what respects civilian railway practice can be ignored, without the safety of the troops being endangered.

ALIGNMENT.

The shortest distance between two points is known to be a straight line, and the location of a railway would present no difficulties if this could always be followed. But hills, valleys, rivers, woods, towns, etc., conspire to make this impossible in practice, and the military engineer has to weigh up all the factors and get his line in as quickly as he can, provided that it is up to a standard which will fulfil the purpose for which it is laid.

An eye for country is essential, particularly when the latter is unsurveyed, and a quick decision must be made as to whether time can be saved by a longer alignment with easier curves or gradients, or by a straighter line which involves heavier earthwork with possibly sharper curves and steeper gradients. All the time he must keep in mind the capacity of the engines and rolling stock which are to work the traffic, and the quantity and quality of the labour which is likely to be available.

It will seldom be possible to make plans of a military railway before construction begins, and, in fact, construction parties will usually press hard on the heels of the survey. For the latter the most essential instrument is a level, with a clinometer to give a rough idea of slopes. As regards direction, a straight line can be laid out with field glasses and ranging rods to an accuracy of about a foot per mile, and curves can be set out by offsets as will be described later.

EARTHWORK.

Assuming that the alignment has been satisfactorily settled, the "formation" can be got on with. It goes without saying that the lower the banks and shallower the cuttings, the quicker will the line be made. In flat country, not liable to floods, the permanent way can even be laid upon the ground, with only such packing or ballasting as will eliminate inequalities of the surface (Fig. 1.)

The method of forming the bank or cutting will depend upon the kind of labour available and the nature of the soil. When there are rocks about, cuttings should be avoided, as blasting will probably be entailed, which interferes with the neighbouring working parties. Boulders up to three feet in diameter can sometimes be split by heating them and pouring over water, if other means of removal fail.

In average soil horse-drawn scoops are very useful for shifting earth, but pick and shovel, or Indian "pharwas" will be the tools most generally used. When the bank is not more than two or three feet high, earth can be dug at each side of the line and thrown into position. With European labour wheelbarrows or tip-waggons on 2-ft. track would be used for higher banks; baskets or donkeys when the labour is African or Oriental. (In this connection it may be mentioned that metal bowls are better than the ordinary Indian wicker basket, as they last much longer, and are available when not in use for the storage of water in camp.) While earthwork is going on, it should be the business of some named person to see that the centre line is properly maintained, or it is certain to get a foot or more out of place.

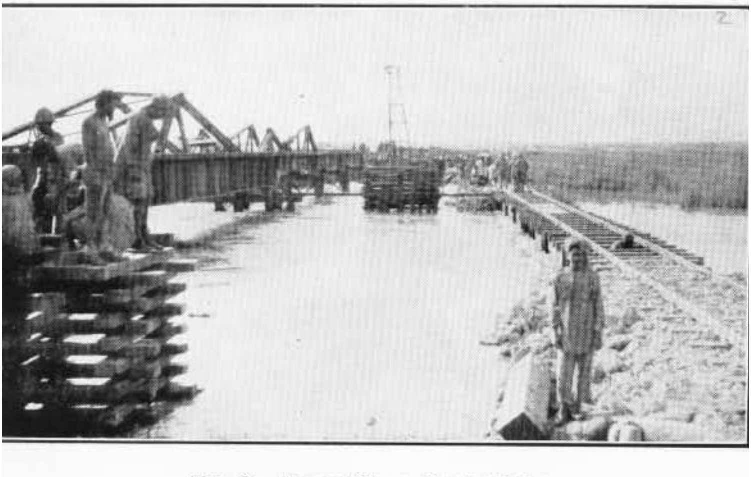
BRIDGES.

These are probably the most interesting feature of railway construction, and sometimes the cause of much "heavy weather." From the military point of view, they are vulnerable; generally need guarding; and should, therefore, be reduced to a minimum in number. When possible culverts should take the form of pipes, whether of concrete, galvanised steel, or wooden boxes, covered over with earth. In this form they are difficult to see, and practically invulnerable from the air.

If the bridge is so situated that a guard has to be provided, time may often be saved by extending it at each end, so as to reduce earthwork. Under ordinary conditions of work a viaduct is quicker to build than an embankment of about eight feet in height.

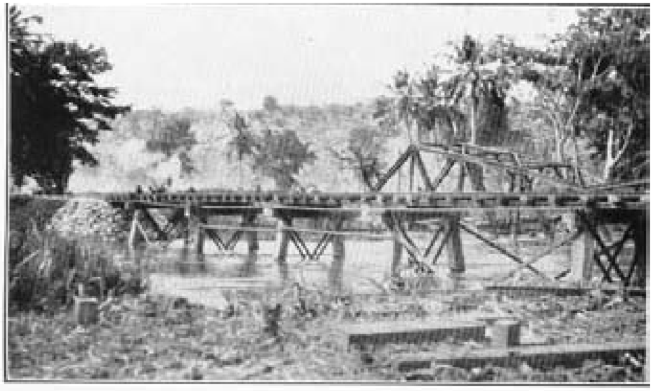
Military bridges, like others, involve consideration of foundations, piers, and superstructure. The simplest form of bridge is when girders can rest on a timber raft on each bank, well above the water-

No. 1. Starting Voi-Kahi-Moschi Railway from Voi.



No. 2. Ruvu River, East Africa.

Railway and River



No. 4. Temporary trestle Bridge built by Indian Sappers across Pagani River, East Africa.

No. 6. Showing engine, tender and trucks heaped up on destroyed bridge.

BRIDGING

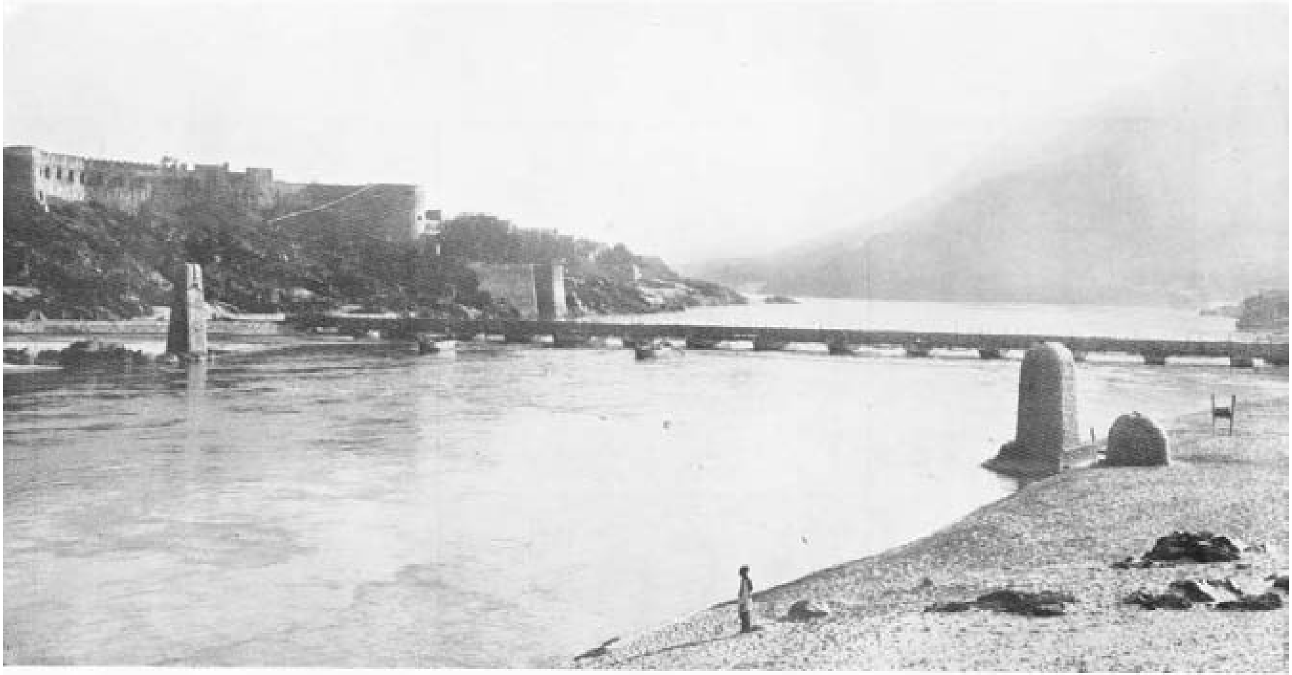


Photo 4. Bridge complete.

BRIDGING

way. When more than one span is required, over swift flowing rivers or those liable to sudden and violent floods, the only safe form of foundation is piling. Fig. 2 shows on the right a low-level bridge, of two forty-feet spans, successfully resisting a flood which has risen nearly half way up the girders, and nearly 20-ft. from the bed of the river. The central pier was made of four 12-in. by 12-in. piles, with crossbracing of sleepers. (The girders for the high level bridge on the left were pulled laterally along greased rails straight from the trucks, which brought them into their proper positions.) These piles, as well as others on similar work, were driven by a one-ton drop-monkey, hoisted by hand.

At the time of writing a satisfactory form of pile driver for use in the field has yet to be found, other than those operated by hand. The trouble with most of the excellent commercial types is that they are too heavy for military purposes, or else work by steam. In the tropics it is often extremely hard to get enough water for one's men, and, at best, a steam pile driver at work is visible from the air for miles. Petrol engines can be used for winding up the dropping type of monkey, but a double-acting hammer wants more free air than the ordinary light petrol-driven compressor can supply. The solution may be found in a battery of compressors feeding one air-reservoir.

No drop-monkey under a ton is satisfactory for railway work and the bearing value of the pile can be found from Trautwine's formula, which gives the load at which the pile is at the point of sinking, and which must, therefore, be halved in practice:

$$\text{Load} = \frac{\sqrt[3]{\text{fall in feet}} \times \text{wt. of monkey (lbs.)} \times .023}{\text{Last sink (inches)} + 1}$$

It is not so easy to find a formula for the double-acting type of hammer, but no doubt empirical ones will eventually be evolved.

If the pile is driven to a standstill, its bearing power may be calculated as for an ordinary strut.

Piles need not be pointed nor steel-shod as a general rule. It sounds paradoxical, but it is a fact that they generally drive as easily, and more truly, if the business end is sawn off perfectly square. The reasons for this are two-fold. First, it is easier to saw a square end than to saw four inclined faces absolutely true, and secondly, it seems probable that the square end forms in front of it, from rammed earth or gravel, an artificial point of the theoretically correct shape. It is not suggested that the above holds good in all conceivable cases; but it is so likely to do so, that it should certainly always be tried, as a great deal of carpenters' time is saved if it comes off.

When rivers are not liable to sudden floods, and their current is not too strong, trestle piers can be used, or piers made of timber cribs weighted with stones.

Trestles should be of as simple design as possible, and without the let-in joints so dear to the carpenter. It is sufficient to saw and adze the capsill and groundsill only so much as will give the raking struts a bearing normal to their thrust. Anything further wastes time. Again, if the vertical and raking struts (or legs) of the trestles are properly triangulated, no diagonal bracing is required with trestles up to twenty feet high. Another fruitful source of wasted time is meticulous levelling up of the trestle. A properly triangulated trestle can tilt sideways a foot out of the vertical if the necessary correction is given by a packing piece on the capsill (Figs. 3 and 5).

Provided that the groundsill can be kept in place by stakes on each side, longitudinal bracing between trestles is not required, it being understood, of course, that the heads of the trestles are secured in a vertical position, as seen from the side, by rigid attachment to the girders. Not only is it not required, but it may even be a source of danger. For instance, if a trestle wants to sink at all, the bracing cannot stop it, and is bound either to split itself or the member of the trestle to which it is secured. In addition any heavy object floating down stream is liable to strike it and imperil the bridge, as the writer once experienced when a hippopotamus got mixed up with some longitudinal bracing (Fig. 4).

This view received further support from the standard design of bridge piers in Tanganyika Territory, where the line from Dar-es-Salaam crosses low-lying land liable to floods. These piers were built on a pile foundation, and provided with a knuckle joint a few feet above ground, so that if their tops had not been pinned to the overlying girders, they would have all fallen down like ninepins. The girders, being fixed to their abutments, kept the top of the piers in their proper position, while the bottoms were free to accommodate themselves to any settlement which might take place. One bridge of this design consisted of seven or eight spans of 30-ft. Provided, then, that the girders are adequately fixed to the top of ordinary wooden trestles, the principle of omitting longitudinal bracing seems to be justified in practice, and no doubt saves time. (It may be objected that braking stresses necessitate longitudinal bracing, but in practice such stresses are transmitted through the girders to the abutments, *e.g.*, on the Khyber Railway.)

Ordinary 12-in. dogs will hold a trestle together when it is once in position, but it is advisable to strengthen it by a Spanish windlass while launching and add drift bolts when any degree of permanency is aimed at.

Crib piers are most easily made by drilling a one-inch hole near the ends of ordinary sleepers and threading them on to ½-in. steel rods, so as to form a square cage which can be weighted with boulders. The chief point to make sure of is that the weight of girders comes upon the corners of the crib and not upon one unsupported sleeper. Single cribs can be used up to about 10-ft. and double cribs to 20-ft. In the South African War, crib piers were made, three sleepers wide, over 34-ft. high, but a great deal depends upon the sleepers being uniform. Cribs more than one sleeper wide should be bonded together every five feet or so by having transverse rails built into them.

The strength of girders can readily be calculated from the formula.

$$\text{Total stress in either flange} = \frac{\text{Distributed load}}{8 \times \text{depth}} \times \text{Span}.$$

the units of stress and load being the same; and those of span and depth. This applies whether the girders are rolled steel or built up out of plates. All that is necessary is to convert to a partially concentrated load, measure up the square inches in the flange, and see that the stress divided by the square inches does not exceed an agreed number of tons between six and eight, according to the views of the particular Chief Engineer. No bridge is known to have failed when working to the Board of Trade rule of 6 tons per square inch, without any allowance for impact. (This is the same as allowing 8 tons per square inch with a 33 per cent. factor for impact.)

Plate girders are almost impervious to ill-usage. Fig. 6 shows a two-span bridge of fifty-feet girders, whose central pier was destroyed with an 80-ton engine and tender stationary over it. The whole dropped some 18-ft., and everything combustible was burnt. No damage whatever was sustained by the girders (which were raised on to a timber trestle pier very quickly) and they are probably in use to this day.

When timber railbearers are used in place of girders, their safe distributed load can be calculated for each inch of width from the formula—

$$\text{Load} = \frac{\text{Depth squared (inches)}}{13 \times \text{Span (ft.)}} \text{ tons.}$$

The load thus given must be multiplied by the number of inches which the beam is wide.

The safe load on timber struts can be taken straight from the tables in Molesworth's or any standard pocket book, but it is convenient to remember that, with 12-in. $\times$ 12in. timber, if the load in tons and the length in feet do not add up to more than 65, the load will not exceed the figure permitted by various formulæ.

The simplest form of girder bridge which will generally be used on military railways are "deck spans." In these the sleepers rest on the top of the girders, being fixed rigidly thereto by hook bolts, and the rails spiked as usual to them. Sleepers on deck spans should be placed so near together that if a wheel or coach becomes derailed it can run along on the top of them, instead of dropping between.

Girders need not be elaborately cross-braced on military lines. It will usually suffice for spans up to 30-ft. if three spacing timbers are cut to fit in between the webs, and the whole bolted together with a couple of tie-rods at each timber.

A very useful substitute for girders can be made by laying rails in their stead. A simple rule is to lay one rail for each foot of span. For instance, over a 12-ft. span six rails under each running rail would be wanted. Spans up to 18-ft. can be bridged in this way, but beyond this deflection becomes excessive. Photos 4 and 5 show two such bridges, in which the spans were 16-ft. It is assumed in the above rough rule that the weight of the rail per yard is not less than five lbs. for every ton of axle-load.

Construction or repair trains can be passed over ordinary track unsupported by sleepers or culvert, up to eight feet ; a very useful fact to remember when a series of small culverts has to be made or repaired. A repetition of such traffic would, of course, bend or cripple the rail. Another interesting example of what trains will do was given in East Africa, when a whole train travelled safely over a gap of 2-ft. blown in one rail by the enemy.

GRADIENTS.

These should be kept as easy as the country will allow, but even with permanent railways steep gradients may be necessary, as with one recently constructed in India, where the line could not be got through with a flatter grade than 1 in 25.

It may sometimes be possible to make the grade in the forward direction easier than those against the return journey. Opinion is divided as to the advisability of this, but it seems to have obvious advantages for a military line, where the heaviest loads are going to the front for consumption there, and most of the return traffic will be empties. Steeper gradients than the above have been successfully worked on civil lines, such, for instance, as the 1 in 22½ over the Rockies in British Columbia ; but this has since been reduced by a spiral tunnel through the mountain, on the Swiss model, to 1 in 45. During the war, one of the camp railways in England had a gradient of 1 in 16, but such gradients, if of any length, need frequent runaway sidings, and are a standing source of danger and anxiety to the operating staff.

When gradients have to be put in on a curved portion of the line, it is necessary to reduce them so that the total resistance to the passage of the train shall not exceed that due to the maximum grade. A simple factor of reduction is .04 per cent. for each degree of curvature. For instance, if the ruling grade is 1 in 40, or 2½ per cent., and the curve one of 10 degrees, the compensated gradient would be 2.1 per cent., or 1 in 47.6.

Backshunts sometimes form an escape from difficulties with gradients, since by their means it is possible to zig-zag up the side of a hill, as with a road. They should, however, be avoided whenever possible, since they cannot fail to be a cause of delay, and are troublesome to negotiate at night. Visitors to India will be familiar with the reversing stations up the Western Ghats, which, however, did not prevent the ruling gradient being 1 in 37. (Within the last 10 years fresh examination of the possibilities has resulted in the reversing stations being cut out, and a much flatter ruling grade being introduced).

CURVES.

Curves can be set out either with ranging rods by offsets, or with a theodolite; and are designated by their radius in feet, or the angle subtended at the centre by a 100-ft. chord. The radius method of designation has certain advantages in the matter of working out formulæ, but the degree nomenclature is almost universally used, except in England (where most of the railways had already been built before it was thought of), and is incomparably better for work with a theodolite.

The offset method of laying out a curve consists in setting off from the straight line and at right angles to it a distance calculated from the formula—

$$\text{Offset} = \frac{(\text{Length of chord})^2}{2 \times \text{Radius of curve}}$$

E.g., on a curve of 1,000-ft. radius the offset 100-ft. from the tangent point of the curve would be 5-ft. This is called the "tangential offset," and fixes the first 100-ft. chord. The next point 100-ft. along the curve is found by producing this chord for 100-ft., and laying off twice the tangential offset. And so on, until the curve reaches the next straight, or "tangent," when the tangential offset for any distance less than 100-ft. will have to be calculated as above.

The disadvantage of setting out curves by this method is that any error is accentuated as the curve proceeds, but it will almost always be employed in military lines, owing to its simplicity, and the absence of instrumental work. It is not so accurate, but quicker than work with a theodolite, which involves logarithmic calculations, unless complete tables giving the length of tangents to the curve, etc., are available.

If a curve is already laid and it is desired to know its radius, the simplest way is to find the midordinate in inches of a chord 61ft. 9½-in. long. This will give the degrees subtending a 100-ft chord at the centre, or "Degree of curve," and the radius can be calculated by dividing this into the figure 5,730, which is approximately the radius of a "one degree curve." *E.g.*, if the midordinate is 10in., the curve will be one of 10 degrees, and its radius 573ft. The accuracy of this method falls off as the sharpness of the curve increases, but it is accurate enough for all practical purposes.

It is not here proposed to describe the laying out of curves with a theodolite, since this method will seldom be used in purely military railways.

PERMANENT WAY.

It is sometimes thought that rails provided for military lines can be of any odd sections which can be picked up cheaply, but this is a thoroughly bad view. It involves a vast waste of time in sorting out the various sections, points and crossings, etc., before linking begins, and particularly when portions of line destroyed by enemy action have to be made good. Special fishplates have to be forged, to bring the tables of the rails level, and any initial saving in cost is quickly dissipated by the subsequent cost of overcoming these drawbacks.

The gauge will usually be fixed either by that of existing lines in the vicinity, or by the rolling stock which can be obtained from other countries. When there is any choice, the metre gauge is possibly the most suitable for military purposes, since high speeds are not required, and the narrower the gauge the sharper are the curves which can be laid. Further, the narrower the gauge, the greater is the proportion of load to the tare weight of vehicles, and the rails can, therefore, be lighter for a given duty. An average metre gauge line would probably not cost more than four-fifths of a broad gauge, and would carry much the same loads. Another advantage is that the line can be constructed more rapidly as the sleepers can each be carried by one man instead of generally wanting two apiece.

Flat-footed rails are sure to be used on military lines, since the use of the bull-headed variety would add fifty tons or more of useless weight per mile. The weight of rails (tons) for a mile of track can be found by multiplying the weight of the rail per yard (in pounds) by the factor 11/7; and the cross-sectional area, in inches, of a rail is one-tenth of its weight per yard in pounds (approximately).

Rails are generally laid with their joints square in this country, but in others, *e.g.*, the U.S.A., they are "staggered," so that the joint of one rail is opposite the centre of the other one. This practice minimises the drop at joints, and makes for quieter running, but, unless the line is very well maintained, is apt to set up dangerous oscillation at high speeds if the rock of the vehicle coincides with the alternate joints.

No form of fishplating can eliminate this drop at the joints, or if the top of a rail is nicked to represent a joint, the same " drop " will quickly develop as at a real joint. On military railways it is not often possible to pay much attention to the position of joints but it is a good thing to have them square on long straight portions, particularly if sidings are likely to be required along it.

Rails should be laid with a cant inwards of about 1 in 20, to correspond with the coned tread of the wheels. The object of this is to make gravity help in keeping the vehicles central with the track, and not throw all the work on the flanges. The larger diameter of the wheel near the flange, as compared with the outer edge, tends also to compensate round curves for the greater distance the outer wheel has to travel.

This cant is given by the shape of the chair with bull-headed rails. In the case of flat-footed rails, it can be given by adzing the sleepers, or by inclining the bed of the bearing plate or steel sleeper on which the rail rests. It may be omitted altogether, if time is short, but the track will be harder to maintain, particularly at points, and the wear on tyres be enormously increased. On the N.W.R. of India, sleepers are adzed and bored at the Dhilwan creosoting works on specially designed machines.

Joints should be given a small gap of about a quarter of an inch between the rails, but at the hottest part of the day less may be allowed for expansion. The men fixing the fishplates should be given the necessary distance pieces to make sure this precaution is not omitted, or the line will be twisted about if much expansion takes place. Fishbolts should not be pulled up tighter than will allow of the rails moving between the plates to take up contraction and expansion. A pull with one hand on an 18-in. spanner gives about the correct pressure. When the line is likely to be permanent the ends of the rails and the insides of the fishplates should be well smeared with a mixture of tar and oil (half and half) and this should be done regularly once a year in the spring, when maximum expansion will occur. When the joint has been made, the outside of the plates, bolts and nuts should also be treated with the mixture to prevent them from rusting.

Sleepers must be laid with the heart side downwards to facilitate drying, and when one spike only is used on each side of the rail, the inner pair should be on the same side of the sleeper's centre line, and the outer ones on the other. This helps to keep the sleeper square to the track. Sleepers should be properly spaced, and those at the joints within a foot of each other, if the fishplates will allow of their being so close.

The secret of rapid linking, provided that the supply of material is adequate, is to have all the fishbolts run down beforehand, and to leave as much work as possible to be done after the passage of the construction train. The latter can be passed over the track, if the rails are merely laid on the sleepers, and kept to gauge by steel ties shaped to grip the foot of the rails—three per 30-in. rail length on the straight, five round curves.

POINTS AND CROSSINGS.

Sidings have to be provided for traffic purposes every four miles or so, and at other places as required for store depots, gun sidings, etc.

It should be the aim of suppliers of material so to design their turnouts, that they fit into a given number of rail lengths without cutting. Apart, however, from engineering contractors, this point seems to be entirely overlooked on English railways, though it was well understood by the suppliers of rails to the late enemy territories in East Africa. (In fact, the line from Dar-es-Salaam to Lake Tanganyika, built to the metre gauge, was one of the best found which the writer has seen, and was ballasted throughout with two cubic metres of 2-in. granite per running metre.)

Crossings are known by their "number," *i.e.*, 1 in 6, 7, 8, 10, etc., as the case may be. The simplest way to recognise them is to measure the distance in feet between the two places on each side of the crossing where the running edges of the rails are six inches apart. This distance gives the correct number.

No difficulty should be experienced in putting in crossings if a few simple rules are observed. One is that the distance between the heel of the switch and the nose of the crossing bears a constant relation to the number of the crossing. On the 4-ft. $8\frac{1}{2}$-in. gauge the distance is found by multiplying the "number" by 6.7. *E.g.*, the distance required, or "lead," for a 1 in 10 crossing is 67-ft. Approximate factors for other gauges are: 5ft. 6-in., $8\frac{1}{4}$; 3ft. 6in., 4.9; metre, 4.6; 2ft. 6in., $3\frac{1}{2}$. These factors give results sufficiently accurate for all practical purposes, whether the turnout is from a straight or curved line.

The second rule of thumb is that when the turnout takes off from a straight line, the midordinate of the "lead" is virtually constant for all numbers of crossing on the same gauge. With the 4-ft. $8\frac{1}{2}$-in. gauge this midordinate is about 7in., and the radius of the curve to the crossing can be found from the formula—

$$R = 2 \times \text{Gauge} \times \text{"Number" squared plus } 1\tfrac{1}{2} \times \text{Gauge.}$$

When turnouts leave a curved line, the midordinates of the two leads will add up to about 7in. if the curves are of contrary flexure, and will subtract to 7in., if they are of similar flexure.

Midordinates to any curve of length L can be found from the formula—

$$\text{Midord.} = \frac{3L^2}{2R} \text{ inches, or } \frac{L^2}{8R} \text{ feet.}$$

This formula is also useful for finding the amount to bend a rail of given length for laying in a given curve.

Usually the number of crossings is standardised for the particular line, but it may sometimes be necessary to put in special ones, as, for instance, when a siding has to be constructed into or between existing buildings. In this case the curve of the siding must first be determined, either with a theodolite, or by trial and error with ranging rods, and the number of the crossing found from the formula

$$\text{Number of crossing} = \sqrt{\text{Radius}} \times \sqrt{1/2 \text{ gauge.}}$$

When turnouts leave a curved line the number of crossings wanted is found from the following formulæ :—

Curves of similar flexure

$$\text{Number} = \sqrt{Rr/(R-r)} \times \sqrt{1/2 \text{ Gauge.}}$$

Curves of contrary flexure

$$\text{Number} = \sqrt{Rr/(R+r)} \times \sqrt{1/2 \text{ Gauge}}$$

The value of $\sqrt{1/2\,G}$ for different gauges is as follows :—5ft. 6in., .3; 4ft. 8½in., .326; 3ft. 6in., .378; metre, .39; 3ft., .41; 2ft. 6in., .44.

Points or switch rails vary in length with the gauge. On the 4ft. 8½in. they are about 1½ times the number of the crossing. At the heel of the switch the distance from the stock rail should not be more than 2in., and the longer the switch the less will be the violence of changing direction. The same applies to the number of the crossing, and the higher the number the faster can a train take the siding.

Crossings are sometimes said to be right or left handed. This means that the rail from which the nose is planed will lie in the main line, and the shorter rail spliced into it will lie in the siding, if it is laid as the makers intended. In practice, however, the same crossing will do for a siding on either side of the main.

Check rails to crossings should have a clearance of 1¾″ on the 4 ft. 8½ in. gauge.

The passage of trains round curves is assisted if the gauge is slightly widened, and various formulæ exist, based on the rigid wheel base of the vehicles, to calculate the amount. Most railways have their own rules on the subject, governed by the degree of curvature, but on a military line this widening will generally look after itself, even if the outer edge of the outer rail is double spiked, as it should be.

The superelevation of the outer rail is a more important matter and here again numerous formulæ exist. The simplest method of arriving at a figure, however, is to measure the versine of a chord of predetermined length (according to gauge and maximum speed anticipated) and to give the same number of inches elevation to the outer rail. The lengths of chord generally chosen are equal to 1.6 times the maximum speed for the 4ft. 8½in. gauge, and 1.3 for the metre. *E.g.*, if the maximum speed on the broad gauge were fixed at 40 m.p.h., the versine of a chord 64-ft. long would give the required superelevation in inches, up to a fixed maximum.

BALLAST.

This fulfils several purposes, the chief one possibly being to distribute the load on each sleeper over a greater area of the formation than the sleeper alone would cover, and so reduce the number of sleepers required to support train loads. Other purposes are to keep the underside of the sleepers from becoming waterlogged, and by biting into them to keep them in true position. With regard to military lines, the necessity for ballast depends upon several things. The length of time the line will be required, the nature of the soil, whether soft, sandy, gravelly, etc., and the average rainfall, all play their part. If the line is of such a length that troops will want to sleep during a journey, the line must obviously be better laid than for short day trips, particularly in open country where an absence of overbridges allows the roofs of coaches to be used as extra sleeping accommodation. When ballast is unobtainable, having regard to all the circumstances of the case, the difficulty can generally be got over by putting in extra sleepers.

The amount of ballast required depends upon the permanence of the line, the amount and speed of the traffic, etc., but it is not of much use putting less than a cubic yard per running yard of line. Two cubic yards per running yard is the average when fast traffic is expected, as on main lines.

The joints are usually packed first, then the intermediate sleepers; and traffic is admitted at reduced speed until the bed has consolidated. When subsequent lifting and packing has to be done, the modern practice is to open out one side only of the sleepers, lift the low places by levers or jacks and spread a small quantity of ¼-in. chippings underneath. This method leaves the old consolidated bed undisturbed, so that the subsidence caused by the passage of the first few trains is less than it used to be when the old method of using beaters was employed. The platelaying gangs get to know very accurately how much small ballast to put underneath the low sleepers, and the net result is a better road kept in condition with a minimum of work. Platelayers who have given the new method a fair trial do not go back to the old use of beaters.

GENERAL ORGANIZATION.

As regards the general organization of military railway construction, a definite daily mileage should be aimed at. Assuming a daily task of two miles, the survey party should be able to peg out two miles a day; the earthwork progress at a like pace; the port of disembarkation be able to unship the necessary material, and see that it is complete in all respects; it should arrive at site in the order in which wanted; and, finally, the linking, lifting and packing gangs must be at full strength.

Since unforeseen delays are bound to occur, the more the survey and material are ahead of schedule, the greater chance is there of the line progressing according to plan.

Far greater lengths of line than two miles have been laid in one day without track-laying machinery. Nearly seven miles were laid in the Kano railway by Capt. (now Brig.-General) H. O. Mance; over five miles were laid by the South Africans during their advance into S.W. Africa; and the Sappers and Miners did four miles in one day in East Africa. These speeds, however, cannot be maintained, and the organization gets "out of breath," with the result that the daily average loses rather than gains. A film recently exhibited, "The Iron Horse," claims that the maximum day's linking achieved from one railhead during the completion of the American Transcontinental line in 1864 was no less than ten miles. For peace work a mile a day without track-laying machines is good average going, and then only when, as in the above cases, no bridges have to be erected.

CO-OPERATION BETWEEN DIVISIONAL ENGINEERS AND THE R.A.F.

By BREVET-MAJOR R. H. DEWING, D.S.O., M.C., R.E.

Co-operation is a good horse, and for that reason it ought not to be over-ridden, but the information to be found in our official books about how the sapper and the airman can mutually help one another is so meagre that it is hardly enough to keep the animal exercised.

Engineer Training, 1922, recognises that "all ranks of engineers must understand the methods employed by aircraft," but practically its only other reference to the air is in connection with the selection of a site for a river crossing, à propos of which the value of air photos is pointed out, and air reconnaissance by engineer officers when circumstances permit is advocated.

F.S.R. Vol. I. gives a little more information. "The preparation of the surface of aerodromes and the provision of aeroplane hangars is the duty of the R.A.F., but labour and material for the same may be demanded from military sources. All buildings, hutments and works are provided by the D. of W."

It is all very well to call the preparation of aerodromes the "duty" of the R.A.F.; it certainly sounds like being the work of the Army.

It seems doubtful whether these few sentences are enough to give a sapper officer much idea of the work which may be required of him in war by the R.A.F., or of the ways in which the work of aircraft may in turn help him, and this seems sufficient justification for trying to see how co-operation between the two arms is likely to be of value.

In its peace organisation the R.A.F. has a "Works and Buildings Department," which carries out barrack construction and all the engineer services required for barracks and aerodromes. The personnel of this department has a civilian status, and though it is anticipated that on the outbreak of war the men will be enlisted for service overseas, their work will be confined to the base and L. of C. areas. In the forward areas there will be only the R.A.F. squadrons and the "Tent Detachments." The former can erect their own light portable hangars, and the latter erect large collapsible hangars of the Bessoneau type. All other engineer work required by the R.A.F. in forward areas will have to be carried out by the Army.

The only R.A.F. units with which divisional engineers will normally be concerned are the Army Co-operation squadrons, which are non-divisional units though they are usually provided on the basis of one squadron per division.

Aerodromes must be kept beyond the reach of the bulk of the hostile artillery, and consequently, whether an A.C. squadron happens to be temporarily allotted for work with a division, or whether it is retained under corps control, its aerodrome will usually be well back towards the rear of a corps area. Under these circumstances an advanced landing ground within easy reach of divisional headquarters will usually be wanted, where machines can land to enable pilots to report personally to the division, and where, if necessary, a few machines may temporarily be kept ready for special work at short notice.

Engineer work will be required both at the squadron aerodrome and at the advanced landing ground, and, though it is the latter which more directly concerns the divisional engineers, it is not unlikely that work at the former may sometimes have to be carried out by a divisional field company; it will, therefore, be as well to consider the probable requirements at both places.

The detail of the requirements will vary with the degree of mobility of the operations, the nature of the country and the type of fighting which is going on. In both cases the preparation of the actual landing ground will be the chief item; and closely connected with this is the improvement of air approaches to the ground. A level field may be useless as a landing ground until the felling of a few trees has converted it into a passable one.

At the squadron aerodrome, roads giving access to it, water supply, hutting, splinter-proof and gas-proof shelters, storage for petrol, bombs and ammunition, and camouflage are suggested as other engineer work which might be required.

At the advanced landing ground these elaborations would probably not be necessary, and beyond the preparation of the ground itself and the provision of a track by which a car could run from the landing ground to divisional headquarters, little would be required.

Work which the R.A.F. might request the division to do for them would be arranged in just the same way as work required by the artillery or infantry formations. The General Staff, in consultation with the C.R.E., would decide upon its priority in relation to other engineer work on hand, and upon the unit or formation to be responsible for finding the necessary labour. The C.R.E. would supervise the work, detail any R.E. parties required and provide R.E. stores.

The selection of an advanced landing ground will be made by an R.A.F. officer of the A.C. squadron, but it is important that any engineer work involved should receive its share of consideration, and, therefore, an R.E. officer should accompany the R.A.F. officer reconnoitring the ground. As the preliminary reconnaissance may often be made from the air, to be confirmed by a hurried ground reconnaissance carried out by car from the squadron aerodrome, it is important that the C.R.E. should be in close touch with the Squadron Leader.

R.E. officers should know what is required at an advanced landing ground, both to enable them to assist in the reconnaissance and in order that they may cultivate an " eye " for likely ground and thereby be able to help the R.A.F. in their search.

In order to land, an aeroplane flies into the wind, and since provision must be made for machines landing with the wind blowing from any quarter, the landing ground must be as broad as it is long. Where machines are only likely to land occasionally, and conditions are otherwise favourable, an area of 400 yards square may be enough. For a landing ground likely to be used simultaneously by numerous machines, or where the type of machine or the atmospheric conditions necessitate high landing speeds, 600 yards square may be the minimum. Future types of machine may be able to land in more confined areas, and experience is needed before the effect of special atmospheric conditions on landing speed can be judged, so preconceived ideas of the space required must be checked by obtaining the views of pilots who know the particular machines and conditions.

Surface drainage must be considered by the sapper. If he does not think of it no one else will. Ground which may be perfectly satisfactory in fine weather may turn into a bog with the first storm of rain. The filling in of a ditch may give the required level area, but may also block the one escape for surface water and so create a quagmire. If these things happen after the sapper has passed the ground as suitable, there will be justification for the wrath of the pilot who crashes his machine on landing.

R.A.F. officers, on their part, should understand how to make their demands for work, and how the work will be carried out when approved by the division. They should also realise some of the difficulties involved in the supply of R.E. stores, and the help which they can give by making an early forecast of their requirements.

This all points to the desirability of liaison between the A.C. squadron and the C.R.E., but the employment of an R.E. officer for liaison with the squadron will seldom be possible; other and more important demands are always present to absorb every officer available for such duties, and the fact that squadron headquarters will usually be situated far back behind the divisional area makes the detachment of an officer even more impossible. Sometimes it may be practicable to effect some liaison through the corps engineer units, which will normally find themselves closer to the main squadron aerodrome than any of the divisional field companies; but the main point is that engineers and airmen should learn what they can of one another in peace. If each has a working knowledge of the other's job, the telephone and an occasional meeting will probably be enough to keep the Squadron Leader and the C.R.E. in touch with one another.

So much for the help which the divisional R.E. may be called upon to give to the R.A.F. The help which the R.A.F. can give to the divisional engineers will be mainly through reconnaissance.

The importance to the R.E. of early information about the jobs which lie ahead is obvious enough. Plans for work in connection with river crossings, the removal of obstacles, demolitions, the development of through traffic routes, or the consolidation of an enemy position after its capture, can only be made beforehand if they can be based on correct information. There are three ways in which the R.A.F. can help to provide such information; by direct observations made by the pilots, by taking up R.E. officers to enable them to see points for themselves and by taking photographs from the air.

The bulk of the engineer information obtained from the direct observations of pilots will be provided in response to definite requests made by the C.R.E. through the General Staff of the division. The value of the information obtained will depend largely on the way in which the request for it is framed. Definite questions usually bring definite answers; vague questions invariably bring vague answers. This point can easily be practised in the course of training; in addition, any practical experience of flying which can be obtained will assist by giving some idea of what can and what cannot be seen from the air at the heights at which service flying has to be done.

The value of the information gained by an R.E. officer, who makes a flight as a passenger to observe some special point for himself, will always largely depend on his previous air experience. The amount of useful observation which a passenger can effect on his first flight is usually negligible; on the other hand, technical knowledge might often enable an R.E. officer who is accustomed to flying, to observe points of value which would have been missed by a pilot. For this reason no R.E. officer should miss such opportunities as may come his way of gaining air experience.

The value of air photographs is sufficiently apparent—if they can be correctly interpreted. During the latter part of the war the majority of officers became fairly familiar with air photos, and learnt something about their interpretation. Since the war opportunities for work with air photos have become comparatively rare, and there must now be quite a number of officers who are inexperienced in their use. It is not difficult to learn something about the subject; there are lots of books on the war, illustrated by air photos, and a very interesting official volume on air photos and their interpretation has also been published, and is now in the Corps and S.M.E. Libraries. Full value is only obtained from air photos when the vertical and oblique are studied in conjunction. The latter give a much clearer idea of heights and contours. It is also worth knowing that the R.A.F. is equipped with cameras of various focal lengths, from the "8in. focal length wide angle camera" for covering a large area on one plate, up to the "12in. focal length camera," which produces a small and very detailed picture. When time permits, the R.A.F. is also able to supply stereoscopic verticals and obliques made up from selected photos. These stereoscopic photos emphasise heights and contours and may be a valuable supplement to the ordinary air photos. When asking for photographs, therefore, no less than when asking for reconnaissance, the best information will only be forthcoming if the squadron is told exactly what the photographs are required to show. Provided that they are told this clearly, the R.A.F. should be able to supply the pictures which best meet the particular case.

On their part, the R.A.F. officers can help by learning something of the sapper's work. Many words can be saved if the other fellow knows what you are talking about.

Besides the help obtained by the sapper through reconnaissance of enemy areas, the assistance of the R.A.F. is essential in all camouflage work designed to give concealment from enemy aircraft. The provision of camouflage material is an R.E. duty which seems to demand the close co-operation of the R.A.F. both in peace and war if it is to be performed efficiently. It is a duty which merits more attention than usually seems to be bestowed upon it in peace.

We have now considered how the sapper may help the airman, and how the airman may help the sapper in the course of the normal employment of each arm. There is at least a possibility that the two arms may sometimes work together for the execution of a minor combined operation. Both the R.A.F. and the R.E. are specialists in destruction, the former possessing far greater range, and the latter greater accuracy, for, however accurate bombing sights may become, dropping a ton of explosive on to a bridge can never be so effective as that same ton of explosive rightly and scientifically laid and blown. It may sometimes be feasible to combine the range of the one with the accuracy of the other.

An attack on an important bridge on the Turkish L. of C. on these lines was contemplated during the Mesopotamian campaign, though it did not materialise. The scheme was that an R.E. officer, equipped with the necessary explosive, should be transported to the vicinity of the bridge, do his work by stealth and trust to being picked up again by the plane. Since those days the development of troop carriers has made more ambitious raids a possibility which is worth keeping in mind.

OURSELVES.

By Captain W. A. FitzG. Kerrich, d.s.o., m.c., R.E.

"I wish to emphasize the fact once more that the Royal Engineer officer must be a first-class engineer and at the same time a first-class soldier."

(Quotation from some remarks made by Lieut.-General Sir G. M. W. Macdonogh at the close of Major General H. F. Thuillier's lecture on "Engineers and the Army," given at the Royal United Service Institution, and printed in the November, 1925, number of the *Journal of the R.U.S.I.*).

I think we all know those brisk discussions that spring up now and then in places where we foregather about that most interesting of all subjects—Ourselves—what we are, why we are what we are, whether we are what we ought to be, and if not, why not.

Apart from the fact that everyone enjoys talking about himself, it must be admitted even by those outside the Corps, if they trouble to consider the matter, that the case of the R.E. Officer presents some points of interest.

Consider a typical specimen of the genus, who shows some aptitude for Survey work while under instruction, leaves Chatham to join a field company, is posted to India and becomes first a G.E., and then a Sapper and Miner, comes home and gets into the Staff College, does Staff work for a time, returns to regimental duty as O.C. a company in the Depot Battalion, goes to the Sudan to serve in the Public Works Department, and after returning home again and acting as S.O.R.E., gets some odd job like British Commissioner for the Delimitation of the Demilitarized Zones of the Straits, Constantinople, winding up his career as Chief Engineer of a Command.

He presents points of interest even if he has failed to strike out a line for himself, like the two officers who are now respectively Governor of Queensland, and Permanent Under Secretary, Colonial Office, S.W.1.

It is not as if the officer whose career is outlined above had had an outstandingly varied one. Quite the contrary, for he was unfortunate enough not to see any war service and so failed to tackle the jobs of Stores Officer, Basra; Water Supply Officer, Palestine; and C.R.E. of a division in France, or display his originality by commanding an infantry brigade. In fact the R.E. officer bears a strong resemblance to the chameleon.

His versatility is what makes him interesting; but at the same time it makes his case correspondingly difficult to view as a complete whole, and arguments on the subject almost invariably descend from the general to the particular. A discussion that starts on the subject of whether the average R.E. officer can be expected to fill such a variety of roles with success and the best method of training him to do so, will soon crystallize out into something easier to handle, such as the need for special training in E. & M. work, or the limitation of entries to the Staff College.

The result of this is that anyone who wants to make up his mind about the more fundamental problem leaves such a discussion feeling rather empty, like a man who has eaten a few succulent tit-bits instead of a good square meal.

The question arises at this point whether there is any necessity for each of us to try to form his own opinion on this matter. Are, for example, the views of a comparatively junior officer, with no experience of big engineering jobs and no Staff or Indian service, of any value? Clearly not much; but it must be remembered that by a natural process junior officers become senior officers in due course, and will then be required to have opinions on such a subject.

There is no harm in forming opinions from the data at your disposal, provided always that you are prepared to modify them if necessary when you have gained further experience. It is encouraging to read that at the end of Major-General Thuillier's lecture on "Engineers and the Army," largely devoted to such an abstruse subject as the functions of the Engineer-in-Chief, General Sir George Milne said:—

"I see a very large number of Royal Engineer officers here to-day, and I came to the meeting hoping that I should hear some opinions, *especially from the more junior Officers.*"

Rejecting then the proffered advice of an officer who maintains that the Corps exists as it is now simply because it is a secret and mysterious society that nobody understands, and would not be half so flourishing as it is if anyone did know anything at all about it, the attempt will be made. The difficulty is to know where to begin, but perhaps the best thing to do will be to show how we are all employed to-day.

Present Employment of R.E. Officers.

This is shown in the Employment Table which has been compiled from the "Station List" in the October, 1925, *R.E. Quarterly List.* Absolute accuracy is not guaranteed (7 officers are sunk without trace), but it is correct enough for present purposes. The *Quarterly List* was chosen in preference to *Peace Establishments* as it goes more into details, and only two parts of the latter (Nos. 1 and 3) could be obtained.

EMPLOYMENT TABLE.

1. Works Services (exclusive of E. & M.)	2. E. & M.	3. Railways.	4. Survey.	5. Staff, Units, Military Schools.	6. Engineering Instruction.	7. Miscellaneous.
Directorate, War Office. C.R.E's. S.O.R.E's. A.E's. (D.O's.) G.E's. (India). P.W.D. (India and Sudan). (Note. Many Fortress company officers are employed mainly on works but are not shown here).	All officers so marked in the list. (Note. The A.A. Searchlight Bn. (24), School of A.A. Defence (5) and School of E.L. instructors (6) are shown elsewhere).	Indian 36. Miscellaneous 7 (Note. The Railway Training Centre Instructors (9) and Railway Coy. officers (8) at Longmoor are shown in other columns).	Ordnance Survey 14 Survey of India 27 Miscellaneous 18	Staff officers (excluding S.O.R.E's.) 39 C.R.E's and Adjutants Divl. Engineers 6 Field Companies 65 Field Squadron 6 Sappers and Miners 105 A.A. Searchlight Battalion 24 Training Battalion 27 Depot Battalion 11 Mounted Depot 6 Students Staff College 12 R.M.A. and R.M.C. Staffs 9 Students S.O.S. 5 School of A.A. Defence 5 Territorial Adjts. 20 Fortress Companies 43 Railway Companies 8 Porton Company 3	S.M.E. and Cambridge 154 E. & M. Courses 32 Railway Training Centre 15 School of Electric Lighting 12 (Note. Both instructors and students are shown here).	Odd jobs 32 Unaccountable 7
307 57*	30 4*	43	59	394 19*	213	39 4*
364	34	43	59	413	213	43

Officers of the Royal Engineers (Indian Army), Coast Battalion, Militia, Territorial, Temporary and retired officers. Officers of the Staff for R.E. Services, Quartermasters, and A.I.R.E.M's are excluded. Grand Total 1085+84=1169.

In order to get a birdseye view of the situation the number of columns has been restricted to seven, though it has not been easy in some cases to decide into which category certain officers ought to be put. An outstanding example are the fortress company officers who have all been put in column 5, whereas many of them ought really to be in column 1.

Every officer on the Active List, from Lieutenant-Colonel downwards, is shown, including Lieutenant-Colonels "removed from the Corps and still on the Active List," and officers on half pay who "retain their present employment."

At the foot of each column are shown certain other officers. These are officers of the Royal Engineers (Indian Army), 33 in number, and 51 Coast Battalion, Militia, Territorial, temporary and retired officers. As *Part I, Regimental Establishments* (including Works), and *Part III, Miscellaneous Establishments and Instructional Institutions*, of *Peace Establishments* alone show 1035+61=1096 regular R.E. Officers, it is presumably intended in due course to replace all these temporary etc., officers, and their inclusion gives a truer idea of the jobs to be filled.

Incidentally it is extremely interesting to note that *Peace Establishments* allow for 222 officers under instruction + 28 instructors =250 for column 6.

We see then, from the table, that about 1/5 of the whole are instructing or under instruction, and that the remainder are divided in the proportion of five to four between "engineering" and "soldiering," to use two very elastic terms. The other important point to note is the comparative unimportance at the present moment in the Royal Engineering world of E. & M., railway or survey work when compared with "works," *i.e.*, constructional engineering.

A Very Brief History of the Corps.

This will not go back beyond the South African War. Major-General Thuillier's lecture gives some very interesting information about the days before that, when the R.E. led a separate existence from the rest of the Army. The picture of Wellington humbly proffering advice to his engineers, to which they paid not the slightest attention, is one which should not be missed.

By the time of the South African War, however, this impossible state of affairs had been largely remedied; yet the Corps still occupied a unique position in that if there was any work to be done, from running railways to revetting trenches, that could by any stretch of the imagination be labelled "scientific," it had to be done by us.

Between the South African War and the Great War there are two events of outstanding importance. Firstly, mechanical transport was taken over from us by the R.A.S.C.; and secondly, military aviation, which had been in our hands, passed to those of the Royal Flying Corps.

During the Great War the situation is somewhat obscured by the fact that there were not nearly enough of us to go round, and that it was, therefore, necessary to call in the civil engineer to our aid. While bearing this in mind the following must be noted.

(*a*) The formation of the Directorate of Transport which took roads and railways out of the hands of our organization.

(*b*) The formation of the Royal Tank Corps with very little assistance from us.

Lastly, since the Great War, the Royal Corps of Signals have broken away from us and started life on their own. The lesson to be learnt from this survey of past events is pretty obvious.

We live in what has been called the Mechanical Age, in which engineering is entering more and more into our daily life. There are for example, those who affirm that a motor car, or at least a motor cycle, is no longer a luxury but a necessity.

As the engineering needs of the Army have increased, certain portions of the Corps have grown to an unwieldy size and have broken off from the parent body.

It must be carefully noted, however, that mere size has not been the only cause ; in addition there has been the necessity for specialization.

Specialization.

Specialization is a relative term of course. The lawyer, the priest, the soldier are all specialists, the outcome of finite man's efforts to cope with an infinite universe. Latterly the growth of science, using the word in its broadest sense, has been abnormal and specialists have sprung up like mushrooms in every field of human activity. Whereas not so long ago we had the leech who knew all that there was then to be known about medical science, to-day every doctor is either a physician first and a surgeon second, or vice versa. In many cases the process is carried still further and you have the Harley Street specialist who devotes his whole time to one particular disease—lunacy, for example.

The process is very clearly seen in our sister profession, civil engineering.

Everybody knows that there are three separate Institutions to which the civil engineer can belong, the Institution of Civil Engineers, the Institution of Mechanical Engineers, and the Institution of Electrical Engineers. The engineer who belongs to one of these, say the mechanical engineer, does not look on himself as a specialist at all. He uses the term to denote one who devotes his energies to steam engines or oil engines, or might even consider that the term should only be applied to the authority on one particular type of steam, etc., engine, say the marine turbine engine.

There is, of course, no hard and fast line between the different branches of engineering, the water supply or the electrical engine expert are proof of this; but the fact remains that the civil engineer who succeeds lays no claim to being an expert on all engineering matters. He is a specialist in his own particular line, has a good working knowledge of cognate subjects, and can do little more than talk intelligently about the rest.

His training is somewhat as follows. Take the case of the young man who thinks that there is a big future for reinforced concrete. He will go to a university for two or three years and then be apprenticed to a firm for a similar period. Universities vary greatly in their methods, but, whichever one he selects, at the start he will divide his time equally between the groundwork necessary for constructional, mechanical, and electrical engineering, while at the end he will study one of the three in much greater detail than the rest. We would call this latter specializing. At Cambridge I understand that specialization is delayed till the last year of three, but that in most of the other big universities it starts at a much earlier period, the student starting to specialize before half his time is up. The process of specialization is carried on during the apprenticeship period, which in this case will be with a firm specializing in reinforced concrete. In delaying specialization to what they consider to be the last possible moment, the universities rely on this probationary period with an engineering firm to supply specialist knowledge and practical experience.

Lastly, after getting his A.M.I.C.E., and becoming a fully fledged civil engineer, he may decide to specialize still further, say, in R.C. bridges.

It is this question of specialization which is the bone of contention among the officers of the Corps at the present moment. So far the argument is that nowadays in any profession a measure of specialization is unavoidable; and that the R.E. Officer is already to some extent a specialist engineer, since he would be well advised to eschew technical arguments when dining in the messes of the Royal Air Force, the Royal Corps of Signals, or the Royal Tank Corps.

The problem of the extent to which it is desirable that the R.E. officer should be a specialist is, of course, anything but new.

Several committees have been appointed by the War Office from time to time to report on the functions and organizations of the Corps of Royal Engineers, and their pages must be studied by anyone who is really interested in the subject under discussion, as they go far more deeply into the matter than it is possible to do in this article.

It will then be seen that the problem has many aspects, only a few of which can be touched on here.

SOME ASPECTS OF THE PROBLEM.

(1) *Finance.*

In peace time this is the most important aspect of any military problem, and we will, therefore, consider it first.

It is clearly useless to-day to advocate any change which means an increase in the Army Estimates; for example, it is useless to advocate an increase in the number of R.E. Officers. Directly after the war this was by no means the case, and many excellent ideas were put forward then, and received serious consideration, which it would be a waste of time to talk about to-day.

To give a few examples:—

It was proposed that D.O's should be entirely relieved of the duties of Quantity Surveying by a specially enlisted civilian staff: and that Fortress Company Officers should not be employed in positions of responsibility in the organization for works services.

It was proposed, from experience gained in the last war, that the proportion of R.E. to Infantry in a division should be as 1 to 6, eliminating the pioneer battalion, and making the proportion of unskilled labour in a field company 70-75 p.c.

Most important of all it was proposed that there should be an Engineer-in-Chief at the War Office with an adequate staff. It is wandering from the subject in hand, but it must be remarked in passing that the idea of having an Engineer-in-Chief at the War Office is not simply to provide the Corps with a head, desirable though that is. It is also intended to provide the Army with an organization charged with the duty of keeping an eye on its ever increasing scientific needs, and making sure that new scientific discoveries which could be of use are noted, investigated, and if necessary, developed for Army purposes. The lack of such an organization may well prove to be a severe and possibly fatal handicap in the wars of the future.

But, except in war time, Finance is an all powerful divinity before whom even the strongest must bow, whose word is law, whose frown means annihilation. Asked at his lecture how it was that in the new *War Establishments* (for small wars), a field company has only been given a small proportion of unskilled labour, and is still the little unit that it was before the war, Major-General Thuillier replied: "The authorities who are responsible for the establishment are in a very difficult position. They are being pressed very strongly to cut expenses to the very bedrock bottom. They have, therefore, to decide between providing, perhaps, more Engineers, or, alternately, providing more guns or tanks or something else." We have, at any rate, now got three field companies and a field park company to a division, instead of the two field companies that were considered to be sufficient before the war. The importance of the financial aspect of any problem cannot be over-estimated, and the tighter money is the more important is it that all requirements should be fully investigated and understood, in order that nothing may be spent on the very desirable at the expense of the essential.

I again urge anyone who is interested in the subject to get hold of and read the reports of the various War Office Committees who have investigated R.E. problems, especially those issued since the war.

(2) *Interchangeability of Personnel.*

It is obvious that, from the point of view of the Army as a whole, it is extremely desirable that all those services which require for their execution personnel with technical knowledge and training of the types which are included in the ordinary engineering professions in civil life, should be organized in a single Corps of Royal Engineers. (All ranks are now being considered, not officers only).

The advantages to be gained are :—

(*a*) Flexibility and consequent economy of personnel, for, on occasions when one class of work becomes temporarily the predominating factor, men and materials can be concentrated on it by depleting the numbers engaged on less essential occupations.

(*b*) Better recruitment, especially as far as the Officers are concerned ; for they are thereby offered a wider sphere of work and interest, with better chances of advancement for the able and ambitious. A small Corps has few inducements to offer to such men and is unlikely to enlist them.

(*c*) Economy and convenience in administration and the elimination of the inevitable waste and inefficiency due to having a large number of small units competing with each other for personnel and material.

During the war the works in the field which came under the category considered above, as requiring technical qualifications of the types available in the engineering professions were broadly the following :—

Bridging, both road and railway.
Water Supply, including pumping installations.
Demolitions.
Construction of roads, railways, and tramways.
Defensive Works, including cover from shell fire.
General Building Works on the Lines of Communication and at bases.
Hutting and Camp Accessories.
Provision of Electrical and Mechanical Power.
Electric Lighting.

In addition there were various technical services which do not fall in quite the same category, which must also be considered. In some cases their personnel is only partially drawn from the engineering professions, in others not at all.

The tactical employment of some of them has furnished overwhelming arguments in favour of their becoming separate Corps or being amalgamated with other arms. These services are :—

Signals.*
Railway operating.
Dock and Canal operating.
Surveys and Map production (including sound ranging* and flash spotting*).
Gas.
Searchlights.
Printing.
Postal.
Meteorological*.
Camouflage.
Forestry.
Tanks (technical branch*).

Notes on the above :—

(*a*) Those marked * are not now R.E. Services.

(*b*) It is difficult to divorce railway operating from railway construction ; for small wars at any rate, these remain R.E. Services, together with dock and canal operating.

(*c*) There is no real reason why gas should be an R.E. Service. Its production may come under the heading of " scientific " but not of " engineering."

(*d*) The printing and postal services are too small to stand alone, and are simply attached to us for convenience of administration.

Lastly, in addition to the above, it must be remembered that there are the unknown future engineering and technical requirements of the Army to bear in mind when considering the functions of the Royal Engineers. The usual practice is to entrust new scientific and technical services to the Corps at the start, and then either incorporate them into its permanent organization, or form a separate Corps of them if they become sufficiently large and important.

(3) *Education of R.E. Officers.*

There was general agreement when the war was over that the pre-war syllabus of education was producing an R.E. Officer with an insufficient technical equipment for modern engineering. Eminent civilian engineers who were consulted were insistent on this point, while speaking highly of our ability. The outcome of the controversy was what is known as the Cambridge scheme.

In 1924 the report of the Haldane Committee on the Education and Training of Officers was published.

This report recommended the following:—

Programme of Courses at Chatham and Cambridge for R.E. Officers.

S.M.E. for the following courses:		
Military duties	10 weeks	
Fieldworks	15 ,,	
Survey	12 ,,	
Workshops	8 ,,	
Electricity	3 ,,	
Leave	8 ,,	
Cambridge.	—	= 56 weeks
3 tours (and 2 vacations)		35 weeks.
Leave	3 weeks	
S.M.E.		
Construction	8 ,,	
Refresher, Military Duties	3 ,,	
Leave	3 ,,	
Cambridge.	—	= 17 weeks.
3 tours (and 2 vacations)		35 weeks.
		143 weeks.

These recommendations are now to be put into force with certain minor modifications.

Among the ideas which came up for consideration before the new scheme took shape the following are of interest:—

(*a*) That Sandhurst and Woolwich ought to be combined, in order to eliminate the idea that the sapper or gunner officer is altogether different from the product of Sandhurst.

The cost of moving the Woolwich establishment to Sandhurst was said to be very great, and there were obvious educational difficulties.

(*b*) That on leaving Woolwich the young R.E. Officer should go to a field unit for six months.

(*c*) That as many of us as possible should, during the first ten years of service, be sent to representative engineering firms in Britain or the Dominions, Crown Colonies or India, to undertake some responsible job and get acquainted with the practical work that is going on in the civil engineering world.

This project, however desirable, is obviously impracticable for financial reasons: the Cambridge scheme, it must be noted, was only made possible by reducing the time at Woolwich from two years to eighteen months.

Summary and Personal Opinions.

No great and successful work, whether it be something concrete like the Taj Mahal or a piece of organization such as the despatching overseas of the Expeditionary Force, was ever accomplished unless those responsible for it were inspired by a high ideal; no work can be done at all unless the worker has some picture in his mind's eye of what he hopes to accomplish, while a low ideal means poor work like the creations of a jerrybuilder.

Imagine for a moment that in a promotion examination one was asked to define the ideal R.E. officer in a single sentence. I suggest that one would get full marks for replying "a first-class all-round engineer and a first-class soldier," and I am definitely of the opinion that the time has now come when this answer should no longer be awarded full marks.

This may seem inconsistent, since it is a high ideal if ever there was one; but it must be remembered that there is another and extremely important side to the picture, and that is the discouraging effect exercised by an ideal that is too high. A simple example will illustrate this. Take the case of a young man who discovers that he possesses a turn of speed over a short distance, and joins the local running club to develop his abilities. If his ideal is only to run faster than his club mates he will never become a big noise in the athletic world, while if on the other hand his ideal is to run as fast as a greyhound a few trial spins will result in his resigning his membership through sheer discouragement.

Clearly the right ideal for him is to break the record for his particular distance, for, while the odds are greatly against his ever doing so, the effort will develop his powers to the uttermost.

To return now to our own case, the march of events has in practice forced us willy-nilly to abandon the all-round ideal: anyone who denies this must deny the existence of the Royal Air Force and the Royal Signal Corps. What then is the use of clinging to it in theory? Let us at least acknowledge that the R.E. officer is a specialist to the extent that he is only expected to be master of constructional engineering, railway engineering, and survey work in all their various branches, electrical engineering (signal work excluded), and mechanical engineering (with many important branches excluded)

Granted all this, it may seem that such an one is still entitled to call himself an all-round engineer, especially when it is remembered that he has to be prepared to meet any hitherto unforeseen developments in electrical and mechanical work, and that this is little better than quibbling.

I will now put forward a further and more cogent argument, namely, that in reality the average R.E. officer is only expected to be a first-class constructional engineer. When he is required for other work, he is in the majority of cases given extra training, and then devotes the rest of his life to that particular branch. This has been the case for a long time as regards Indian Railways, the Survey of India, and the Ordnance Survey to a more limited extent, and these employ the majority of railway and survey officers. A certain amount of interchange goes on with the rest of the Corps due to fluctuations in numbers (on survey commissions for example), unsuitability for the work, or the desire to go to or return from India; but the statement that Railway and Survey Officers are whole time specialists holds good in general. Very naturally all the higher posts in these branches are held by such officers.

If the above is not true of E. & M. work at the present time, it very soon will be; the proof lies in the fact that 32 officers are now undergoing a two-year specialist course in this work. Two years is so long a time that, at the end of it, it will be highly uneconomical to employ these officers on anything but E. & M. work; while on the other hand it is clear that the average officer, who has not been through this course, can no longer pose as an expert where E. & M. work is concerned.

These three, Survey, E. & M. and Railways are the only branches of engineering outside Construction to employ enough of us to merit attention here.

The total number is comparatively small, say 1/3 of those employed either on ordinary works services or with units. It has been explained above why small bodies of specialists such as these are retained in the Corps; while past experience shows clearly that should any of them grow in importance, as might very conceivably occur in the case of the E. & M. branch, they are bound to break away from the rest of us.

On account of their small size they are in a privileged position in that, without involving too great a strain on the Army Estimates, they can give their officers extra tuition before entrusting them with responsible work.

I am, therefore, of the opinion that the time has now come for the great majority of R.E. officers to adopt as their ideal "A FIRST CLASS CONSTRUCTIONAL ENGINEER AND A FIRST-CLASS SOLDIER," replacing the word "constructional" by "railway," "survey" or "E. & M." in the case of the remainder.

This seems to me to be legalizing a state of affairs that exists in actual practice and to be in no way revolutionary; but, be that as it may, I consider it an absolutely essential step to take, for I believe that the official "all-round" ideal is having a prejudicial effect on the Corps at the present moment. Firstly, for the reason that ours is a calling that demands high resolution and earnest endeavour if we are to render ourselves fit for the tasks that lie before us, and it is inevitable that resolution should weaken and endeavour grow slack when faced by an impossible task. More is demanded of us than the efficient performance of our daily avocations; but it is not encouraging, to say the least, to an officer who is prepared to work in his spare time to be told that the whole field of engineering has got to be covered in addition to mastering the art of waging war. Confronted with this situation there is bound to be a tendency to be content with passing promotion examinations, and cultivating the art of talking convincingly about matters that in reality one knows nothing about.

If anyone thinks that the ideal I advocate is not a sufficiently high one let him talk it over with a competent civil engineer, and start the conversation by explaining that about half his life is going to be spent performing military duties which involve little or no high-grade engineering practice.

In the second place it appears to me that if the all-round ideal were officially discarded a change would follow in the system of educating the Y.O. Education is a thorny subject for the amateur to tackle; but it is impossible to ignore it in this connection, for it has been acknowledged that the system of pre-war training is not good enough for present needs; a programme of the present course of instruction which is to remedy this state of affairs is given above. The solution of the difficulty that has been adopted is to increase the period of instruction from two years to nearly three years, and send the Y.O. to Cambridge for his theoretical instruction. At Cambridge, if the experience of the Supplementary Classes who went there is a correct guide, the Y.O. will devote his time equally to (the theory of) construction, electricity and mechanics. At Chatham the time spent on construction is only to be one quarter of that devoted to (practical) instruction in E. & M. work, and a very thorough course of survey.

As a generalization I am in agreement with the dictum that specialization breeds a narrow outlook, and should be delayed to the last possible moment; but surely this is carrying things too far if it is agreed that the officer for whose benefit the programme has been got out is to be a constructional engineer only, as most of us have to be. It differs widely from the method of training the young civil engineer who spends only half or less of his time at college on his all-round education and then proceeds to specialize in one of the three branches for the remainder. Surely our present programme must be the practical expression of an all-round ideal. There is not a hint of specialization in it, and remember that in our case there is nothing corresponding to the apprenticeship period of the civil engineer, which is always devoted to specialization.

I advocate taking at least nine months away from the time at present devoted to electricity, survey and mechanics and devoting it to construction (even if this means the severing of our connection with Cambridge).

How these nine months should be spent is a different problem. Personally I would devote it to practical experience of big constructional engineering work. It is practical experience, not books, that teaches one the great fundamental principles of engineering to which reference is so often made and which I really believe some people think are Newton's Laws or something of that kind. To quote from the discussion after the lecture referred to above "In engineering operations you have to consider five things (i) the skilled labour available (ii) the unskilled labour available (iii) the time (iv) the transport and (v) the stores and plant. All these details have to be proportioned and co-ordinated." The remarks were made in quite a different connection and referred to engineering in war-time, consequently no mention was made of (vi) the money available; but the words serve admirably to illustrate what I want to say. Advanced theory on the other hand can be acquired from books in after life: not an ideal method of course, but then time is so limited with us. I would point out that my proposals involve no extra financial strain. Indeed, if the practical side is studied in a government department which has suitably big new work in hand, there will be a considerable saving. If civil firms were selected in preference to government departments, on the ground that one's outlook would be more broadened thereby, there might still be a small saving over the present scheme.

It is clear that this practical training must be given during the three years allotted to instruction if it is to be given at all. Financial considerations will not permit of any extension of the training period.

Lastly to consider the question of interchangeability. I think that the man who has thoroughly mastered one branch of engineering and gained confidence in himself and in his ability to get things done, is more likely to be a success when he is transferred to work of a totally different kind than one who only has a half-knowledge of both.

All officers might as well take the course I have outlined. Survey officers would only require an additional survey course. Railway and E. & M. officers already get a good specialist training. The nine months' practical experience might perhaps in their case be with railway companies or firms specializing in E. & M. work, but I think it would be better if they went through the same process as the rest.

Conclusion.

Two ideals other than those discussed above have always had their advocates and must in conclusion be briefly examined.

Throughout the above the "first-class soldier" part of the programme has been taken for granted, though clearly it adds enormously to the difficulties of the situation. It is obvious that it is much easier to be a tip-top engineer if you do not have to be a soldier as well, and vice versa; in fact some say that it is impossible to be both even when you have got rid of the word "all-round."

Those who maintain that this is so are from the very nature of the case divided into two opposing camps.

In peace our time is divided almost equally between training for war and working as engineers pure and simple (cp. the Employment Table, page 227). In war a very similar dividing line appears, and *Field Service Regulations* differentiate clearly between field engineering on the one hand, which is what those now organized in units are training for, and works services which differ only in degree from works services in peace.

F.S.R., Vol. I, paras. 66-73, and 43 should be studied in this connection. It will be seen that the dividing line between the two is quite reasonably distinct, though not absolutely hard and fast of course. These facts lead to the formulation of two new ideals. One is "a first-class engineer with a good knowledge of Army needs," the other is "a first-class soldier with a sufficient knowledge of rough and ready engineering."

Take the latter first. Those who uphold it will argue somewhat as follows. "Soldiering as it is to-day is a whole-time job, and we are lowering our efficiency by making a half-time job of it. Every soldier nowadays is a specialist of some sort, and at the same time has to know what all the other specialists can do in order to work in with them. Constant intercourse and combined training are necessary to attain this result. D.O. work and all that kind of thing cause us to lose touch and incidentally lower our prestige, for who can be expected to regard the man who keeps his drains in working order and refuses to give his room a fresh coat of paint, as a brother officer? We have always prided ourselves on being a combatant corps but others see us in the guise of an administrative service; and we are severely handicapped thereby when we compete for the higher posts in the Army. The vital services which we are called on in war to perform are three in number, communications, water supply, and demolitions. No vast amount of engineering skill is required for these under front line conditions where speed is the essential, cost is a negligible consideration, and it doesn't matter how rough and ready the work is so long as it functions during the short time for which it is required. Bridging too, has been much simplified by the introduction of stock spans. There should be no difficulty in teaching what is required of the field engineer in suitable field-work schools. Works further back, where conditions approximate to peace time, can be performed by civilian engineers."

The other side reply on these lines, "Soldiering is not nearly so difficult an art to master as you make it out to be, not nearly so difficult as engineering. A capable engineer will pick up all that you say is required in the front line in less than no time, and, what is more, will do it a great deal better than the product of the field-work school, who, in fact, will be merely a pioneer.

If you expect to raise the prestige of the Corps by becoming pioneers you will find yourselves sadly mistaken. What do you mean when you talk about being a combatant Corps? If you have got any war service you know perfectly well that in an advance the R.E. are stretched to the breaking point working on communications, and that in position warfare the Higher Command will not allow us to be expended on hand-to-hand fighting. In a retreat, of course, you may be called on to act as infantry if the situation is sufficiently critical, but in that case so will everyone else within reach, whatever his normal duties are. You are quite on the wrong tack, the paramount need of the average R.E. officer at the present moment is to devise some way of increasing his technical efficiency."

When we come to consider the arguments roughed out above, it is at once obvious that there is very little in them if it is possible for the R.E. officer under present conditions to be efficient at both engineering and soldiering. Both protagonists are clearly of the opinion that it is not possible.

Now, apart from those under instruction, the employment table shows that, in order to perform their peace time duties, about half the Corps must be efficient engineers, while the other half must be efficient soldiers.

It follows then that there is only one possible solution of the difficulty, and that is for each officer to spend his whole time becoming either one or the other. Since the two resultant types would no longer be interchangeable, the Corps would become two Corps.

It has been shown above that from the point of view of the Army (which is the only thing that really matters), this would be a most undesirable state of affairs, and it will, therefore, have to be very clearly proved that it is impossible for each of us to be both a first-class engineer and a first-class soldier before the Corps will be allowed to break in two.

Personally I have only tried to prove that it is not possible to be every sort of engineer and a soldier as well, and have no wish to go any further. If there really are any who do, it seems to me that they are unfortunate enough to have missed their true vocations. They should either have become civil engineers or joined another arm of the service.

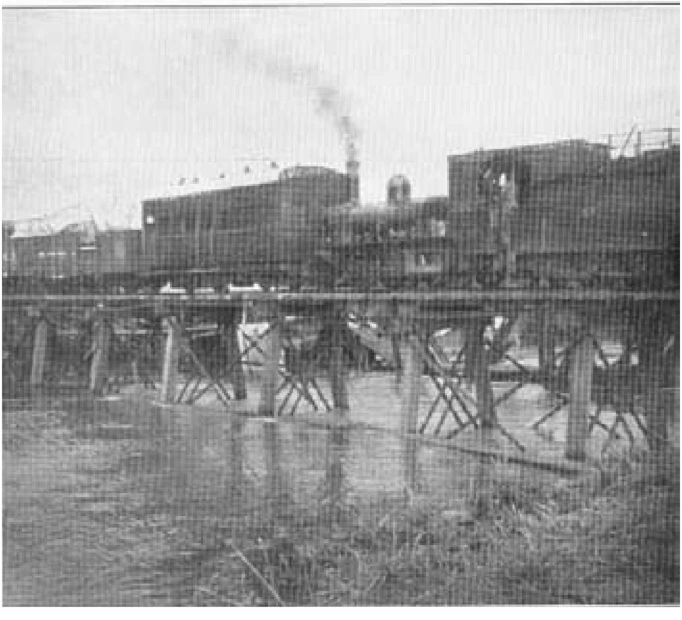
Photo 1. Commencing Shore Bay.

Photo 2. The anchor party.

Photo 3. The towing party.

A BRIDGE OF BOATS OVER THE RIVER INDUS

No. 3.



BRIDGES

A BRIDGE OF BOATS OVER THE RIVER INDUS.

By CAPTAIN C. DE L. GAUSSEN, M.C., R.E.

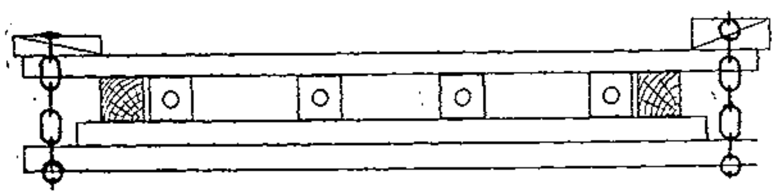
THE bridge described in this article was built over the River Indus for the Northern Command manœuvres in November, 1925. The permanent road bridge, which runs below the railway bridge of the main N.W. Railway line to Peshawar, besides being closed when trains are crossing, necessitates travelling an extra five miles of road length down and up the river valley, and would have caused a bottle neck which would have resulted in great delay to troops from the Peshawar side approaching the scene of operations. It was, therefore, necessary to bridge the Indus just above Attock Fort, where the roads on both banks join the river valley. This operation of bridging, which was entrusted to 19th Field Company Royal Bombay Sappers and Miners, brought out some interesting points which may be of use to other officers.

The bridge was required to carry all but heavy loads, which had to use the permanent bridge, under the railway line.

The site selected was in proximity to that used for an old bridge of boats which existed before the railway bridge was constructed. There were, therefore, quite fair metalled approach roads, which only required patching, to within about 200 yards of the shore on each bank; below this no road can stand, as the difference of flood (July) levels and winter levels is about 50 feet. The immediate approaches were over loose sand, particularly on the east bank, where it was almost quicksand on a level stretch until it meets a high wall of rock cliff. On the west bank the shore slopes at about 1 in 6 and the sand is much too loose to allow of wheel traffic over it. Construction was carried out from this bank. The river level was sinking rapidly at the time of bridging and the actual gap bridged was 630 feet (measured by pocket sextant) and, though probably at its annual minimum, the current in mid-stream was seven to eight miles an hour. Statements as to the depth vary from 40-ft. to 70-ft.

As will be seen from the photographs, there are a number of masonry pillars up-stream of the site, which are relics of the old bridge of boats. Their position does not seem to follow any rhyme or reason and no direct use was made of them, though they were of assistance in a minor way.

The material used was collected from bridges at Jahangira and Nowshera over the Kabul River, a tributary which joins the Indus about a mile up-stream of Attock. The boats are of two patterns, though there are variations within the patterns. The smaller boats, or Jhelum patterns, are 35-ft. long, and the larger, Attock pattern, about 60ft. completely decked, and require considerable skill in handling in the strong current. When not in bridge the boats are propelled and steered by heavy "oars" manipulated by two men standing, and consisting of long spars with planks lashed on as blades. These large boats are essential to withstand so strong a current and to provide stability on a long bridge. The large boats had scow bow and stern and the small boats full bow and stern. Road bearers were four trussed beams 33ft. long, requiring 14 men to carry them, designed for gunwale loading. The span between boats was 30ft., and astride the boat 10ft., for which the inside road bearers (called crossbeams to distinguish them) were 12ft. 6in. by 6in., but the outside ones 25ft. long. Between boats near bow and stern were distance pieces with prongs which fitted over and were lashed to bollards on the boats. These add a great longitudinal stiffness to the bridge and, in default of any means of holding the road bearers to the gunwales, keep the boats in position. On either side of the boats, a stiffening beam is placed, below the road bearers and the projecting ends of the outside crossbeams, astride the boats and kept in position by chains joined above the roadway planks and tightened by means of chocks, thus :—



It is on these that the stiffness of the bridge depends almost entirely, and if properly adjusted they function excellently, as they allow just sufficient play for the boats tilting slightly and for the ends of road bearers sinking. This design is very satisfactory and requires only proper cleats to be put on the road bearers and slots made in the gunwales in which to fit them.

The roadway planks were 2in. thick and generally 15ft. long. A proportion had stancheons fitted to take handrails, for which spars or scantlings were used. Similarly ribands were made of any suitable timber available, racked down with plain wire.

For construction purposes, small country dog-boats were employed. These are similarly rowed and steered by heavy oars manned standing. It was necessary first of all to train men in rowing these; the difficulty is to impress on them the necessity of using their whole weight. The steering is a real art as practised by the Attock boatmen, an experienced and hardy class of men, a party of whom gave invaluable assistance in all the work, as far as knowledge of the river and its dangers were concerned. In steering a boat across the river they keep it at such an angle to the current that it crosses almost straight, exactly as a flying boat, and the crew simply keep sufficient way on to prevent her from being carried down stream.

It was decided to build the bridge of 14 boat piers and two trestle piers, with a subsidiary short trestle pier on the east bank, as the sand was so soft that it had to be dug back until firm enough to take a shore transom, which consisted, on both banks, of large buried baulks. The pace of the current and depth of water precluded the use of anchors, so the boats had to be moored to steel wire cables stretched across the river. These were ⅞in. plough steel wire, especially loaned from the Khyber ropeway stores, each coil being 440 yards long. Their weight, stiffness and inflexibility made them very difficult to handle, especially when contesting with the strong current at the same time. Three of these were to be stretched across for the main mooring cables, and, in addition, one was stretched over each of the bows and sterns of boats and made fast to boats' thwarts, to add stability. It was found more satisfactory to place the main cables well up-stream of the bridge and not have them all along the bows of boats, as is the local practice. By having them clear of the boats, it is possible to dress bridge better, and makes no difference to the steadiness of the bridge. In addition, it very much simplifies taking boats out, should it be necessary. The anchorage for the main cables on the west bank was a buried log, 16ft. long, 2ft. diameter, buried 8ft. in the ground. Fortunately, rock was struck about 3ft. below the surface of the sand, otherwise it would have been necessary to bury sleepers longitudinally on the face of the baulk. On the west bank iron ring bolts (relics of the old boat bridge) fastened in the rock cliff were made use of. One was blasted out, to judge of their strength, and found to have a shaft 4in. diameter, buried 3ft. in the ground, and had been fixed by molten lead poured into the hole bored in the rock. Each cable was, nevertheless, taken to a different ring, and turned round a thimble forged on it. Though the tension in the cables was never actually measured, it appeared to be very much less than that calculated for as the normal strain, as there is a very considerable longitudinal stiffness in the bridge which relieves the pull on the cables.

The method of getting the cable across was as follows :—A 1½in. rope, about 200 fathoms long, was run along the bank, one end made fast to a holdfast and the other taken on a small boat about 250 yards up the bank, and the spare very carefully coiled. Two other small boats were placed at equal intervals along the rope. The first boat was rowed out by picked rowers, and the rope paid out as they proceeded across. Directly there was danger of the belly in the rope, caught by the current, dragging them down stream, the second boat swung out to buoy up the line, and similarly the third. Meanwhile a party had been sent across the river beforehand, and waded in as far as they could to meet the first boat, got out the end of the line and ran away with it, to get it tight as quickly as possible before it was carried down. The line was then tightened and made fast.

Next a series of loops of plain wire were hung on this line, and ½in. steel wire cable threaded through them, tightened by a block and tackle stoppered on to it, and made fast. The rope line was then removed. The first ⅞in. steel cable was then loaded on to one of the smaller type of the bridge boats, which was warped along the light cable and the heavy cable attached to it at about 30ft. intervals by lashings tied in draw hitches. After making fast, the draw hitches were released by a party working themselves along in a boat. The cable was then tightened as before and then the next cable similarly attached, and similarly the third. The greatest difficulty was encountered in controlling this heavy and stiff cable and at the same time keeping the boat up to the wire. Some sort of capstan, or axis on which to revolve the cable coil is essential, otherwise appalling kinks form at once. The other essential is to keep the cable out of water, by interpolating small buoying boats at intervals. The cables were tightened equally in turn between these supports, until all hung in the same catenary, being firmly bound at each boat and the difference adjusted in the last bay at the anchorage. They were left sufficiently loose to take up an estimated horizontal dip of 1/10 when boats' weights were on them.

The stores were next floated down from the Kabul River, and boats collected just down stream of the bridge site in the order in which they were to come into the bridge, *i.e.*, small ones at either end and largest in the centre. The superstructure was made up into rafts and floated down. The steering of these rafts with four heavy oars is no mean accomplishment, and if once caught in the full current on a straight reach there is little chance of pulling out before a bend is reached. The first raft was thus caught, and crashed into the cable which tore all the oars away, the men just saving themselves by lying flat. The raft was eventually brought to shore some two or three miles down the river. After this, a long line of 2in. cordage was kept ready at a promontory about 300 yards upstream of the bridge, to be taken out by a small boat to the raft crew, who could then be towed in to shore.

As far as the clumsiness of the equipment allowed, bridge construction was based on forming-up drill for pontoons. The detachments were as follows :—

(*a*) Boat party. Towed up boats, with two men at each of the steering oars. Owing to the strength of current, the towing rope must always have a turn round a bollard of one of the boats in bridge. The boats, too, must always be kept by the steerers pointing directly up stream.

(*b*) Anchoring party, working in a small boat along the steel wire cables. Taking two turns round the cables in the centre of 3in. falls, they let themselves down stream on this, handed the ends to the party which had towed the bridge boat up to the head, who then belayed in the ordinary way. The anchor party then pulled themselves up again, on the 3in. fall to the cable ; here again very skilful steering is necessary to insure that the boat is always directly up and down the direction of current. A slight mistake was made once with almost disastrous results, though no lives were lost, owing to the boat capsizing. The anchor party attached falls thus at 40ft. intervals along the cables.

(*c*) Construction party at the head of the bridge, ten men got into the foremost boat and ten remained on the boat at bridge head. The two outside road bearers (inverted) were placed astride the two boats and the forward boat party pushed themselves out on these, until they could be placed the right side up. Distance pieces were then slid out on them, the prongs placed on the bollards on the two boats and lashed, and tie lines made fast between the two boats at bow and stern. To place the inner road bearers, a spar with lines fore and back was placed astride the outside road bearers already in position, and the inside ones, one at a time, inverted and placed with end about 3ft. beyond it, and thus slid out. Of course, preventer ropes must always be attached when dealing with these heavy members.

One of the greatest difficulties was the alarming angle to which the boats tilt when the weight of superstructure is only bearing on one side. This can be partly lessened by not laying chesses completely in the first instance, and by keeping all superstructure and carriers well back on the bridge until actually required. A man had to be put on continuous bailing duty directly each boat was brought up to bridge head, and was kept pretty busy while the boats were thus leaning over.

The cross beams, over the boats, and tie beams were then put in as described above, and the chains tightened by means of chocks by a party following behind.

(*d*) Stores party bringing up superstructure exactly as in pontooning, on the command "chesses," "baulks," etc. The only requirements in this are organisation of traffic and muscle. A good

N.C.O. was necessary on shore to control the material taken away and warn parties what to get ready.

The strength of parties is impossible to lay down as it varies largely with the length of bridge already constructed, the size of boats and strength of current, but the following was an average :—

Boat Party	2 subsections.
Anchor Party	1 sub-section.
Building Party	4 sub-sections.
Stores Party	5 sub-sections.

There were, too, other constant calls for men, such as bailing and caulking boats (day and night), unloading rafts of superstructure as they arrived, and bringing up the material from the raft which had "taken charge."

Handrail stancheon roadway planks and handrails and ribands were not put in until the whole bridge was completed, as they hinder the carriage of materials greatly.

On the advice of the local boatmen, two of the large boats were put into bridge stern up-stream (the difference of bow and stern is only slight), partly to make the bridge more steady and partly in case of a storm and gale from the south, not a rare occurrence. Another aid to stability and to getting an even pull on the bridge for dressing, is to tie chesses dragging in the water at every fourth bay from the sterns of boats.

The finishing of the bridge brings out no points of interest. Side screens and grass (which should be damped) were provided for the benefit of the animals. Of the thousands that crossed in the course of a few days not a single one caused any trouble. The effect of traffic is, of course, to loosen tie beam chains and riband lashings and to make the chesses creep sideways, and maintenance parties were on duty day and night adjusting these.

A ¾in. steel wire cable was stretched across the river about 100 yards up-stream of the bridge and buoyed at intervals, as a guard against stray logs that might float down. There was no chance of stopping them when going at full speed, but it checked them sufficiently to render it easy for men to poke them off by long bamboos to between boats, otherwise a heavy log would make a very nasty hole.

Work on erection was not continuous owing to having to collect the material, but the following were the times taken for various parts of the work :—

Getting cables across, anchored and made fast—20 hours.

Actual erection from shore transom to shore transom—18 hours.

The approach roads over the sand were given a slope of 1 in 10, and corduroyed continuously, with grass laid on the timbers. No motor vehicle had any difficulty in passing up and down them.

THE EARLY DAYS OF M.T. AND SOME IDEAS ON ITS FUTURE.

By CAPTAIN A. MASON, M.C., R.E.

(Extracted from *Proceedings of the Royal Society of Arts* by kind permission of Col. R. E. B. Crompton, C.B.)

AN apology is due for the publication of such secondhand information as is contained in this article, compiled from two lectures delivered at an interval of 12 months to a Society whose proceedings are not widely known to Officers of the Corps. Mechanical Transport is of great importance to the Army at present, and it is hoped that the following summary may create interest both in its beginnings and in its possible developments.

The first lecture was delivered by Col. R. E. B. Crompton, who should need no introduction to readers of this Journal, and contained many personal reminiscences of the progress of the road vehicle after the introduction of steam traction engines. His interest in this apparently dated from his intimacy with Sir Frederick Bramwell, who had worked on the Hancock road engines about the year 1827, and, as a result of a visit to the Royal Agricultural Show at Leeds in 1861, where a traction engine was on view, Crompton "was "fired with the ambition to produce a steam-driven motor-car "for passengers which would travel at a reasonable speed."

This car, presumably one of many which firms and private individuals were experimenting with in various parts of the world, ran on wooden wheels and iron tyres, and was on the road in 1863, having been taken out to India by its designer and completed there, and achieving a speed of 20 miles an hour.

Crompton, however, at this time, heard of the work of R. W. Thomson, a prolific inventor, one of whose earliest patents, taken out in 1845, was for the use of "india-rubber" for the tyres of vehicles. For some years this patent led to nothing, but in 1867 Thomson produced a steam-tractor for road work, the wheels of which consisted of double-flanged W.I. drums, about 4-ft in diameter and 13-in. wide, in between the flanges of which lay flat india-rubber bands about 4½-in. thick and 12-in. wide. This tractor successfully towed a large trailer at 12 miles an hour, and Crompton, seeing a report of the tests in the papers of the day, got into touch with Thomson and eventually persuaded the Government of India to try the Thomson engine on the bullock train system which supplemented the then unfinished railways.

Accordingly a department was formed, called the Government Steam Train. Crompton was appointed the first superintendent, and a trial engine was ordered from Thomson. This arrived in due course, and after assembly in the Government workshops at Aligarh, was tried on the run from Amballa to Kalka in 1869. However, having a firebox designed for coal, and wood fuel being all that was available, it "had to stop so frequently to raise steam "that its speed was not much greater than that of the bullock-train "that it was meant to supersede." In other respects it was satisfactory, and the Viceroy was persuaded to continue the experiment and to order four steam trains of improved design, complete with wagons and passenger vehicles: as at this time Crompton's health gave way, he was ordered home to supervise the carrying out of the order.

The first new engine, the "*Chenab,*" with wheels 6ft. 6ins. in diameter and rubber tyres 15in. wide and $4\frac{1}{2}$ to 5in. thick, was fitted with a new "*pot*" boiler designed by Thomson, which was still, in Crompton's opinion, unsuitable for wood fuel. Actually it was found necessary, in order to maintain steam, to increase the draught to such an extent that the chimney spouted sparks, and, during one of its early trials in 1871 it "set fire to the grand "stand on the Ipswich race-course, and the Government of India "had to pay for a new one."

The second engine, the "*Ravee,*" was, therefore, ordered to be fitted with the Field type of boiler then used by Merryweathers on steam fire-engines. In the meantime the makers of the *Chenab*, Messrs. Ransomes, Sims and Head, of Ipswich, were sufficiently pleased with it to wish to exhibit it at the Royal Agricultural Society's Show at Wolverhampton in the summer.

The run by road from Ipswich to Wolverhampton, nicknamed "Lieutenant Crompton's honeymoon trip," occupied eight days and was not a great success: the boiler was troublesome, and it was fortunate that the crew included two boiler-makers, for the boiler-tubes had to be expanded every night. The total crew numbered about 15 persons, including two married couples. This train was a five-wheeled affair, for *Chenab* had three wheels and the trailer was a two-wheeled rubber-tyred omnibus, designed to carry 130 people, 60 below and 70 above. It is hardly surprising therefore that its passage across England created some sensation. The lower deck of the omnibus gave ample sleeping accommodation for the crew of fifteen.

At Wolverhampton it was possible to compare the rubber-tyred *Chenab* with the ordinary steel-tyred agricultural engine. The makers of the latter appear to have been unfriendly to the newcomer and to have blamed the tyres for breakdowns, which were generally the fault of the boiler. It was found, as might be expected, that, for ploughing, the rubber tyres were an advantage in dry weather, but, in wet, non-skid chains were necessary. The omnibus was offered to the judges of the Show as an office and *Chenab* was lent to tow them round. A request for an exhibition of manœuvring was readily granted by Crompton, who was driving, and he eventually achieved "figures of eight at nearly 20 miles per hour"; the sway of the 'bus on its thick soft rubber tyres was, however, enough to make many of the judges sea-sick.

Chenab was eventually sent home by train in disgrace, and *Ravee*, ready in August, 1871, was taken out on trial. The Field boiler worked satisfactorily with wood fuel, and it was decided to run from Ipswich to Edinburgh and back, so that Thomson, who lived in Edinburgh as an invalid, could see the train. The same omnibus was taken as a trailer, but through the influence of the Government of India the limit of speed of four miles per hour under the Red Flag Act was not enforced, and a maximum of more than 25 miles an hour was achieved.

There was very little trouble with horses on the road; they stared at the engine, but were not greatly frightened, owing to the lack of any noise. The attitude of human spectators was, however, more varied. A certain amount of night running was done, and at one place the toll-gateman, who had closed and locked his gate for the night, refused to open it and let the train through. Crompton, in righteous indignation and in the satisfactory position of being on duty, gently opened the throttle, *Ravee* gently pressed against the gate, the gate flipped away into the adjoining field, and the train went on its way.

The run was entirely satisfactory; the distance was 424 miles, which was covered in 77 and 61¼ hours running time, going and returning respectively: on the last day of the return journey the average speed was about 10 miles per hour. Where the Great North Road ran parallel to the Great Northern Railway, the road train overtook and passed several goods trains travelling in the same direction.

At Edinburgh adhesion tests were carried out which gave a co-efficient of adhesion of 60 per cent. of weight on the driving wheel, a figure considerably in excess of that obtainable without rubber tyres. For wet weather the non-skid chains were replaced by clip shoes, which suffered less wear; in dry weather the running was on bare rubber, which, being prevented by the flanges from expanding sideways, had to expand in the direction of its length, the result being that the tyres "rolled out in front of the driving "wheels and actually left the polished steel treads, so that the "engine practically ran on the upper (inner ?) surface of a con-"tinuous track resembling the modern caterpillar track." This was not objectionable and friction on the inner side of the tyre was afterwards "taken up by transverse metal rods covered with "anti-friction metal." The train, being thus insulated by rubber from earth, acquired a high static electric charge which had to be dissipated by trailing a wire along the ground behind.

Crompton left for India in the autumn, and, being ordered to work the trains on the Grand Trunk road from Rawal Pindi to Attock (70 miles), spent the spring of 1872 in preliminary work. Two trains were running by the next autumn, but both engines broke their crankshafts within two months. "At that time "it was thought that as the driving wheels could slip, to a certain "extent inside their tyres, a differential gear was unnecessary, "but this view proved to be mistaken, for although this slip, un-"doubtedly, did take place and was sufficient to allow of accurate "steering round curves of great radius, on curves of small radius "the drivers were instructed to throw out of gear the wheel on "the inner side of the curve, but the drivers did not always obey "orders, and undoubtedly this was the cause of the crankshaft "failures." Differential gearing was designed by Mr. Monteith, of the Post Office (identical in every way with that fitted to the Super-Sentinel steam waggon, 1923), but owing to inadequate workshops could not then be carried out, and, instead, an alteration of gearing enabled the torsion strains to be shifted from the crankshaft to the countershaft.

During the winter of 1873 the trains were employed on manœuvres at Hassan Abdal with great success, and Lord Roberts, who was present, afterwards admitted that his subsequent belief in the value of mechanical transport originated with the excellent work done that winter by the steam trains..

At this time a Government Committee of Inquiry under the Chairmanship of Col. Hyde, R.E., with another R.E. Officer as a member, was investigating the progress and value of the road trains. The trains tested consisted of 19 vehicles of a gross load of about 70 tons and a paying load of 40 tons. The "wag of the tail" of such a procession was somewhat dangerous until eliminated by careful proportioning of coupling lengths.

The report of the Committee was very favourable, but the spread of railways of various gauges eventually rendered the road trains superfluous and they were handed over to the railway authorities about 1878.

During the progress of this interesting experiment a good many modern transport problems had to be faced and all were overcome with the exception of "side-slip."

II.

Colonel Crompton has seen such great strides made in methods of transport and has been personally involved in so many of them that his views on the future are of great value. It is of interest to compare them with the suggestions of Sir Alan Burgoyne, who delivered the second lecture referred to.

The latter confined himself to developments in the internal combustion engine. In the line of engine design, he prophecies the disappearance of the magneto, the poppet valve, and all drive by belts; the modification of the carburettor towards the elimination of jets; and the introduction of a super charger or "booster." This device, which is little known in this country outside technical circles, would undoubtedly be too much for the motor engine in its present form, but there seems no reason why the design should not be strengthened to stand it, and, once it has been applied, the main advantage of steam engines over I.C. engines—their reserve power—should largely be overtaken.

The extra power of the supercharger, utilized on gradients and backed by more powerful engines, should render gears eventually unnecessary; in the meantime gear changing by present methods may be replaced fairly soon by infinitely variable mechanism which may later become automatically actuated.

The possibility of the application of hydraulic action to gear and drive is an interesting speculation: four-wheel drive is already desirable under some circumstances, and the abolition of water cooling under others.

Col. Crompton, on the other hand, is a keen electrical man and hopes for a great future for the electrical vehicle. He believes that "the use of a rapidly reciprocating internal combustion engine "is not conducive to noiselessness, to economy or to low cost "of upkeep" and looks forward to its eventual supersession by a new engine on the lines of the gas turbine. Presumably in his mind the drawbacks of the I.C. engine apply to the Petrol-Electric type and, therefore, his electric vehicle will be either accumulator driven or else an entirely new development. Until accumulators can be reduced very greatly in weight, the economic use of vehicles driven by them is limited to those of heavy load and low speed, when they compete more with the road steamer.

The present difficulty with the gas turbine appears to be that of obtaining reasonable efficiency with the smaller types, say of less than 1,000 h.p.; but, in view of the fact that French designers have succeeded in getting high efficiency from turbines driven by the exhaust gases of an I.C. engine, it does not seem that the further development necessary to produce the gas turbine need be long delayed.

Two rather longer shots into the future were made, viz.: "The "direct production of electricity by the consumption of fuel, and, "secondly, the direct conversion, possibly through the thermionic "valve of wireless telephony, of those electro-magnetic waves "of energy which reach the earth from the sun."

One or two gaps are left in this picture of the future. Steering arrangements at present can hardly be termed perfect. The present lorry body leaves a great deal to be desired: the tendency is for the chassis to become more flexible; but, if the torsion in the springing is to be limited, the body must follow. For general utility long bodies there is a limit beyond which flexibility cannot go, and this will probably require new methods of suspension and shock-absorption, allowing easy, controlled, motion in three dimensions.

Neither speaker mentions the future of tyres or tracks. To have to pump up a tyre is in these days an anachronism as well as a nuisance, and substitutes for pneumatics for light as well as heavy vehicles are to be expected. For the heavy vehicle, modification of the track system may go a long way, and Col. Crompton with his early experience should take considerable interest in the track vehicles recently placed on the Swiss roads for heavy snow-work, where the drive is from rubber-tyred wheels, through rubber cogging to a rubber track.

Even if, in 100 years' time, the world may be dry of petrol, rubber will probably be in even greater use, for supply is expected to keep ahead of demand after five or ten years.

BATTLE HONOURS OF ROYAL ENGINEER UNITS.

ADDITIONS AND CORRECTIONS.

The last day of the Battle of the Aisne is 12th *October*, and not as previously published. The following is a corrected list for this Battle and should replace that published on pp. 240 and 241 of the June 1925 *R.E. Journal*.

AISNE, 1914. 12TH SEPTEMBER—12TH OCTOBER, 1914.

Unit.	Formation.		
CAVALRY CORPS.			
1st Field Sqn.	1st Cav. Div.	E.	
4th Field Troop.	2nd ,,	,,	Absorbed in 2nd Field Sqn 15th Oct.
I ARMY CORPS.			
23rd Field Co.	1st Div.	E.	
26th ,,	,,	,,	
5th Field Co.	2nd Div.	,,	
11th ,,	,,	,,	
II ARMY CORPS.			
56th Field Co.	3rd Div.	E.	
57th ,,	,,	,,	
17th Field Co.	5th Div.	,,	
59th ,,	,,	,,	
III ARMY CORPS.			
7th Field Co.	4th Div.	E.	
9th ,,	,,	,,	
12th Field Co.	6th Div.	,,	
38th ,,	,,	,,	
ARMY TROOPS.			
1st Bridging Train	I & II Corps.	E.	
2nd ,,	III Corps.	,,	
20th Fortress Co.	I Corps.	,,	Attached 2nd Div.
42nd ,,	II Corps.	,,	Attached 3rd Div.
	SIGNALS.		
Cavalry Corps Signal Sqn.	Cavalry Corps.	N.E.	
1st Signal Sqn.	1st Cav. Div.	E.	
2nd Signal Sqn.	2nd ,,	D.	No diary.
I Army Corps Signal Co.	I Army Corps	E.	
1st Divl. Signal Co.	,, ,,	,,	
2nd ,, ,, ,,	,, ,,	,,	
II Army Corps Signal Co.	II Army Corps	,,	
3rd Divl. Signal Co.	,, ,,	,,	
5th ,, ,, ,,	,, ,,	,,	
III Army Corps Signal	III Army Corps	,,	
4th Divl. Signal Co.	,, ,,	,,	
6th ,, ,, ,,	,, ,,	,,	

On page 89 of March 1926, *Journal*, the 1st. Field Sqdn. belonged to I *Cavalry* Division, not *Canadian*.

BATTLE HONOURS OF ROYAL ENGINEERS UNITS.

(Continued.)

BAPAUME, 1917. 17TH MARCH, 1917.

Unit.	Formation.		Remarks.
FIFTH ARMY.			
I ANZAC CORPS.			
5th Australian Fd. Co.	2nd Aust. Divn.	D.	
6th ,,	,,	E.	
7th ,,	,,	,,	
8th ,,	5th Aust. Divn.	D.	
2nd Aust. Divl. Sig. Co.	2nd Aust. Divn.	,,	
II CORPS.			
5th Field Co.	2nd Divn.	N.E.	In attack on Irles, 10th March.
226th ,,	,,	,,	In attack on Irles 10th March.
79th ,,	18th Divn.	,,	In attack on Irles 10th March.
80th ,,	,,	,,	In attack on Irles 10th March.
92nd ,,	,,	,,	In attack on Irles 10th March.

NOTE.—No fighting took place on the 17th March.
No other R.E. unit can be traced as within the area.
No Labour Battalion was within the area.

N.B.—"ARRAS, 1917" COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN ANY OF THE BATTLES FROM "VIMY" to "HILL 70."

VIMY, 1917. 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
No. 2 Special Co.	Special Bde. G.H.Q.	E.	
No. 4 ,,	,,	,,	
D ,,	,,	,,	
F ,,	,,	,,	
M ,,	,,	,,	
No. 4 Advanced R.E. Park	1st Army.	D.	No diary.
No. 8 ,,	,,	,,	No diary.
25th Army Troops Co.		N.E.	
31st ,,	I Corps.	,,	
134th ,,		,,	
215th ,,	I Corps.	,,	
285th ,,		D.	No diary.
552nd (Aberdeen) Army Troops Co.	XI Corps.	N.E.	
556th (Glamorgan) Army Troops Co.	,,	,,	
560th (Hants.) Army Troops Co.	I Corps.	,,	
1st Canadian Army Troops Co.	Canadian Corps.	E.	
2nd Canadian Army Troops Co.	,,	N.E.	
3rd Canadian Troops Troops Co.	,,	E.	
4th Canadian Army Troops Co.	,,	,,	

VIMY, 1917. 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
170th Tunnelling Co.	XI & I Corps.	N.E.	
172nd ,,	Canadian Corps.	E.	
173rd ,,	I Corps.	,,	
176th ,,	Canadian Corps.	,,	
182nd ,,	,,	,,	
185th ,,	,,	,,	
251st ,,	XI Corps.	N.E.	
253rd ,,	I Corps.	,,	
254th ,,		,,	
255th ,,	Canadian Corps.	D.	No diary.
257th ,,		N.E.	
3rd Australian Tunnelling Co.	I Corps.	,,	
197th Land Drainage Co.		D.	No diary.
350th Elect. & Mech. Co.		,,	No diary.
1st Field Survey Co.		,,	No diary.
2nd Forestry Dett.		,,	No diary.
No. 1 Pontoon Park	XI Corps.	N.E.	
I CORPS.			
103rd Field Co.	24th Divn.	N.E.	
104th ,,	,,	D.	
129th ,,	,,	E.	
223rd ,,	31st Divn.	N.E.	
CANADIAN CORPS.			
59th Field Co.	5th Divn.	E.	
491st (Home Counties) Field Co.	,,	,,	
527th (Durham) Field Co.	,,	,,	
1st Canadian Field Co.	1st Can. Divn.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th Canadian Field Co.	2nd Can. Divn.	,,	
5th ,,	,,	,,	
6th ,,	,,	,,	
7th Canadian Field Co.	3rd Can. Divn.	,,	
8th ,,	,,	,,	
9th ,,	,,	,,	
10th Canadian Field Co.	4th Can. Divn.	,,	
11th ,,	,,	,,	
12th ,,	,,	,,	

SIGNALS.

VIMY, 1917. 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
A Army Corps Signal Co.	I Corps.	N.E.	
24th Divl. Signal Co.	,,	,,	
Canadian Army Corps Signal Co.	Canadian Corps.	D.	
5th Divl. Signal Co.	,,	E.	
1st. Can. Divl. Sig. Co	,,	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	,,	,,	

SCARPE, 1917 (FIRST BATTLE). 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
25th Army Troops Co.	XIII Corps.	N.E.	
230th ,,		E.	
185th Tunnelling Co.	Canadian Corps.	D.	

SCARPE, 1917 (FIRST BATTLE). 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
THIRD ARMY.			
No. 1 Special Co. Sects. A. & B.	Special Bde.	E.	
No. 3 ,,	,,	,,	
J ,,	,,	,,	
O ,,	,,	,,	
Q ,,	,,	,,	
Z ,,	,,	,,	
No. 5 Advanced R.E. Park		D.	No diary.
No. 8 ,,		,,	No diary.
No. 12 ,,		,,	No diary.
178th Railway Co.		N.E.	
42nd Army Troops Co.	VI Corps.	E.	
132nd ,,	VII ,,	D.	
133rd ,,	VI ,,	E.	
141st ,,	XVIII ,,	N.E.	
144th ,,		D.	No diary.
145th ,,	VII ,,	N.E.	
146th ,,	VI ,,	E.	
147th ,,	VII ,,	N.E.	
221st ,,	XVII ,,	E.	
235th ,,	VII ,,	,,	
236th ,,		D.	No diary.
280th ,,	XVII ,,	E.	
283rd ,,	XVII ,,	D.	
288th ,,	VII ,,	E.	
289th ,,	XVII ,,	,,	
557th (Glamorgan) Army Troops Co.	VI ,,	N.E.	
179th Tunnelling Co.	VI ,,	E.	
181st ,,		N.E.	
184th ,,	XVII ,,	E.	
New Zealand Tunnelling Co.	VI ,,	,,	
352nd Elec. & Mech Co.		,,	
3rd Field Survey Co.		D.	No diary.
No. 3 Pontoon Park	VI & XVII Corps.	E.	
No. 3 Labour Bn. R.E.		N.E.	
No 1 Army Tramway Co.	XVII Corps.	,,	
No. 4 ,,	VI ,,	,,	
FIRST ARMY, XIII CORPS.			
5th Field Co.	2nd Divn.	E.	
226th ,,	,,	,,	
483rd (East Anglian) Field Co.	,,	,,	
207th Field Co.	34th Divn.	,,	
208th ,,	,,	,,	
209th ,,	,,	,,	
THIRD ARMY, CAVALRY CORPS.			
1st Field Squadron	1st Cav. Divn.	E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
VI CORPS.			
56th Field Co.	3rd Divn.	E.	
438th (Cheshire) Fld. Co.	,,	,,	
529th (East Riding) ,,	,,	,,	
69th Field Co.	12th Divn.	,,	
70th ,,	,,	,,	
87th ,,	,,	,,	
73rd ,,	15th Divn.	,,	
74th ,,	,,	,,	
91st ,,	,,	,,	

SCARPE, 1917 (FIRST BATTLE). 9TH-14TH APRIL, 1917.

Unit.	Formation		Remarks.
VI CORPS.			
77th ,,	17th Divn.	E.	
78th ,,	,,	,,	
93rd ,,	,,	,,	
455th (W. Riding) Fld. Co.	29th Divn.	,,	
497th (Kent) Fld. Co.	,,	,,	
510th London) ,,	,,	,,	
152nd Field Co.	37th Divn.	,,	
153rd ,,	,,	,,	
154th ,,	,,	,,	
VII CORPS.			
61st Field Co.	14th Divn.	E.	
62nd ,,	,,	,,	
89th ,,	,,	,,	
97th Field Co.	21st Divn.	,,	
98th ,,	,,	N.E.	
126th ,,	,,	E.	
504th ,,	58th Divn.	N.E.	Attached 21st Divn.
200th Field Co.	30th Divn.	E.	
201st ,,	,,	,,	
202nd ,,	,,	,,	
11th Field Co.	33rd Divn.	,,	
212th ,,	,,	,,	
222nd ,,	,,	N.E.	
7th Field Co.	50th Divn.	E.	
446th (Northn.) Fld. Co.	,,	,,	
447th ,,	,,	,,	
416th (Edinburgh) Fld. Co.	56th Divn.	,,	
512th (London) Fld. Co.	,,	,,	
513th ,,	,,	,,	
XVII CORPS.			
9th Field Co.	4th Divn.	E.	
526th (Durham) Field Co.	,,	,,	
406th (Renfrew) ,,	,,	,,	
63rd Field Co.	9th Divn.	,,	
64th ,,	,,	,,	
90th ,,	,,	,,	
400th (Highland) Fld. Co.	51st Divn.	,,	
401st ,,	,,	,,	
404th ,,	,,	,,	

SIGNALS.

SCARPE, 1917 (FIRST BATTLE). 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
First Army Signal Co.		N.E.	
N Corps Signal Co.	XIII Corps	D.	
2nd Divl. Signal Co.	2nd Divn.	E.	
34th ,,	34th ,,	,,	
Third Army Signal Co.		N.E.	
Cavalry Corps Signal Co.	Cavalry Corps	E.	
1st Signal Squadron	1st Cav. Divn.	,,	
2nd ,,	2nd ,,	,,	
3rd ,,	3rd ,,	,,	
F Corps Signal Co.	VI Corps.	D.	
3rd Divl. Signal Co.	3rd Divn.	E.	No diary.
12th ,,	12th ,,	,,	
15th ,,	15th ,,	,,	
17th ,,	17th ,,	,,	
29th ,,	29th ,,	,,	
37th ,,	37th ,,	,,	
C Corps Signal Co.	VII Corps.	D.	

SCARPE, 1917 (First Battle). 9th-14th April, 1917.

Unit.	Formation.		Remarks.
14th Divl. Signal Co.	14th Divn.	E.	
21st ,,	21st ,,	,,	
30th ,,	30th ,,	,,	
33rd ,,	33rd ,,	,,	
50th ,,	50th ,,	,,	
56th ,,	56th ,,	,,	
R Corps Signal Co.	XVII Corps.	D.	
4th Divl. Signal Co.	4th Divn.	E.	
9th ,,	9th ,,	,,	
51st ,,	51st ,,	,,	

SCARPE, 1917 (Second Battle). 23rd-24th April, 1917.

Unit.	Formation.		Remarks.
Third Army.			
No. 3 Special Co.	Special Bde.	E.	
J ,,	,,	,,	
O ,,	,,	,,	
Q ,,	,,	,,	
178th Railway Co.		,,	
25th Army Troops Co.	XIII Corps.	,,	
42nd ,,	VI ,,	,,	
132nd ,,	VII ,,	,,	
133rd ,,	VI ,,	,,	
145th ,,	VII ,,	,,	
146th ,,	VI ,,	,,	
221st ,,	XVII ,,	,,	
230th ,,	XIII ,,	D.	
235th ,,	VII ,,	E.	
280th ,,	XVII ,,	,,	
283rd ,,	XVII ,,	N.E.	
288th ,,	VII ,,	E.	
289th ,,	XVII ,,	,,	
179th Tunnelling Co	VI ,,	D.	
181st ,,		E.	
184th ,,	XVII Corps.	,,	
New Zealand Tunnelling Co.	VI ,,	,,	
352nd Elec. & Mech Co.		,,	
No. 3 Pontoon Park	VI & XVII Corps.	E.	
No. 1 Army Tramway Co.		D.	
No. 4 ,,	VI Corps.	E.	
First Army, XII Corps.			
247th Field Co.	63rd (R.E.) Div.	N.E.	
248th ,,	,,	E.	
249th ,,	,,	,,	
Third Army, VI Corps.			
73rd Field Co.	15th Divn.	,,	
74th ,,	,,	,,	
91st ,,	,,	,,	
77th ,,	17th Divn.	,,	
78th ,,	,,	,,	
93rd ,,	,,	,,	
455th (W. Riding) Fld. Co.	29th Divn.	,,	
497th (Kent) Fld. Co.	,,	,,	
510th (London) ,,	,,	,,	
56th Field Co.	3rd Divn.	,,	
438th (Cheshire) Fld. Co.	,,	,,	
529th (East Riding) ,,	,,	,,	
VII Corps.			
200th Field Co.	30th Divn.	E.	
201st ,,	,,	,,	
202nd ,,	,,	,,	

SCARPE, 1917 (SECOND BATTLE). 23RD-24TH APRIL, 1917.

Unit.	Formation.		Remarks.
VII CORPS.			
11th Field Co.	33rd Divn.	E.	
212th ,,	,,	,,	
222nd ,,	,,	,,	
7th ,,	50th Divn.	,,	
446th (Northn.) Fld. Co.	,,	,,	
447th ,,	,,	,,	
XVII CORPS.			
152nd Field Co.	37th Divn.	E.	
153rd ,,	,,	,,	
154th ,,	,,	,,	
400th (High.) Field Co.	51st Divn.	,,	
401st ,,	,,	,,	
404th ,,	,,	,,	
207th Field Co.	34th Divn.	,,	
208th ,,	,,	,,	
209th ,,	,,	,,	

SIGNALS.

SCARPE, 1917 (SECOND BATTLE). 23RD-24TH APRIL, 1917.

Unit.	Formation.		Remarks.
First Army Signal Co.		N.E.	
N Corps Signal Co.	XIII Corps.	D.	
63rd Divl. Signal Co.	63rd Divn.	E.	
Third Army Signal Co.		N.E.	
F Corps Signal Co.	VI Corps.	D.	
15th Divl. Signal Co.	15th Divn.	E.	
17th ,,	17th ,,	,,	
29th ,,	29th ,,	,,	
3rd ,,	3rd ,,	D.	Diary missing.
G Corps Signal Co.	VII Corps.	,,	,,
30th Divl. Signal Co.	30th Divn.	E.	
33rd ,,	33rd ,,	,,	,,
50th ,,	50th ,,	,,	
R Corps Signal Co.	XVII Corps.	D.	
37th Divl. Signal Co.	37th Divn.	E.	
51st ,,	51st ,,	,,	
34th ,,	34th ,,	D.	

ARLEUX. 28TH-29TH APRIL, 1917.

Unit.	Formation.		Remarks.
FIRST AND THIRD ARMIES.			
No. 3 Special Co.	Special Bde.	E.	
O ,,	,,	,,	
Q ,,	,,	,,	
178th Railway Co.		D.	
261st ,,	XIII Corps.	N.E.	
25th Army Troops Co.	XIII ,,	E.	
42nd ,,	VI ,,	,,	
133rd ,,	VI ,,	,,	
146th ,,	VI ,,	,,	
221st ,,	XVII ,,	,,	
230th ,,	XIII ,,	,,	
280th ,,	XVII ,,	,,	
283rd ,,	XVII ,,	N.E.	
289th ,,	XVII ,,	E.	
176th Tunnelling Co.	Canadian ,,	D.	
79th ,,	VI ,,	E.	
184th ,,	XVII ,,	,,	
185th ,,	Can. ,,	N.E.	
New Zealand Tunnelling Co.	VI ,,	E.	
No. 3 Pontoon Park	VI & XVII Corps.	,,	
No. 1 Army Tramway Co.		,,	
No. 4 ,,	VI Corps.	,,	

ARLEUX, 28TH-29TH APRIL, 1917.

Unit.	Formation		Remarks.
FIRST ARMY, XIII CORPS.			
5th Field Co.	2nd Divn.	E.	
226th ,,	,,	,,	
483rd (East Anglian) Field Co.	,,	,,	
274th Field Co.	63rd (R.N.) Divn.	,,	
248th ,,	,,	D.	
249th ,,	,,	E.	
CANADIAN CORPS.			
1st Canadian Field Co.	1st Can. Divn.	E.	
2nd ,,	,,	D.	
3rd ,,	,,	N.E.	
4th ,,	2nd Can. Divn.	D.	
5th ,,	,,	E.	
6th ,,	,,	,,	
THIRD ARMY, VI CORPS.			
56th Field Co.	3rd Divn.	E.	
438th (Cheshire) Fld. Co.	,,	,,	
529th (E. Riding) ,,	,,	,,	
69th Field Co.	12th Divn.	,,	
70th ,,	,,	,,	
87th ,,	,,	D.	
XVII CORPS.			
207th Field Co.	34th Divn.	E.	
208th ,,	,,	,,	
209th ,,	,,	,,	
152nd ,,	37th Divn.	,,	
153rd ,,	,,	,,	
154th ,,	,,	,,	
400th (High.) Field Co.	51st Divn.	N.E.	
401st ,,	,,	E.	
404th ,,	,,	,,	

SIGNALS.

ARLEUX. 28TH-29TH APRIL, 1917.

Unit.	Formation.		Remarks.
First Army Signal Co.		N.E.	
N Corps Signal Co.	XIII Corps.	D.	
2nd Divl. Signal Co.	2nd Divn.	E.	
63rd ,,	63rd (R.N.) Div.	,,	
Canadian Corps Sig. Co.	Can. Corps.	N.E.	
1st Can. Divl Sig. Co.	1st Can. Divn.	E.	
2nd ,,	2nd ,,	,,	
Third Army Signal Co.		N.E.	
F Corps. Signal Co.	VI Corps.	D.	
3rd Divl. Signal Co.	3rd Divn.	E.	
12th ,,	12th Divn.	,,	
R Corps Signal Co.	XVII Corps.	D.	
34th Divl. Signal Co.	34th Divn.	E.	
37th ,,	37th Divn.	,,	

SCARPE, 1917 (THIRD BATTLE). 3RD-4TH MAY, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
No. 4 Advanced R.E. Park		D.	No diary.
20th Army Troops Co.	XIII Corps.	E.	
25th ,,	,,	,,	
31st Army Troops Co.		N.E.	
215th ,,		,,	
230th ,,	XIII Corps.	,,	
285th ,,		D.	No diary.
560th (Hants.) Army Troops Co.		N.E.	

SCARPE, 1917 (THIRD BATTLE). 3RD-4TH MAY, 1917.

Unit.	Formation.	E.	Remarks.
FIRST ARMY.			
1st Can. Army Troops Co.	Can. Corps.	N.E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	,,	,,	
170th Tunnelling Co.		,,	
172nd ,,	Can. Corps.	,,	
176th ,,	XIII Corps.	E.	
182nd ,,	Can. Corps.	N.E.	
185th ,,		,,	
253rd ,,		,,	
255th ,,	Can. Corps.	,,	
261st Railway Co.	XIII Corps.	,,	
350th Elect. & Mech Co.		,,	
1st Field Survey Co.		D.	No diary.
No. 1 Pontoon Park		,,	No diary.
No. 7 Army Tramway Co.		,,	No diary.
FIRST ARMY, XIII CORPS.			
5th Field Co.	2nd Divn.	E.	
226th ,,	,,	D.	
483rd (East Anglian) Field Co.	,,	N.E.	
59th Field Co.	5th Divn.	,,	
491st (Home Counties) Field Co.	,,	E.	
527th (Durham) Fld. Co.	,,	D.	
210th Field Co.	31st Divn.	E.	
211th ,,	,,	,,	
223rd ,,	,,	,,	
247th ,,	63rd (R.N.) Div.	N.E.	Under C.E. XIII Corps.
248th ,,	,,	,,	,,
249th ,,	,,	D.	Under C.R.E. 31st Div.
CANADIAN CORPS.			
1st Canadian Field Co.	1st Can. Divn.	N.E.	
2nd ,,	,,	E.	
3rd ,,	,,	D.	No diary.
4th ,,	2nd Can. Divn.	E.	
5th ,,	,,	,,	
6th ,,	,,	,,	
7th ,,	3rd Can. Divn.	N.E.	
8th ,,	,,	,,	No diary.
9th ,,	,,	,,	
THIRD ARMY.			
O Special (Cylinder) Co.	Special Bde.	E.	
Q ,,	,,	,,	
No. 3 Special (Mortar) Co.	,,	,,	
J Special (Cylinder) Co.	,,	D.	
No. 5 Advanced R.E. Park		,,	No diary.
No. 8 Advanced R.E. Park		,,	No diary.
No. 12 Advanced R.E. Park		,,	No diary.
42nd Army Troops Co.		N.E.	
132nd ,,	VII Corps.	,,	
133rd ,,		,,	
144th Army Troops Co.		D.	No diary.
145th ,,	VII Corps.	E.	
146th ,,		N.E.	
147th ,,		E.	
221st ,,	XVII Corps.	,,	
235th ,,	VII ,,	,,	
236th ,,	XVII ,,	N.E.	

SCARPE, 1917 (THIRD BATTLE). 3RD-4TH MAY, 1917.

Unit.	Formation.		Remarks.
THIRD ARMY			
280th Army Troops Co.	XVII Corps.	E.	
288th ,,	VII ,,	,,	
289th ,,	XVII ,,	,,	
557th (Glamorgan) Army Troops Co.	VI ,,	N.E.	
179th Tunnelling Co.		E.	
181st ,,	VII Corps.	,,	
184th ,,	XVII ,,	,,	
New Zealand Tunnelling Co.		,,	
352nd Elec. & Mech. Co.	VII Corps.	N.E.	No diary.
3rd Field Survey Co.		D.	No diary.
No. 3 Pontoon Park		N.E.	
No. 3 Labour Bn. R.E.	VII & XVII Corps.	,,	
No 1 Army Tramway Co.	XVII Corps.	D.	
No. 3 ,,	VI ,,	N.E.	
No. 5 ,,		D.	No diary.
VI CORPS.			
56th Field Co.	3rd Divn.	E.	
438th (Cheshire) Fld. Co.	,,	,,	
529th (E. Riding) ,,	,,	,,	
69th Field Co.	12th Divn.	,,	
70th ,,	,,	,,	
87th ,,	,,	,,	
416th (Edinburgh) Fld. Co.	56th Divn.	,,	
512th (London) Fld. Co.	,,	,,	
513th ,,	,,	N.E.	
VII CORPS.			
61st Field Co.	14th Divn.	E.	
62nd ,,	,,	,,	
89th ,,	,,	,,	
79th ,,	18th Divn.	,,	
80th ,,	,,	,,	
92nd ,,	,,	,,	
97th ,,	21st Divn.	,,	
98th ,,	,,	,,	
126th ,,	,,	N.E.	
XVII CORPS.			
9th Field Co.	4th Divn.	E.	
526th (Durham) Fld. Co.	,,	,,	
406th (Renfrew) ,,	,,	,,	
63rd Field Co.	9th Divn.	,,	
64th ,,	,,	,,	
90th ,,	,,	,,	
77th ,,	17th Divn.	N.E.	
78th ,,	,,	,,	
93rd ,,	,,	,,	

SIGNALS.

SCARPE, 1917 (THIRD BATTLE). 3RD-4TH MAY, 1917.

Unit.	Formation.		Remarks.
First Army Signal Co.	First Army	N.E.	
N Corps Signal Co.	XIII Corps	D.	
2nd Divl. Signal Co.	2nd Divn.	E.	
5th ,,	5th ,,	D.	
31st ,,	31st ,,	E.	
Canadian A.C. Sig. Co.	Can. Corps	D.	
1st Can. Divl. Sig. Co.	1st Can. Divn.	E.	
2nd ,,	2nd ,,	,,	
3rd ,,	3rd ,,	D.	
Third Army Signal Co.	Third Army	N.E.	

SCARPE, 1917 (THIRD BATTLE). 3RD-4TH MAY, 1917.

Unit.	Formation.		Remarks.
F Corps Signal Co.	VI Corps	N.E.	
3rd Divl. Signal Co.	3rd Divn.	E.	
12th ,,	12th ,,	,,	
56th ,,	56th ,,	,,	
G Corps Signal Co.	VII Corps	D.	
14th Divl. Signal Corps	14th Divn.	E.	
18th ,,	18th ,,	,,	
21st ,,	21st ,,	,,	
R. Corps Signal Co.	XVII Corps	D.	
4th Divl. Signal Co.	4th Divn.	E.	
9th ,,	9th ,,	,,	
17th ,,	17th ,,	D.	

OPPY, 28TH JUNE, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
XIII CORPS.			
59th Field Co.	5th Divn.	E.	
491st (Home Counties) Field Co.	,,	N.E.	
527th (Durham) Fld. Co.	,,	E.	
210th Field Co.	31st Divn.	,,	
211th ,,	,,	,,	
223rd ,,	,,	,,	

SIGNALS.
OPPY. 28TH JUNE, 1917.

Unit.	Formation.		Remarks.
N Corps Signal Co.	XIII Corps	N.E.	
5th Divl. Signal Co.	5th Divn.	E.	
31st ,,	31st ,,	,,	

BULLECOURT. 3RD-17TH MAY, 1917.

Unit.	Formation.		Remarks.
FIFTH ARMY.			
No. 7 Advanced R.E. Park		N.E.	No diary.
138th Army Troops Co.	1 Anzac Corps	,,	
148th ,,		,,	
149th ,,		,,	
559th (Hants) Troops Co.	V Corps	,,	
567th (Devon) ,,		,,	
577th (Sussex) ,,		,,	No diary.
No 2 Siege Co. R. Anglesey	1 Anzac Corps	,,	
No. 1 Siege Co. R. Monmouth	V Corps	,,	
174th Tunnelling Co.	,,	E.	
252nd ,,	,,	N.E.	
258th ,,	1 Anzac Corps	E.	
354th Elec. & Mech. Co		N.E.	
5th Field Survey Co.		,,	
No. 7 Pontoon Park	1 Anzac Corps	,,	
No. 2 Labour Bn. R.E.		,,	
No. 6 ,,		,,	
No. 9 ,,		,,	
No. 11 ,,		,,	
V CORPS.			
54th Field Co.	7th Divn.	E.	
95th ,,	,,	,,	
528th (Durham) Field Co.	,,	,,	
503rd (Wessex) Fld. Co.	58th Divn.	,,	
504th ,, ,,	,,	,,	
511th (London) ,,	,,	,,	
457th (W. Riding) ,,	62nd Divn.	D.	

BULLECOURT. 3RD-17TH MAY, 1917.

Unit.	Formation.		Remarks.
V CORPS.			
460th (W. Riding) Fld. Co.	62nd Divn.	D	
461st ,, ,,	,,	E.	
I ANZAC CORPS.			
1st Aust. Field Co.	1st Aust. Div.	N.E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
5th ,,	2nd Aust. Div.	E.	
6th ,,	,,	,,	
7th ,,	,,	,,	
8th ,,	5th Aust. Div.	D.	
14th ,,	,,	E.	
15th ,,	,,	,,	

SIGNALS.
BULLECOURT, 3RD-17TH MAY, 1917.

Unit.	Formation.		Remarks.
Fifth Army Signal Co.	5th Army	N.E.	
O Corps Signal Co.	V Corps	,,	
7th Divl. Signal Co.	7th Divn.	E.	
58th ,,	58th ,,	,,	
62nd ,,	62nd ,,	,,	
K Corps Signal Co.	1 Anzac Corps	N.E.	
1st Aust. Div. Signal Co.	1st Aust. Div.	D.	
2nd ,,	2nd ,,	E.	
5th ,,	5th ,,	,,	

HILL 70. 15TH-25TH AUGUST, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
B Special (Cylinder) Co.	Special Bde.	E.	
O ,,	,,	,,	
No 4 Special (Mortar) Co.	,,	,,	
No. 1 Advanced R.E. Park.		D.	No diary.
No. 4 Advanced R.E. Park		,,	No diary.
25th Army Troops Co.	XIII Corps	N.E.	
31st ,,	I Corps	,,	
215th ,,		,,	
230th ,,	XIII Corps	,,	
560th (Hants) Army Troops Co.		,,	
1st Can. Army Troops Co.	Can. Corps	,,	
2nd ,,	,,	,,	
3rd ,,	,,	E.	
4th ,,	,,	N.E.	
5th ,,	,,	,,	
170th Tunnelling Co.	I Corps	,,	
172nd ,,	Can. Corps	E.	
176th ,,	XIII Corps	N.E.	
182nd ,,	Can. Corps	D.	
185th ,,		N.E.	
3rd Aust. ,,	Can. Corps	E.	
196th Land Drainage Co.		N.E.	No diary.
350th Elec. & Mech. Co.		,,	No diary.
No. 1 Field Survey Co.		,,	No diary.
No. 1 Pontoon Park		,,	No diary.
No. 7 Army Tramway Co.		,,	No diary.
FIRST ARMY. I CORPS.			
12th Field Co.	6th Divn.	E.	
459th (West Riding) Fld. Co.	,,	N.E.	
509th (London) Fld. Co.	,,	,,	
465th (N. Midland) ,,	46th Divn.	,,	
466th ,, ,,	,,	E.	
468th ,, ,,	,,	D.	

HILL 70. 15TH-25TH AUGUST, 1917.

Unit.	Formation.		Remarks
CANADIAN CORPS.			
1st Can. Field Co.	1st Can. Div.	E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	2nd Can. Div.	,,	
5th ,,	,,	,,	
6th ,,	,,	,,	
7th ,,	3rd Can. Div.	,,	
8th ,,	,,	,,	
9th ,,	,,	,,	
10th ,,	4th Can. Div.	,,	
11th ,,	,,	,,	
12th ,,	,,	,,	

SIGNALS.

HILL 70. 15TH-25TH AUGUST, 1917.

Unit.	Formation.		Remarks.
First Army Signal Co.	1st Army	N.E.	
A Corps Signal Co.	I Corps	D.	
6th Divl. Signal Co.	6th Divn.	,,	
46th ,,	46th ,,	,,	
Canadian Corps Sig. Co.	Can. Corps	,,	
1st Can. Divl. Sig. Co.	1st Can. Div.	E.	
2nd ,,	2nd ,,	,,	
3rd ,,	3rd ,,	,,	
4th ,,	4th ,,	,,	

MESSINES, 1917. 7TH-14TH JUNE, 1917.

Unit.	Formation.		Remarks.
SECOND ARMY.			
A Special (Cylinder) Co.	Special Bde.	E.	
K ,,	,,	,,	
L ,,	,,	,,	
O ,,	,,	,,	
P. ,,	,,	,,	
Z Special (Projector) Co.	,,	,,	
No. 2 Spec. (Mortar) Co.	,,	,,	
No. 3 ,,	,,	,,	
171st Tunnelling Co.	II Anzac Corps	,,	
175th ,,	IX Corps	D.	
177th ,,		N.E.	
183rd ,,	X Corps	E.	
250th ,,	IX Corps	,,	
1st Can. Tunnelling Co.	IX Corps	,,	
2nd ,,	X Corps	,,	
3rd ,,	II Anzac Corps	,,	
1st Aus. Tunnelling Co.		,,	
2nd ,,	X Corps	D.	Diary missing.
136th Army Troops Co.		,,	No diary.
167th ,,	IX Corps	E.	
216th ,,	II Anzac Corps	,,	
236th ,,	X Corps	D.	No diary.
285th ,,	IX Corps	,,	No diary.
290th ,,	II Anzac Corps	E.	
554th (Dundee) Army Troops Co.	,,	,,	
567th (Devon) Army Troops Co.	X Corps	,,	
568th (Devon) Army Troops Co.	,,	N.E.	
573rd (Cornwall) Army Troops Co.	,,	,,	
No. 4 Siege Co. R. Monmouth	,,	E.	
No. 351 E. & M. Co.		N.E.	No diary.

MESSINES, 1917. 7TH-14TH JUNE, 1917.

Unit.	Formation.	E.	Remarks.
SECOND ARMY.			
2nd Field Survey Co.		D.	No diary.
No. 2 Pontoon Park		N.E.	
No. 5 Labour Bn. R.E.		,,	
No. 7 ,,		D.	No diary.
No. 4 Army Tramway Co.	II Anzac Corps.	N.E.	
No. 8 ,,		D.	No diary.
IX CORPS.			
67th Field Co.	11th Divn.	E.	
68th ,,	,,	,,	
86th ,,	,,	,,	
155th ,,	16th Divn.	,,	
156th ,,	,,	,,	
157th ,,	,,	,,	
81st ,,	19th Divn.	,,	
82nd ,,	,,	,,	
94th ,,	,,	,,	
121st ,,	36th Divn.	,,	
122nd ,,	,,	,,	
150th ,,	,,	,,	
X CORPS.			
101st Field Co.	23rd Divn'	E.	
102nd ,,	,,	,,	
128th ,,	,,	,,	
103rd ,,	24th, Divn.	,,	
104th ,,	,,	,,	
129th ,,	,,	,,	
228th ,,	41st Divn.	,,	
233rd ,,	,,	,,	
237th ,,	,,	,,	
517th ,,	47th Divn.	,,	
518th ,,	,,	,,	
520th ,,	,,	,,	
II ANZAC CORPS.			
105th Field Co.	25th Divn.	E.	
106th ,,	,,	,,	
130th ,,	,,	,,	
9th Australian Fld. Co.,	3rd Aust. Div.	,,	
10th ,,	,,	,,	
11th ,,	,,	,,	
4th ,,	4th Aust. Div.	,,	
12th ,,	,,	,,	
13th ,,	,,	,,	
1st New Zealand Fld. Co.	N.Z. Divn.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	,,	,,	

SIGNALS.

MESSINES, 1917. 7TH-14TH JUNE, 1917.

Unit.	Formation.		Remarks.
Second Army Signal Co.	2nd Army	N.E.	
Corps Signal Co.	IX Corps	E.	
11th Divl. Signal Co.	11th Divn.	,,	
16th ,,	16th ,,	,,	
19th ,,	19th ,,	,,	
36th ,,	36th ,,	,,	
X Corps Signal Co.	X Corps	D.	
23rd Divl. Signal Co.	23rd Divn.	E.	
24th ,,	24th ,,	,,	
41st ,,	41st ,,	,,	
47th ,,	47th ,,	,,	
Y Corps Signal Co.	II Anzac Corps	D.	
25th Divl. Signal Co.	25th Divn.	E.	
3rd Aust. ,,	3rd Aust. Divn.	,,	
4th Aust. ,,	4th Aust. Divn.	,,	
New Zealand ,,	N.Z. Divn.	,,	

SOME HOUSING EXPEDIENTS.

By Captain G. Streeten, M.C., R.E.

Introduction.

The Housing Problem has been dealt with at such length in the Press that there is no need to point out the necessity for the speedy erection of a large number of houses for all classes of society and mainly for the so-called working classes. The present shortage of houses is due largely to the fact that very little building was carried out during the late war.

The demand cannot be satisfied by the sole use of normal brick construction for the following reasons:—

1. Shortage of skilled labourers, chiefly bricklayers and plasterers.
2. Difficulty in obtaining a sufficient quantity of bricks.
3. Increase in the cost of building due to the high rates for labour and the price of materials. It is impossible to build houses of normal brick construction at a price such that a reasonable economic rent can be asked. Some cheaper form of construction is desirable—if it can be found. However, it is questionable whether any of the various types of construction examined below do show an appreciable saving over brickwork.
4. The brick house takes too long to build and speedier erection is necessary if the demand is to be met.

Attempts have been made on an extensive scale to overcome these difficulties. The use of materials other than brick and plaster is being tried out. In many cases it has been found impossible to eliminate the bricklayer and plasterer altogether, but the work necessitating these trades has been considerably reduced. Bricks have been replaced to a great extent by steel, timber and concrete. Asbestos cement and various types of wall board are being used instead of plaster.

Economy in construction has been attained in various ways. Where a large number of houses of one type are required, mass production of the main components is found possible, notably in connection with steel and timber construction. The use of concrete on sites where the aggregate is easily obtainable has reduced the cost of transport of materials. Much of the internal joinery now used is standardised and constructed on mass production lines. For example, a glance at the advertisements in any building periodical will show a number of manufacturers of stock doors. These are mainly Continental or American, but Canada produces equally good, if not superior, doors at much the same price. Standard steel casement windows are also made by many firms. They are in most cases cheaper than wooden casements.

The cost of building is also somewhat reduced by the use of unskilled or semi-skilled labour to a greater extent than formerly. This is possible owing to the introduction of simplified forms of construction.

Cheaper materials are now being used. For instance on roofs, asbestos cement tiles have very largely replaced slates and clay tiles. The saving in cost is due to some extent to the fact that the roof timbers may be lighter with this type of covering. Cheap French and Belgian tiles are also being used largely in Housing Schemes.

The speed of erection is often increased by the use of types of construction other than brick. In some cases timber and steel sections, fabricated in workshops in large quantities, are sent to the site all ready marked for erection. They then take only a comparatively short time to put together, especially when a number of houses of the same type are to be built and the erection gang becomes practised.

By the use of a steel framework, with panels filled with brick or concrete, the roof may be put on early, thus preventing delays due to bad weather.

The preparation of carcassing for roofs, joinery etc., in workshops makes also for increased speed of erection.

There are, however, certain disadvantages inherent in some of the new types of construction which did not apply to brick houses. Where the building is made up of components fabricated by mass production in the workshop, there is apt to be lack of elasticity in design. In many cases only a small number of designs is catered for and it is impossible to vary the design without extra cost, which may entirely cancel any saving due to mass production. In other cases it may be possible to vary the design to a certain extent but the hands of the architect are tied by the fact that the size of the unit with which he has to build is very much greater than the brick. For example, in the Cuypers timber house, described below, the unit is a section measuring 4 ft. by 9 ft.

Another disadvantage, apparent particularly in timber and steel houses which have to be painted and to some extent in those concrete houses which have to be rough cast, is the increased cost of maintenance. This is often heavy compared with expenditure necessary for pointing brickwork.

NEW TYPES OF CONSTRUCTION.

The new types of construction in use at the present time may be divided up roughly into the following categories :—

(*a*) Steel frame, (*b*) Steel, (*c*) Wood, (*d*) Concrete.

It is proposed to examine in some detail one variety of each type and to touch lightly on a few of the other varieties.

(*a*) STEEL FRAME.

DORMAN LONG.

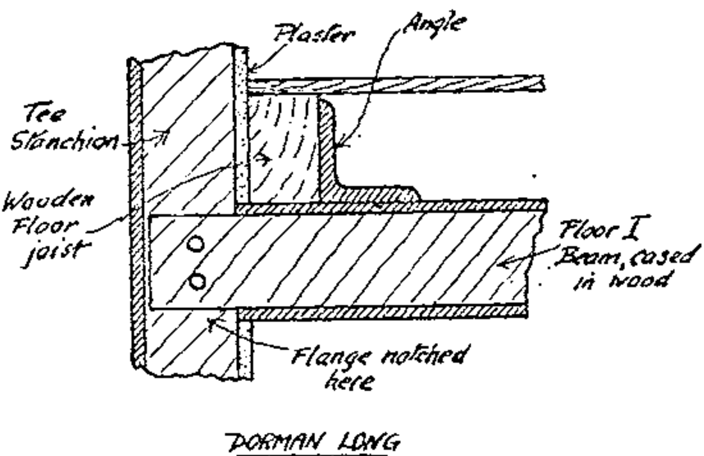
(The Dorman Housing Co., Ltd., 4, Central Buildings, Westminster, S.W.1.)

Description.—Ordinary foundations are laid. These vary of course with the nature of the soil, but the normal system is a concrete wall 18″ wide and 12″ deep forming the surround of a concrete raft 6″ thick composed of a 2″ layer of breeze concrete over 4″ of ballast concrete.

A bitumen sheet damp-proof course is laid on the concrete wall. This carries a steel cill plate on which the steel frame work is erected. The cill is secured to the concrete by means of Lewis bolts at 4 ft. intervals grouted in solid with cement.

The framework consists of vertical steel tees, 4′ 0⅞″ centre to centre, all round the building. The only places where this spacing is varied are where the chimney flues come in the outside walls. Here the stanchions are somewhat further apart. The feet of these tees are fixed to the cill plate. The stanchions are tied together at first floor level by means of an angle, and at eaves level by means of a steel flat, both of which completely surround the building.

At first floor level steel joists are carried across the building from back to front. These are attached to the tee stanchions by bolting their webs thereto after the flanges have been notched, as shown in Fig. 1.



DORMAN LONG
Fig. 1.

These steel joists carry the timber floor joists.

The panels between the stanchions are filled with blocks made up of breeze concrete and corkboard. The corkboard is composed of granulated cork compressed in moulds and baked. Its finished thickness is 1½″. It has been tested at the National Physical Laboratory, and it was found that it did not swell appreciably after being soaked in water for some hours. A slab of this corkboard 4ft. by 1ft. is placed in a mould and covered with a mixture of breeze and cement. When rammed, the finished thickness of the breeze concrete, which adheres well to the corkboard, is 2″, making a total thickness of 3½″ for the block.

These blocks are erected to fill the space between the stanchions, the corkboard being placed towards the outside of the building. They are laid in cement mortar and rest against the flanges of the tee stanchions.

Stout welded wire mesh reinforcement is then attached to the exterior of the steel frame by wire ties at every 18″ vertically. The reinforcement is kept just clear of the corkboard slabs by means of small steel chairs which rest against the cork. Additional reinforcement is provided diagonally across the corners of all openings and down each of the angles of the building, to prevent the outer covering cracking at these points. The outer covering, consisting of rendering (1 cement, 2 sand and 2 gravel or stone chips), is applied under pressure by means of a cement gun. The finished thickness of the "gunnite" is 2″. The surface may be smooth, stippled or rough cast. String courses may be provided and the gunnite may be coloured if desired.

The interior is finished with cement or plaster applied by means of the gun or by hand, to a thickness of ½″.

The party wall between two semi-detached houses is composed of slabs of 1½″ corkboard with 2″ of breeze concrete on each side, both sides being plastered.

Partitions are of 2″ breeze concrete plastered. They carry no weight.

Wall board, of which there are a number of types on the market, may be used for internal finish, instead of plaster.

Ordinary timber roofs covered with tiles or slates are provided. Timber is used in preference to steel, as it is considered that more scope is given thereby to the architect to vary his elevation.

Fireplaces and chimneys are built in brickwork. Standard steel casement windows are provided.

Cost.—This type of construction is probably no cheaper than brickwork, unless the aggregate is easily obtainable and from 30 to 50 houses are built at one time, thus allowing for repetition in steelwork.

Remarks.—The insulation properties of the walls are very good. There is no possibility of the insulation being impaired by means of convection currents within the wall, as may be the case with ordinary hollow brick construction.

The walls are sound proof.

The roof may be erected directly the framework is completed and "wet" time saved thereby. The steelwork for a pair of parlour type houses can be erected by four men in one day. The heaviest member does not exceed 2 cwt.

It is claimed that there is no condensation on the inside walls, and this is a reasonable claim owing to the good insulating properties of the walls.

Very little skilled labour is employed. Owing to the closeness of the stanchions the breeze and corkboard blocks can be laid by unskilled labour. No plasterers are required to rough cast the outside, as is usually the case with concrete construction. The gunnite is very dense, being applied at a pressure of 60 lbs. per sq. in. Consequently the outside walls are waterproof, and there should be no danger of the corkboard becoming wet.

The position of the stanchions at 4′ 0⅞″ centres rather limits the scope of the architect in design, as the windows and doors must come in the panels between the stanchions, and the length of the building is limited to some multiple of 4′ 0⅞″. The width of the building can, however, be varied if the chimney flues are in the outside walls, as the distance apart of the stanchions on either side of the flues is not fixed.

Some of these houses are being erected by the Air Ministry near Wendover.

DENNIS WILD.

(Messrs. James Wild & Co. (Housing) Ltd., Engineers, 49, Deansgate, Manchester).

Description.—This is another type of steel frame building. In this case the steel stanchions are bolted to padstones formed on a reinforced concrete raft, which acts as a foundation for the ground floor walls. The stanchions are arranged within the thickness of the walls and are completely cased in concrete up to the roof.

On the ground floor, the panels between the stanchions are filled by means of an outer shell of 4½″ brickwork and an inner shell of breeze concrete slabs, an air cavity being formed between the shells. On the first floor, the walls consist of timber framing hung externally with slates or tiles, backed with a lining of "Ruberoid" or similar material. They are lined internally with breeze concrete slabs. This system is not rigidly adhered to for the first floor walls. They may be constructed with bricks or concrete slabs externally or poured concrete may be used.

The roof covering is of tiles supported by patent cradle roof trusses. These are composite trusses of timber and steel.

The fireplaces and chimneys are built in brickwork.

Cost.—It is stated by Messrs. Wild that this type of construction is cheaper than brickwork, but it is questionable whether this is actually the case, unless a large number of similar houses are built at one time.

Remarks.—Less than one-third of the bricks required for an all brick house are used, where the walls of the first floor are of tiles on timber framing. The bricklayer is therefore largely eliminated. As the exterior walls do not have to be rough cast and ceiling boards are used instead of plaster, the work of the plasterer is reduced to some extent.

The design of the building can be varied to a greater extent than is possible with the Dorman Long house, as the distance apart of the stanchions is not fixed, owing to the nature of the filling used in the panels between them.

The roof can be erected early, thus saving "wet" time and allowing scope for the continuous employment of all trades.

The steel framework can be used as scaffolding.

The houses can be built more quickly than brick houses. A block of 4 houses was finished ready for occupation at Blackpool in January, 1925, in 9 days after the foundations had been laid.

Messrs. Wild do not actually erect the houses, but supply the steel framework and cradle trusses and supervise the erection, which is carried out by one of their licensed contractors.

Nissen-Petren.

(Nissen-Petren Houses, Ltd., 75b, Queen Victoria Street, E.C.4).

Description.—This type of construction is quite different from the two already described, but may also be termed steel frame construction.

Concrete foundations are laid and semi-circular steel ribs are erected thereon, each being bolted to the concrete with two bolts. The ribs are each sent in five parts, which are bolted together on the site. Up to about the height of the ground floor ceilings, walling of any normal type, such as hollow brickwork, 9" brickwork rough-cast, concrete blocks, etc., is erected on the concrete foundations outside the steel ribs along the length of the building. The ends of the building are filled in with the same type of construction. The upper portion of the steel ribs forms the support for the roof covering, which consists of Robertson's Asbestos Protected Metal. It is fixed to wooden purlins, which are supported by the upper portion of the steel ribs. Roofing of asbestos cement slates is, however, being introduced as an alternative.

The fireplaces and chimneys are of brickwork.

Cost.—It is claimed that the cost is 15% less than that for a brick house of equivalent floor area.

Remarks.—It is stated that the Nissen-Petren house can be erected in half the time required for a brick house and with half the number of skilled operatives.

Standardised joinery is used throughout.

Mass production is anticipated in the future.

The total cubic contents are reduced, owing to the adoption of the semi-circular construction. The waste of space in the roof is thereby much reduced.

The design has limitations, as the architect is restricted to a fixed width for the building, depending on the size of the ribs. In the standard designs the ribs project into the scullery and bathroom. If these designs are departed from it is necessary that the stairs should be near the lower part of the steel ribs, the space between the stairs and the outer wall on the ground floor being used only for such small rooms as scullery, larder, bathroom, etc., and it is necessary to ensure that the ribs come in the partitions between these rooms, or in such positions that they do not interfere with fittings in the rooms.

(*b*) STEEL.

ATHOLL.

(Atholl Steel Houses, Ltd., Glasgow, English representatives are: The Housing Corporation of Great Britain, 20, St. James's Square, S.W.1. The steel work is factored by J. Westwood & Co., Ltd., Millwall, E.14, and also in Scotland).

Description.—This is an all steel house, consisting of a steel framework covered with steel sheets.

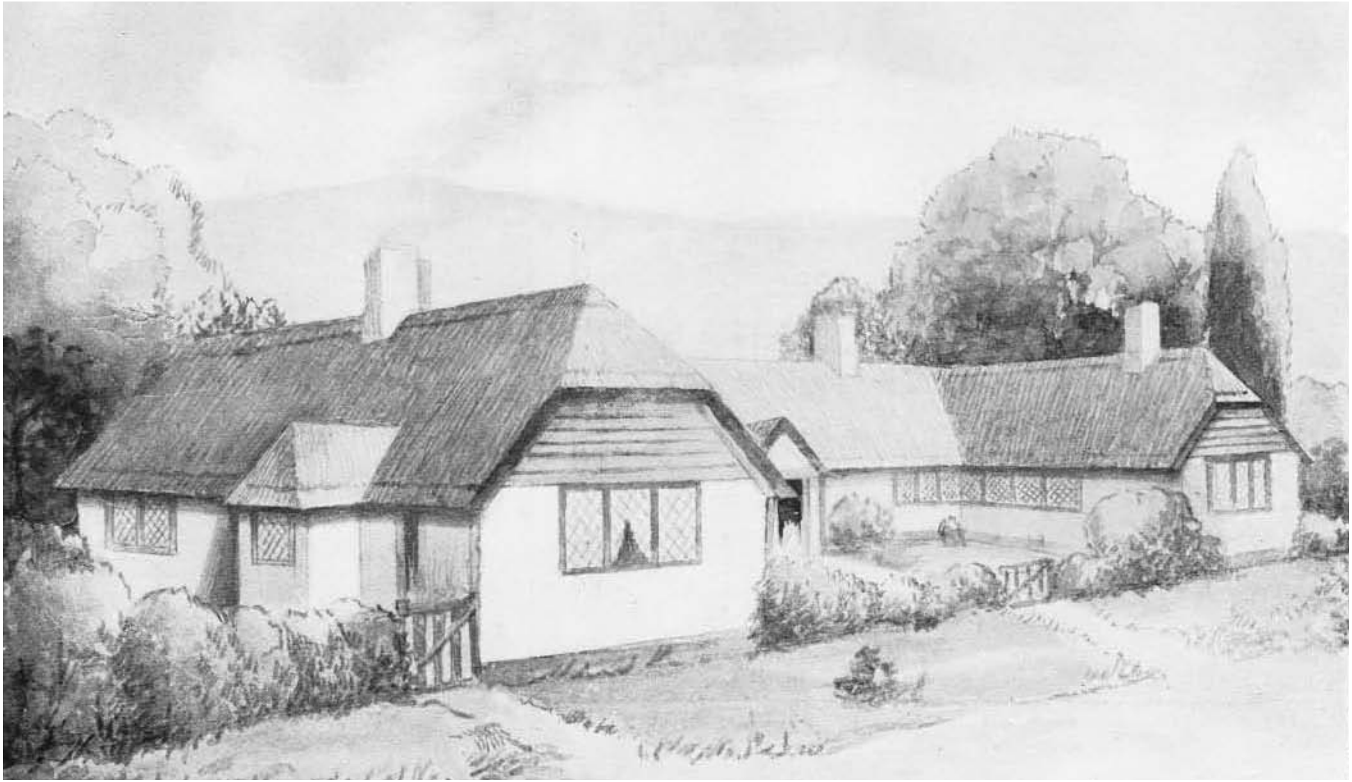
The foundation is a light concrete raft deepened and reinforced under the walls.

A continuous footing angle is attached to the concrete foundation by means of rag bolts. To this are fixed angle and tee steel uprights. The angles are used at the corners of the building and the tees in intermediate positions. These uprights are connected together at first floor level by angles and channels. Along the length of the building bulb angles are used, and along the end, where there are two angle uprights at the corners and two intemediate trees, the tees are connected together by a channel, and to the corner uprights by angles. The channel supports an I beam, which runs down the centre of the building longitudinally. This I beam supports the floor joists. The uprights are also connected at eaves level all round the building by means of an angle, to which is fixed a timber wall plate carrying the roof rafters.

The Dennis Wild House.

The Cuypers House.

HOUSING EXPEDIENTS



EXTENSIBLE UNIT BUILDINGS (W H COLT LTD) BUNGALOW

Atholl Houses at Lewisham.

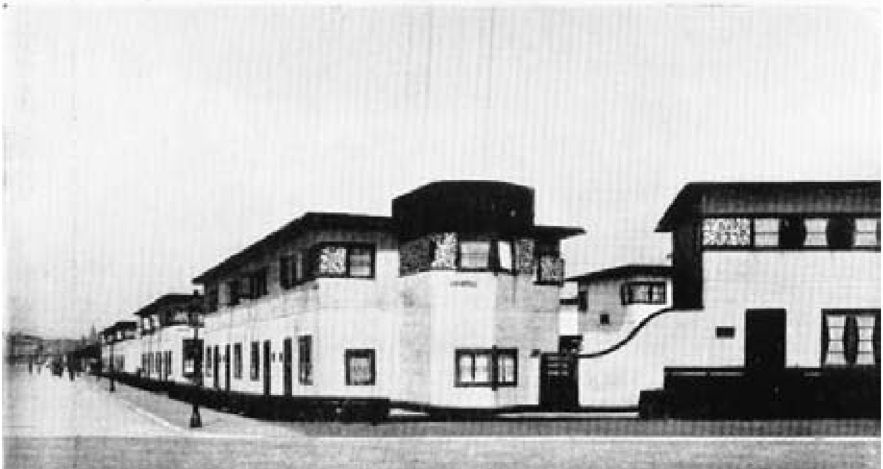
Boot Concrete Houses at Birmingham.

HOUSING EXPEDIENTS

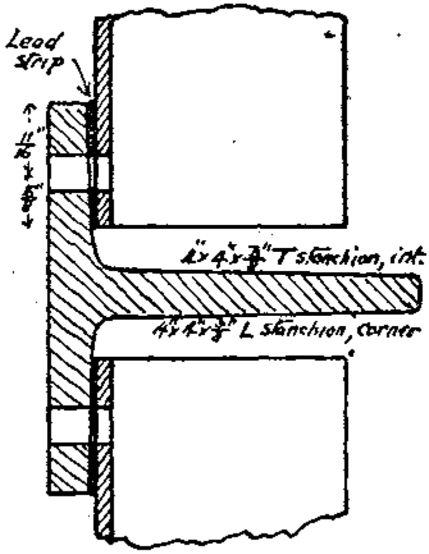
Group of Weir Houses in Mid Lanarkshire

Cuypers bungalow at Rukewell

Corolite House During Erection.

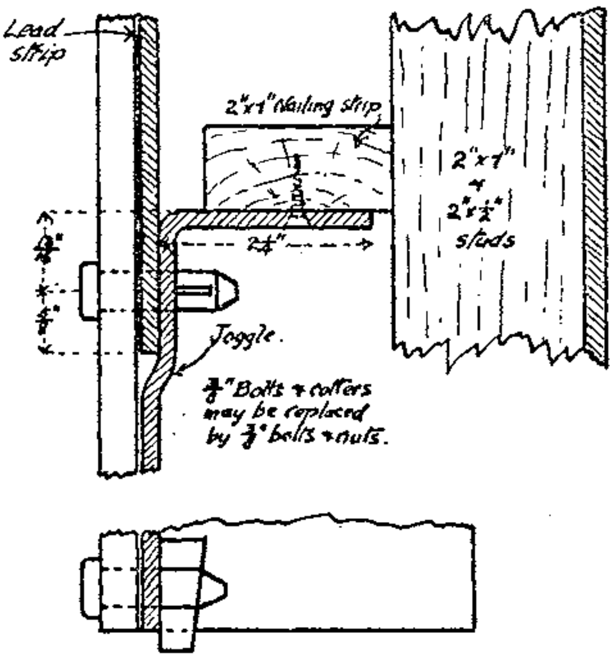


COROLITE HOUSES



Section through stanchion, int.
Corner stanchion similar
Fig. 2.

ATHOLL.



Section of Plates at
horizontal joints.
Fig. 3.

ATHOLL

The space between the steel uprights is filled in with an exterior panelling of steel plates, which are about 8′ 9″ long by 2′ 10″ deep, and 3/16″ thick, for a height of about 6 ft. above ground level. Above that height they are $\frac{1}{8}$″ thick. The top edges of these plates are flanged inwards. They also have small joggles to take the lower edges of the sheets above, as shown in Fig. 3. The method of securing the steel plates to the uprights is shown in Figs. 2 and 3. A tight joint is obtained by the use of lead strips inserted between the flanges of the uprights and the steel plates.

The party wall between two semi-detached houses is constructed in a similar manner, but the steel plates are only 3/32″ thick.

The exterior surface of the steel plates is given three coats of paint. If desired, sand can be sprayed over the surface just after the second coat of paint has been given, and the third coat applied over the roughened surface. This method gives a rather more pleasing appearance than plain paint.

The interior surface of the steel plates is given two coats of paint, and while the final coat is drying granulated cork is sprayed on to the sticky surface, in order to minimise condensation on the inner surface of the steel sheets.

The inner lining of the walls consists of asbestos cement sheets on matchboarding. In place of this "Celotex" boarding has been successfully used in Scotland. If it were generally adopted, the soundproof and heat-resisting qualities of the walls would be improved. The lining is fastened to wooden studding secured in turn to battens nailed or screwed to the top of the flanges on the steel plates, in which holes for the purpose are provided. See Fig. 3.

The building is roofed with French tiles on wooden battens and rafters.

The fireplaces and chimneys are of concrete.

The partitions between rooms are of wooden framing lined on each side with matchboarding covered with asbestos cement sheets.

American ready-made joinery is used for doors, cupboards, etc., and all woodwork is treated with wood preservative and not painted.

Steel casement windows are provided.

Cost.—The house is cheaper, in first cost, than a brick house of the same floor area, but the steel requires periodical painting. It is estimated that this would cost between 30s. and 40s. a year, the capitalised value of which will bring the cost up to the neighbourhood of brickwork. It may, however, be possible to coat the exterior with some permanent protective coating such as "Caementum." In this case maintenance should be less than for brickwork, which requires pointing, but the first cost will be greater than for a painted exterior.

Remarks.—The bricklayer and plasterer are entirely eliminated. It is, however, questionable as to whether there is any appreciable saving in using concrete for fireplaces and chimneys rather than brickwork.

Mass production makes for cheapness, especially if the houses are erected in large numbers.

" Wet " time is avoided by the fact that the roof can be put on early.

The building will probably not be so warm and comfortable as one of brick and has not such a pleasing appearance. It is probably less soundproof and is costly to maintain.

Some of these houses are shortly to be erected at Larkhill.

Weir.

(G. & J. Weir, Ltd., Cathcart, Glasgow).

Description.—The foundations consist of a concrete raft over the site of the building extending for a distance of 2′ 3″ all round the outside, forming a plinth. Messrs. Weir do not lay the foundations themselves except in special circumstances, but only erect the houses on foundations already laid.

The external walls consist of ⅛″ steel-plates joined up into panels 9 ft. by 9 ft., and screwed with galvanised iron screws to 4″ by 2″ wood studding. The steel plates are painted two coats on each side at the factory, and one external coat is added after erection.

There are two internal linings; first an intermediate one of felt or mill-board fastened inside the studding, midway between the steel and the inner lining, and secondly, one of "Beaver" board fixed to the studding. To guard against dry rot a few saw cuts are made in the studding to allow air to circulate in these two air spaces.

The fireplaces and chimneys are of " Ciment fondu " concrete blocks. It is claimed that as they are fire resisting there is no need to line them with fireclay.

The roof is of asbestos slates on boarding and timber rafters.

Partitions are of 4″ by 2″ wood studding with " Beaver " board on each side.

The windows are steel frame casements.

Cost.—If within easy reach of Glasgow, where the sections are factored, this type of house should be somewhat cheaper than brickwork.

Remarks.—The bricklayer and plasterer are eliminated.

Copper pipe is used for water supply throughout. The plumber is thus eliminated also.

The makers claim that the insulation value of the walls is intermediate between 4½″ brickwork plastered and 9″ brickwork plastered.

They also claim that observation has shown that there is absolutely no condensation on the inner painted surface of the steel.

After the foundations have been laid and the materials transported to the site, a single house can be erected ready for occupation in ten to fourteen days.

Mass production lessens the cost.

Messrs. Weir send a team of 6 men to erect a small number of houses, and 2 teams of 6 men for about 50 houses.

The exterior face of the steel has to be painted periodically, thus increasing maintenance costs over those for construction in brick.

There are two standard designs. Any departure from these would probably increase the cost considerably.

TELFORD.

(Messrs. Braithwaite & Co., Engineers, Ltd., Broadway Buildings, S.W.1).

Description.—The shell of this house is made up entirely of steel plates. The plates are 3′ 6″ wide and flanged on every edge towards the inside in a similar manner to the plates which form a pressed steel tank. The plates give support to the upper floor and roof. A horizontal stringer course ties all the four walls together at first floor level. Beams carrying the floor joists run the full width of the building and are secured to this horizontal stringer.

The plates are dipped in a special anti-corrosive paint at the works and further coats are applied after erection.

Brackets are fixed to the flanges of the steel plates and a light timber studding is carried by them. To this studding thick asbestos cement sheets or other wall board are secured, leaving a 6″ air cavity in the wall. This cavity is sealed, there being no inlet from the outside air.

Party walls are also built in steel plates.

Chimneys and flues are of cast iron and chimney breasts of pressed steel.

The roof may be composed of steel flanged plates in a similar manner to the outer walls, but tiled or slated roofs are now usually provided.

Steel casement windows in wooden frames are provided.

The doors are of wood.

Cost.—The house should be considerably cheaper than brickwork, if within reasonable distance of London where the steel is factored. The cost of maintenance will, however, be greater. The walls should be painted every 3 to 5 years, and it is claimed that the cost would be £1 per house per annum. This would appear to be distinctly on the low side.

Remarks.—Bricklayers and plasterers are entirely eliminated.

The houses can be erected speedily. A pair of semi-detached houses can be completed ready for occupation within 3 weeks.

The building is fireproof.

The units are manufactured by mass production, which makes for cheapness.

The houses are by no means soundproof, particularly if they have a steel roof. It is suggested that if " Celotex " were substituted for the asbestos cement sheets and a tile roof provided, they would be improved in this respect.

Their appearance is not very pleasing and there is difficulty in giving variety of treatment.

(c) Wood.

Cuypers.

(Burt, Boulton and Haywood, Ltd. (Cuypers Construction Dept.), Salisbury House, London Wall, E.C.2.).

Description.—The outer walls of the house are built up with timber framing in sections with 1″ boarding vertically on one side and horizontally on the other side. There is an air cavity 2″ wide in each section, the inner side of the boarding being covered with cardboard in each case. The timber used is Baltic redwood. The sections are 9′ by 3′ 8″ and 4″ thick.

The sections are grooved along their vertical edges and rebated top and bottom. They are jointed together by means of 4″ by 4″ vertical posts, which are grooved along three faces in the same way as the wall sections. The latter are locked to the posts by loose tongues. The posts are 9 ft. high and rebated top and bottom. Besides the ordinary sections there are special sections containing doors and windows.

The walls may be finished externally in any chosen material. They may be strapped, lathed with expanded metal lathing, and finished with cement, rough cast or hanging tiles, or weather-boarding may be used.

Normal concrete foundations are laid, a raised plinth being formed on the top. The ground floor outer wall sections and posts are set up on this plinth, the space left by the rebated edges at the bottom of the sections and posts being filled by means of a filling strip. The walls are then aligned and a horizontal binding beam is set in the rebated heads of the sections and posts, thus binding all the sections together.

The floor joists at 14″ centres rest on the top edges of the sections —see Fig. 4. The space at the top of each section between the floor joists is filled with a filling strip.

A wall plate is fixed on the top of the horizontal binding beam, and the first floor sections erected thereon in the same manner as the ground floor sections.

All woodwork is planed so that the internal faces of the walls may be left plain or papered if desired. If left plain, they are painted or

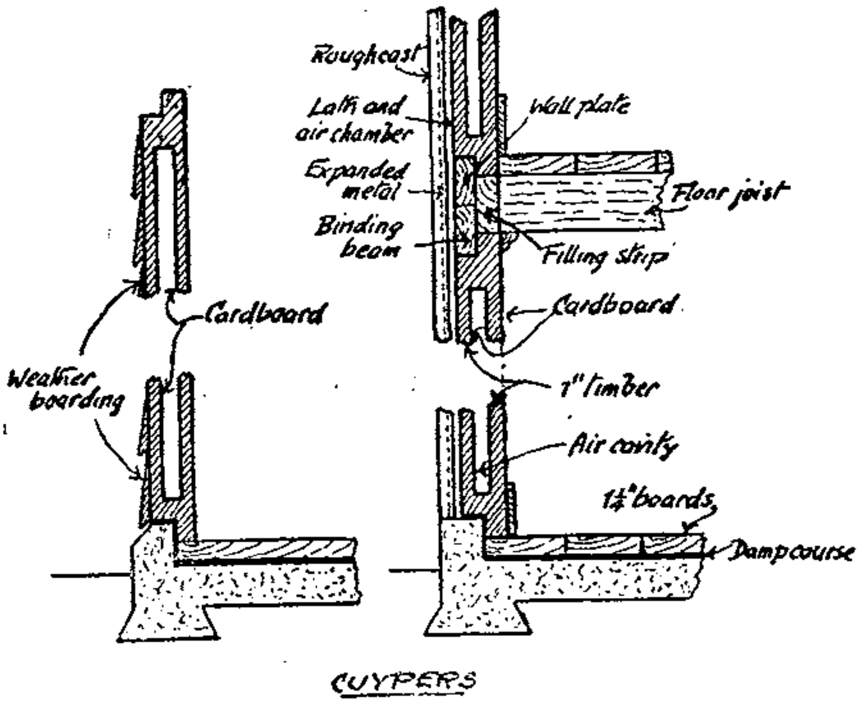


Fig. 4.

varnished. If papered, a layer of carton boards or canvas is fixed to the wood.

Double casement windows are provided. It is questionable whether there is need for double windows in this climate.

The ground floor partitions are set up direct on the floor boards.

An ordinary timber roof covered with slates or tiles is provided. Chimneys and fireplaces are of brickwork.

Cost.—It is claimed that the cost is 24% less than for brickwork, but it is questionable whether this is so, even if a number of such houses are built to one design and erected by an experienced gang.

Remarks.—The walls should be good insulators judging from experience of these houses built in Scandinavia, where there is a much greater range of temperature variation than in this country.

The bricklayer and plasterer are eliminated to a great extent.

The amount of skilled labour required for erection is small. The timber is all prepared before being transported to the site, so that carpentry on the site is reduced to a minimum.

The average time taken to build a house is about 3 weeks. The houses can be occupied immediately they are built and there is no fear of damp.

It would seem that there would be considerable danger of fire with a wooden house, but this danger is not so great as might appear, as the houses can be insured for 1/3 per £100, which is the normal rate for houses of brick.

Planning is somewhat limited by the size of the sections and by the fact that every dimension must be a multiple of 4 ft.

3 "Group V" Married Officers quarters have been built at Bulford on this system.

Century Timber House.

(Henry Boot and Sons (London) Ltd., 12, Lower Grosvenor Place, S.W.1.)

Description.—Messrs. Boot build two types of timber house, viz.—

1. Shingled Type.
2. Gunnite Type.

1. This is a timber framed structure covered externally on the lower storey with weather boarding laid over felt, and on the upper storey with Canadian cedar shingles. It is lined internally with wood panelling or a pulp board as an alternative to plaster.

All timber which is covered up is treated with "Solignum." Weatherboarding or tile hanging may be used in place of the shingles if desired.

2. This is also timber framed. The framework is covered with felt, sufficiently supported to form a shuttering, against which a mixture of cement and sand is blown by means of a cement gun, reinforcement having been previously placed at the proper distance from the felt.

Extensible Unit Buildings.

(W. H. Colt, Ltd., Bush House, Aldwych, W.C.2.).

Description.—The walls consist of timber framed sections made up of 4" by 4", 4" by 3" and 4" by 1½" scantling. The outer covering is 1" weatherboarding, which is tongued and grooved and has a chamfered edge. The sections are bolted together.

"Fiberlic," "Ten-test" or "Beaver" board is recommended as a lining for the walls, ceilings and partitions.

Special king post trusses, which drop into niches in the panel uprights, are provided, and the roof covering consists of "Ruberoid" strip slating on boarding made up in panel form.

The chimneys and fireplaces are of brickwork.

The foundations consist of concrete, brick or oak posts on which a sill is laid to carry the sections.

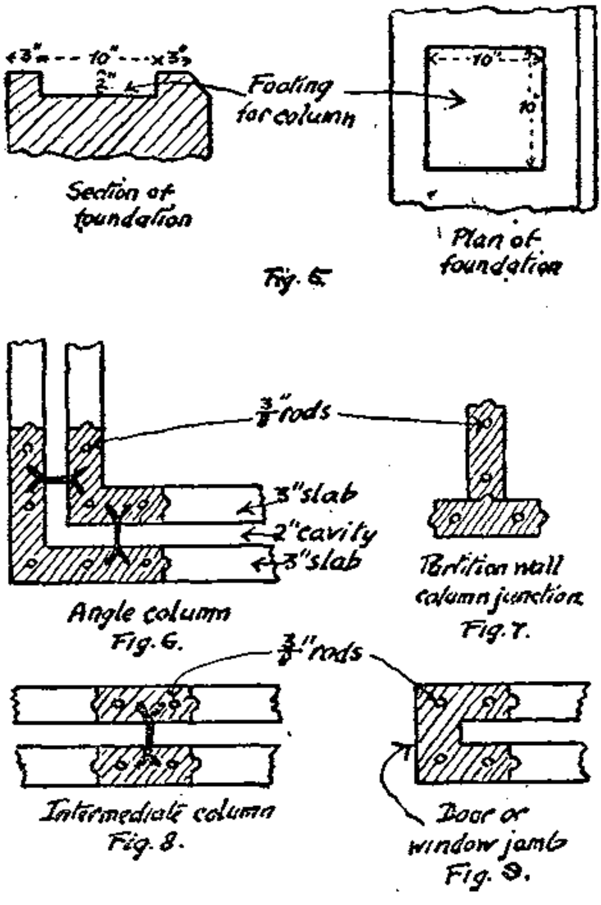
(*d*) Concrete.

Boot.

(Henry Boot & Sons (London), Ltd., 12, Lower Grosvenor Place, S.W.1.)

Description.—This type of construction consists of reinforced concrete columns with breeze concrete panelling between.

Normal concrete foundations are laid and footings for the columns at about 3 ft. centres are prepared. See Fig. 5. A 3″ concrete seal is laid over the whole area inside the foundations.



BOOT

The columns are pre-cast on the site. Figs. 6, 7 and 8 show sections of angle and intermediate columns for exterior walls and those used for partition walls. It will be seen that there is a 2″ air cavity in those for exterior walls. Where doors and windows occur this cavity is stopped by the use of special columns as shown in Fig. 9. On the sides of the columns tongues are cast. Grooves cast on the edges of the breeze concrete slabs fit over these tongues, which are interrupted at intervals equal to the height of 3½ slabs, and for a distance equal to the height of one slab, to allow the slabs to be placed in position. The columns are 16′ 8″ long and normally 8″ wide, the intermediate columns being normally 8″ square. Wall ties of 1″ by ⅛″ iron are used to tie the outer and inner sections of the column together. A number of special columns are also cast for particular positions, such as junctions between the party wall and the side wall. There are 17 different types of column used in each pair of houses.

The feet of the columns are set in the footings in neat cement. This acts as a damp-proof course. Below the breeze slabs a slate damp-proof course is provided.

When the foundations have been laid all the columns in the outer walls are erected. In order to keep them in position while the slabs are being laid, the next step is to place a 5" by 3" wooden wall plate along the top of the columns and bolt it to them. See Figs. 10 and 11.

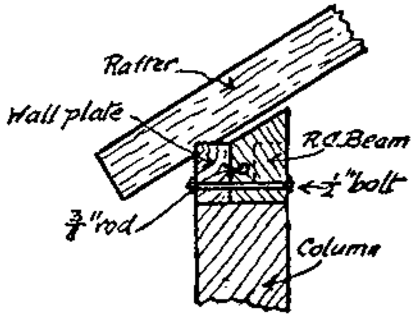


Fig. 10

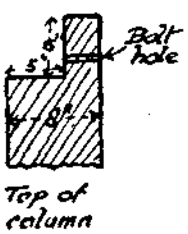


Fig. 11.

Fig. 12.

BOOT

Also at ground level the corner columns are fixed to those on each side of them by bolts, and at first floor level a series of horizontal bolts connects the columns all round the building. Five men can erect the columns for one pair of houses in one day.

The breeze concrete slabs, also pre-cast on the site, are then laid in lime mortar, the outer and inner shells being connected by iron ties.

When first floor level is reached, instead of "dry" (breeze) concrete slabs, a course of "wet" (ballast) pre-cast reinforced concrete slabs is laid. These take the floor joists and transmit the weight from them to the columns, by means of joggles cast on sides of the columns, as shown in Fig. 12. Similar "wet" cast slabs are placed as lintels over doors and windows.

When the breeze concrete slabbing is finished up to the level of the wall plate, suitable shuttering is erected and a $\frac{3}{8}''$ reinforcing bar is placed all round the building on top of the columns, which are then connected by a reinforced concrete beam cast in situ. The wooden wall plate forms one side of the shuttering. See Fig. 10. Five men can complete the erection of the slabs for a pair of houses in one day.

An ordinary timber roof covered with slates or tiles is used.

Partition walls on the ground floor consist of pre-cast columns 3" thick, the panels being filled in with 3" breeze concrete; abs. See Fig. 7. On the first floor the partitions are built of timber framing and lath and plaster.

The outside of the walls is rough cast and the inside plastered.

Fireplaces and chimneys are normally built in brickwork. Concrete has been used when bricklayers were not available, but it is no cheaper, owing to the complicated shuttering needed.

Cost.—It is unlikely that this type of construction would be cheaper than brickwork for houses, where less than 100 are built in one place.

Remarks.—The bricklayer is almost entirely eliminated, but the plaster work is considerably greater than for a brick house with facing bricks.

The continuous air cavity should give an equable temperature in the house.

The houses can be built quickly, and where a number are to be built in one place the parts can be made by mass production. All joinery and the necessary carcassing for roofs is made to a standard design in shops by machinery.

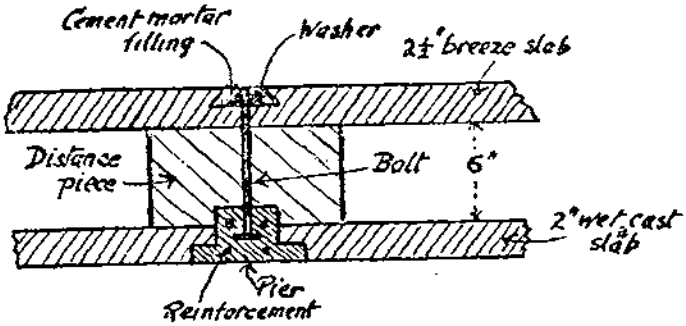
Unskilled labour is very largely employed.

KENT.

(Col. H. Vaughan Kent and Partners, 34, Victoria Street, S.W.1.)

Description.—This is another example of the concrete pier and panel method. It consists of pre-cast reinforced concrete piers about 4' 6" apart, the intervals being filled with concrete slabs.

A section through a pier and portion of the wall is given in Fig. 13. The outer walls are formed by inner and outer skins of concrete slabs fixed to the piers and forming an air cavity. The piers are rebated on two sides, and have projecting bolts embedded to secure the slabs of the inner skin to them. The bolts are either of non-corrosive metal or are properly protected.



KENT

Fig. 13.

The piers are first erected all round the block, their feet being fixed into sockets in the concrete foundation and their tops tied together by a stout wall plate. They are also held in position by temporary struts.

The slabs for the outer skin are of "wet" cast concrete 2" thick and 4 ft. by 1ft. 6 in., a suitable size for handling by two men.

The concrete slabs for the inner skin are made with breeze or a similar non-conducting aggregate. They are 4′ 6″ by 1′ 6″ and 2″ or 2½″ thick.

After the piers have been erected the slabs for the outer skin are placed against the rebates on the piers and a joint formed by pouring cement grout into grooves on the tops of the slabs. This is squeezed out by the tongues on the undersides of the slabs above.

Small concrete distance pieces, about 12″ by 6″ by 6″, holed for bolts, are then threaded on to the bolts, which are left projecting on the inside of the piers. The thickness of these distance pieces determines the size of the air cavity.

The slabs for the inner skin are cast with a quadrant hole and quadrant countersinking in each corner, which, at the corners, where four slabs meet, form a complete hole and countersinking, a quarter on each slab. These slabs are then placed so as to butt up against each other vertically and horizontally, the slabs being kept plumb by the fact that their corners fit close up against the distance pieces. The holes formed at the corners of four slabs correspond with the bolts which project internally from the piers. Over the end of the bolt is placed a large washer which fits into the countersinking mentioned above. The end of the bolt also lies in the countersinking and does not project as far as the inner face of the slab. After the nut has been tightened the whole of the countersinking is filled with cement mortar. See Fig. 13.

Window and door frames are secured to the piers by distance blocks in the same way as the slabs. These frames can be made of pre-cast concrete.

Corbels or brackets are cast on the piers at first floor level to take wall plates which carry the timber floor joists.

The exterior of the wall is finished with a cement wash. Rough cast is not considered necessary.

The internal slabs fit so closely that a satisfactory finish can be obtained by the use of fabric glued to the walls.

Asbestos cement sheets or ceiling board is used for ceilings.

Cost.—This type of construction is probably no cheaper than brickwork when bricks can be obtained, unless the houses are built in large quantities.

Remarks.—Bricklayers and plasterers are eliminated. Unskilled labour under skilled charge hands can be used for casting and erecting piers and slabs.

The buildings can be erected speedily.

The air cavity should enable an equable temperature to be preserved inside, and the inner skin of breeze concrete slabs should prevent condensation.

Maintenance costs are small. No re-pointing is necessary.

Planning and architectural treatment are somewhat limited by the fixed position of the piers.

A cottage has been erected on this system at Shoeburyness as a caretaker's quarter.

COROLITE.

(Corolite Construction, Ltd., 12-13, Henrietta Street, Strand, W.C.2.).

Description.—This is a type of construction with walls formed of concrete poured in situ.

The chief point of interest in this system is the composition of the concrete. The aggregate is usually hard burnt clinker, but may be furnace slag, broken brick or pumice. It is all of a like size, small and large being screened out. No sand is used. It is mixed with cement cream so that each particle is completely covered with cement mortar. The proportions of cement to aggregate are 1 to 10 for walls and 1 to 5 or 1 to 3 for floors and roofs, a finer aggregate being used for the latter. The particles of aggregate then stick together on their salient points, leaving air cavities. These voids amount to 30% to 50% of the total volume.

The walls so formed require little finish externally or internally. It is claimed that a coating splashed on with a brush will sufficiently stop external cavities and make the wall weatherproof, while a skimming coat or almost a brush coat will finish the interior; but the exterior may be rough cast and the interior plastered if desired. Walls 9" thick are said to be waterproof with no external finish.

Special shuttering, consisting of light wooden frames covered with thin sheet iron plates, is used. This is made up in standardised units to suit any architectural design.

The shuttering for the first floor is more difficult to arrange and timber framed upper walls are sometimes provided.

The normal method of construction is first of all to make a 4" raft floor. The concrete for the walls is then poured to first floor level. Next the upper floor is laid, also of Corolite, and then the concrete for the first floor walls is poured.

The outer walls are 8" thick and partitions 4" thick.

Flat or pitched roofs are constructed in the same way as the floors. They are covered with a bituminous layer or tiles. Owing to the small weight of Corolite, which must on no account be tamped, it is possible to use a very light shuttering. It sets very quickly and the shuttering can therefore be removed early. No damp-proof course is required.

Cost.—If a suitable aggregate can be obtained reasonably near the site, it is claimed that the cost of this type of construction is 12½% cheaper than brickwork. This will only be the case if the houses are to be built in fairly large numbers in one place.

Remarks.—A block of 4 houses takes 2 or 3 weeks to complete.

It is stated that no condensation occurs on the walls or ceilings.

The bricklayer is eliminated and the work of the plasterer much reduced. Unskilled labour can be used to a great extent. Carpenter's work is also reduced to a minimum.

In view of the air cavities, the concrete has good insulating properties.

AEROCRETE.

(The Aerated Concrete Co., Abbey House, Westminster, S.W.1.)

Description.—With this type of construction the composition of the concrete is again the chief interest.

It is made from aerated cement "Aerocrete," neat or mixed with different aggregates, such as broken stone, brick, clinker, slag, scoria, etc.

By a chemical action hydrogen is liberated, causing the mixture to swell to about twice its original volume. The mixture subsequently hardens like ordinary concrete and the resulting material has a texture resembling cork. 70% of its volume consists of small and large evenly-distributed cavities, each cavity being a closed compartment with thin walls.

It is possible to produce an aerated concrete whose weight is 20 lbs. per cu. ft. compared with the weight of ordinary concrete, about 130 lbs. per cu. ft. Aerated concrete at 45 lbs. per cu. ft. is recommended, however, as being stronger. Mixed with an aggregate the weight of course will be greater, up to 100 lbs. per cu. ft., depending upon the aggregate used.

It is best for the exterior surface to have a brush-coat of "Aerocrete," but there is no need for internal plastering.

The concrete may be poured in situ or cast in moulds for blocks.

Cost.—This construction is cheaper than brickwork if the aggregate is easily obtainable and houses are built in large quantities, say more than 50 in one place.

Remarks.—The bricklayer and plasterer are eliminated and unskilled labour can be used to a great extent.

It is said to be three times as good an insulator as brickwork, consequently thinner walls can be used. The thickness can be reduced to the limit of weight-carrying efficiency owing to the high insulation value.

It can be worked with wood-working tools.

It is claimed that, if reinforced, it has as good adhesion to the steel as ordinary concrete.

It is said to be fireproof.

OTHER TYPES.

There are, of course, a very large number of other types of construction in use at the present time. This is particularly the case with methods of concrete construction. There are, for example, those involving (1) special shuttering for houses of concrete poured in situ (2) various types of hollow blocks (3) piers of concrete poured in situ and breeze block panels (4) a steel framework cased in hollow blocks with panels of hollow blocks (5) building moulds by which layers of breeze concrete are placed in situ (6) asbestos cement sheets and steel framework, used as shuttering for concrete and left in position, etc., etc.

It has only been possible to describe a very small proportion of the systems in use, but perhaps the examples chosen will give some idea of the number and variety of expedients which are being tried in order to produce houses quickly and cheaply, to meet the enormous demand existing at the present time.

WATER SUPPLY ON ACTIVE SERVICE.

ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1925.

By CAPTAIN C. G. MARTIN, V.C., D.S.O., R.E.

SUBJECT SELECTED: "WATER SUPPLY ON ACTIVE SERVICE."

The essay is to take the form of a report and recommendations on the following points which arise in connection with the particular case outlined in paras. 2 to 9.

(a) Would it be desirable to issue any special water supply equipment to field and other engineer units of the Expeditionary Force, and if so, on what scale and how should such equipment be carried?

(b) What water supply stores and equipment should be sent out to the Base with the Expeditionary Force?

(c) What further consignments of such stores and equipment might be wanted within the next few months?

2. The Force consists of two divisions and one cavalry brigade with the normal proportion of non-divisional and L. of C. units. All are at Small War Establishment. A third division with additional non-divisional troops is to be sent out later if required.

3. The Base will be a small seaport town of about 10,000 inhabitants in a somewhat backward country. The objective will be 100 miles inland. Landing and advance will be opposed. The attitude of the civil population is uncertain. Operations are not expected to last more than six months.

4. The climate is good on the whole but apt to be malarious in places.

5. Timber is available in most places (trees and small scantlings) in limited quantities. Building stone is generally obtainable.

6. At the Base there is a piped water supply, but if used, water would have to be chlorinated for drinking. Water is also obtainable from a river, but would require sedimentation and chlorination. The piped water supply is derived from an open aqueduct leading from springs in the hills near the town.

7. Up to 50 miles from the Base, water is said to be fairly plentiful in small streams and from shallow wells which are said never to run dry in summer.

8. Beyond that distance, water is not so plentiful and both streams and wells are apt to run dry in summer, but deep well bores would probably give satisfactory results.

9. There is no railway, but the country would admit of its fairly rapid construction. Roads are not numerous and are said to be generally unmetalled except in low-lying ground.

Country transport includes both carts and pack transport.

10. Competitors may make any reasonable assumptions supplementing the information given above, but should draw attention in footnotes to such assumptions.

The first duty of an Engineer-in-Chief on being appointed to an Expeditionary Force is to make himself thoroughly conversant with every detail of the proposed campaign. The information given in the setting of the problem is not sufficient for him to be able to make a detailed appreciation of the situation, and it has been necessary to visualise the origin of the campaign and the plan of operations from the commencement.

The full narrative will be found in Section I under the following headings:—

1. The origin of the campaign.
2. The Plan of campaign.
    (*a*) Detail of Forces to be employed.
    (*b*) Forces of the enemy.
    (*c*) Topographical data.
    (*d*) Policy of occupation and administration of conquered country.

The information given in this section is limited to what the Engineer-in-Chief would require on which to base his appreciation of the situation for the solution of the water supply problem.

Recommendations under the headings (*a*), (*b*) and (*c*) of the setting are based on the appreciation made by the Engineer-in-Chief which is contained in Section II.

The special water supply equipment required by Field and other Engineer units are tabulated in Section III.

SECTION I.

ORIGIN OF THE CAMPAIGN IN LUCITANIA.

Under the Treaty of Lucerne the mandate for " Lucitania " was given to Great Britain in 1920.

At the capital " Lux," a High Commissioner and a small garrison had been successfully carrying on the administration, but it was known for some time that the " Stygians " have been carrying on organised propaganda among the " Lucitanians " against Great Britain, and at the end of 1923 several local disturbances broke out. These were suppressed, but in December, 1925, a general revolt broke out, the British garrison was overpowered and imprisoned, and Prince " Leo " declared himself King of the independent state of " Lucitania."

At a Cabinet Meeting held in December, 1925, the C.I.G.S. was instructed to put into operation the approved plans prepared for this eventuality, and the forces to be employed were mobilised.

PLAN OF CAMPAIGN.

The Expeditionary Force will arrive off the coast of " Lucitania " during the first week of March, 1926. Landings will be made on each side of the seaport town of " Lumen " which, when captured, will be the base of operations inland.

It is reported that the " Lucitanians," assisted by " Stygian " engineer officers, are throwing up defences on the coast line and will oppose any landing.

The objective is the capital " Lux," the centre of government and trade. " Lux " is surrounded by old fortifications built about 1870, and it is known that the " Lucitanians " have been supplementing these defences with field fortifications.

The advance on "Lux" will be made by a force of 2 Divisions and a Cavalry Brigade, and, should the enemy be able to occupy the prepared defensive position around "Lux" without a previous battle, a third division may have to be employed.

Rapid movement and surprise are the deciding factors of this campaign, and the fullest use will be made of Mechanical Transport which, during the dry season, can move on all existing routes for wheeled traffic.

DETAIL OF FORCES TO BE EMPLOYED WITH ESTABLISHMENT.

Summary.		Men.	Horses.
1. Striking Force	2 Divisions ... ... 1 Cavalry Brigade ... Non Divisional Units	48,264	13,466
2. L. of C. Units	... ...	3,996	469
3. Base Units ...	... ...	12,521	1,774
4. Royal Air Force	... ...	2,140	
	Total ...	66,921	15,709

(1). STRIKING FORCE UNITS.

	Men.	Horses.	Total Men.	Total Horses.
2 Divisions	34,760	10,054		
1 Cavalry Brigade	2,119	2,329		
			36,879	12,383
NON-DIVISIONAL UNITS.				
Headquarters.				
G.H.Q. 1st Echelon	419	52		
,, 2nd ,, ...	210			
H.Qs. of Services	466	4		
Corps H.Qs.	238	35		
			1,333	91
Artillery.				
1 Medium Artillery Brigade ...	750	299		
			750	299
Engineers.				
1 Army Troops Coy.	249	20		
1 Electrical and Mechanical Coy. ...	340			
1 Light Bridging Park	92			
1 Workshop Park	187			
1 Field Survey Coy.	77			
			945	2
C.F. ...			39,907	12,793

(1) STRIKING FORCE (*cont.*)

	Men.	Horses.	Total. Men.	Total. Horses.
B.F.			39,907	12,793
Signals.				
G.H.Q. Signals	846	246		
Corps Signals	618	106		
1 Sig. Sec. Med. Art. Bde.	32	12		
1 ,, Group H.Qs., R.A.F. ...	75			
2 ,, Wing ... ,, ...	88			
6 ,, Squadron... ,, ...	126			
1 ,, Aircraft Park ,, ...	37			
			1,822	364
Tanks.				
1 Battalion	765	23		
3 Armoured Car Coys.	603			
1 Salvage Coy.	207			
			1,575	23
Medical.				
2 C.C.S.	190			
2 Motor Amb. Convoys	364			
2 Mobile H. & B. Labs.	14			
1 Adv. Depot Med. Stores	18			
			586	
Supply and Transport.				
1 Cav. Bde. M.T. Coy.	130			
2 Div. M.T. Coy.	902			
1 Med. Art. M.T. Coy.	299			
1 Tank Corps M.T. Coy.	270			
2 Reserve M.T. Coy.	732			
1 Aux. H.T. Coy.	167	231		
G.H.Q. Troops M.T. Coy.	97			
Corps Troops M.T. Coy.	428			
1 M.T. Water Tank Coy.	289			
Adv. M.T. Vehicle Recpt. Depot. ...	220			
			3,534	231
Ordnance.				
1 Ord. Mobile Workshop Light ...	30			
1 ,, ,, Med. ...	36			
1 Ammunition Coy.	112			
1 Gen. Store Coy.	112	1		
			290	1
Veterinary.				
1 Vet. Evacuating Station	43	11		
1 Adv. Depot. Vet. Stores	4			
			47	11
C.F. ...			47,761	13,423

(1) STRIKING FORCE (*cont.*)

	Men.	Horses.	Total Men.	Total Horses.
B.F. ...			47,761	13,423
Pay.				
1 Command Pay Unit	109			
1 Command Cash Office	6			
2 Field Cash Offices	8			
			123	
Postal.				
G.H.Q. Post Office	10			
Corps	8			
2 Convoy	10			
			28	
Provost.				
1 Provost Squadron	57	28		
1 Provost Coy.	55	15		
			112	43
Printing and Stationery.				
1 Photo Sect. A.P. & S.S.	25			
Mobile Printing Press	27			
			52	
Miscellaneous.				
Intelligence Corps	150			
Graves Registration & Eng. Unit	38			
			188	
Total ...			48,264	13,466

(2) L. OF C. UNITS.

	Men.	Horses.	Total Men.	Total Horses.
Headquarters.				
H.Qs. L. of C.	72	6		
2 H.Qs. L. of C. Sub-area	124	8		
			196	14
Infantry.				
2 Battalions	1782	194		
			1,782	194
Engineers.				
1 Army Troops Coy.	294	20		
1 E. & M. Coy.	340			
			634	20
Signals.				
L. of C. Signal Coy.	731	32		
			731	32
C.F. ...			3,343	260

(2) L. OF C. UNITS (*cont.*)			Total.	
	Men.	Horses.	Men.	Horsts.
B.F. ...			3,343	260
Supply and Transport.				
1 Aux. H.T. Coy.	117	152		
1 Adv. H.T. Depot.	66	43		
1 Res. M.T. Coy.	366			
			549	195
Remounts.				
2 Field Remount Sect.	44	14		
			44	14
Medical.				
2 San. Sect. L. of C....	56			
			56	
Veterinary.				
1 Adv. Depot. Vet. Stores	4			
			4	
Total ...			3,996	469

(3). BASE UNITS.			Total.	
	Men.	Horses.	Men.	Horses.
Headquarters.				
H.Q. Base Sub Area	89	4		
			89	4
Engineers.				
1 1st Class Workshop	426			
1 2nd ,, ,, ...	213			
1 Dock Coy.	153			
			792	
Supply and Transport.				
H.Qs. Main Supply Depot.	12			
1 L. of C. Supply Depot.	154			
1 Field Bakery	321			
1 Field Butchery	57			
1 Base M.T. Vehicle Rep. Depot. ...	136			
4 Aux. Motor Amb. Convoys ...	480			
1 Heavy Repair Shop M.T. ...	449			
1 Aux. H.T. Coy.	117	152		
			1,726	152
Signals.				
1 Post Depot. R.A.F. Sig. Sect. ...	66			
Remounts.			66	
Remount Depot H.Qs.	25	6		
1 Remount Sqdn.	303	30		
			328	36
C.F. ...			3,001	192

(3). Base Units (*cont.*)

	Men.	Horses.	Total Men.	Total Horses.
B.F. ...			3,001	192
Medical.				
1 Sanitary Sect.	28			
3 General Hospitals 1200 beds ...	1008			
1 General Hospital 600 beds ...	210			
2 Convalescent Depots.	214			
1 Base Depot Med. Stores	22			
			1,482	
Ordnance.				
2 Ammunition Coys....	224	2		
2 General Store Coys.	224	2		
2 Workshop Coys.	220			
1 Boot repair coy.	108			
			776	4
Veterinary.				
1 Vet. Hospital	590	34		
1 Convalescent Home Depot ...	192	27		
1 Vet. Bact. Lab.	5			
1 Base Depot Vet. Stores	8			
			795	61
Pay.				
1 Command Pay Unit	109			
1 Base Cash Office	5			
			114	
Postal.				
1 Base Post Office	61			
1 Aux. Post Office	81			
			142	
Provost.				
5 Provost Sections	70	15		
			70	15
Printing and Stationery.				
1 Stationery Depot A.P. & S.S. ...	31			
			31	
Miscellaneous.				
1 Military Prison	31			
1 Labour Group H.Qs.	17	2		
1 Infantry Base Depot.	7			
1 General Base Depot.	7			
1 Graves Reg. & Eng. Unit ...	38			
			100	2
First Reinforcement left at Base ...			5,000	1,500
Labour Corps.			1,000	
Total ...			12,511	1,774

(4) ROYAL AIR FORCE.

		Total.
	Men.	Men.
1 Group H.Q.s.	47	
2 Wing H.Q.s.	94	
6 Squadrons	1,164	
1 Adv. Aircraft Park	119	
1 Aircraft Depot	688	
1 Post Depot. R.A.F.	28	
		2,140
Total ...		2,140

FORCES OF THE ENEMY.

1. The forces of "Lucitania" have been organised on the old lines existing before Great Britain took over the Mandate. It is estimated that 30,000 men have been mobilised, and that arms and munitions, supplied for the most part by the "Stygians," are available for a further 20,000.

2. It is reported that several batteries of Field Artillery have been mobilised but that ammunition for same is scarce.

3. The "Lucitanians" have obtained two squadrons of aeroplanes with Stygian airmen.

4. The armed forces of "Lucitania" are based on the capital "Lux."

TOPOGRAPHICAL DATA.

(Additional to that given in the setting).

1. Water supply at the seaport "Lumen."
   Existing supply about 300,000 gallons a day. This can be increased to 600,000 a day by improving the catchment area. Large stocks of C.I. piping are available.

2. Water supply at the capital "Lux."
   A piped supply from deep bore wells 250′ deep supplies the government organisations; it is estimated that the supply available is about 100,000 gallons a day. The inhabitants depend on rain water collected in cisterns, and on shallow wells during the rains.

3. Rainfall—average rainfall 30″.
   Rains commence on or about November 10th, and end in March; the maximum is reached in December.

4. Temperature—Maximum 105° F., Minimum 35° F.
   Readings have been taken from 1920 to 1924.

5. Roads.
All unmetalled tracks used by wheeled traffic are suitable for pneumatic-tyred vehicles, including lorries, during the dry season.
During the rains the tracks are passable within 24 hours of rain, except in low lying areas.

POLICY OF OCCUPATION AND ADMINISTRATION OF "LUCITANIA."

On the cessation of hostilities a local administration will be set up at the capital.

It is proposed that one Cavalry Brigade will be stationed at the capital, and that the Air Ministry will take over the duty of policing the country from an air base on the coast, at Lumen, the cavalry brigade being withdrawn as soon as possible.

SECTION II.

APPRECIATION OF THE SITUATION AFFECTING THE WATER SUPPLY PROBLEM OF THE CAMPAIGN IN LUCITANIA MADE BY THE ENGINEER-IN-CHIEF, BASED ON THE INFORMATION SUPPLIED BY THE C.I.G.S.

Problem (General).

To supply a suitable and sufficient supply of water to meet every possible military situation.

Factors affecting Problem.

See Section I.

Problem (Detail).

The general problem can be sub-divided into a number of situations in which the conditions resulting from the military situation are quite distinct, and each will have to be considered separately.

These situations are—

(1). Protracted landing operations owing to strong resistance of the enemy.

(2). A rapid withdrawal of the enemy from the coast to the objective—a distance of some 100 miles—necessitating a rapid pursuit.

(3). A deliberate attack on a prepared position with a maximum concentration of forces at the decisive point.

In each of the above, the problem will have to be considered under the worst conditions from the water supply point of view, i.e., in an area where no water supply facilities are available above ground.

The remaining problems to be considered are:—

(4). Water supply at the base.

(5). Water supply on the L. of C.

Each of these problems will now be considered in detail in the appreciation of the situation made by the Engineer-in-Chief.

Landing Operations.

Conditions to be expected.

1. Protracted resistance by the enemy.
2. No local water supply available on landing.
3. Landing places under long range shell fire.

Requirements Necessary.

1. Supply and storage by condenser plants on ships.
2. Transport of water from ship to shore.
3. Storage on shore to allow for bad weather.
4. Distribution on shore.

Organisation of Supply.

The following water points will be required in order of urgency, sited in accordance with instructions from the General Staff, based on the plan of attack.

6 Infantry Brigade Points
1 Cavalry " "
2 Divisional Artillery "
2 Divisional Troops "
1 Point for remainder of Landing Force.

Each water point to hold three days' supply for men and animals at the rate of ½ gallon per man and 5 gallons per animal.

Gallons of water required at each point:—

	3 days' supply.
Infantry Brigade	17,310
Cavalry Brigade	37,970
Div. Artillery	47,910
Div. Troops	7,320
Other Units	41,220

Method of Storage.

Storage to be in 7,000 gallon canvas tanks.

These tanks can be rapidly erected and can be distributed over the area available, to minimise the effect of shell fire.

Number of 7,000 gallon tanks required.

6 Brigade Points	18
1 Cav. Bde. Point	6
2 Div. Art. Points	14
2 Div. Troops Points	4
Other Units	12
Total	54

Transport from Ship to Shore.

Assuming that barges can get in close to the shore at all landing places, special tank barges will be employed to transport water from condensers to tanks ashore. Barges of a capacity of 25,000 gallons discharging 12,000 gallons an hour, through two 4″ pipes against a head of 600′, will be required.

These barges will fill three 7,000 gallon tanks in two hours, and allowing a round trip for filling and discharging of eight hours, each tank barge will fill nine tanks in 24 hours.

It is essential that a day's supply be put ashore within twelve hours for the attacking infantry, as no animals will be landed until the enemy have been pushed back from the shore.

This will necessitate filling one tank in each of the six infantry brigade groups and can be carried out by two tank barges, and within 24 hours one day's supply for the whole force will be on shore.

A third barge will be required as a reserve in case of a breakdown.

Distribution.

The R.E. field units will arrange distribution from the 7,000 gallon tanks, but, until it is possible to land animals, transport to the advanced troops will have to be carried out by hand.

For this purpose each infantry brigade will require 500 4-gallon petrol tins, making 3,000 in all.

Rapid Pursuit from Landing Point to Objective.

General Remarks.

Two distinct operations are involved.

(1). Over the first fifty miles of well watered country.

(2). Over the second fifty miles where water is scarce.

Problem.

To avoid holding up the pursuit on account of lack of water.

Essential conditions to be fulfilled.

1. Rapid reconnaissance of available supply.
2. Rapid development of same.
3. Distribution.
4. Salvage of apparatus no longer required and transport to more advanced area.
5. Handing over installations required by the L. of C. and taking over from the water supply units of the L. of C. similar apparatus for use further forward.

Considering each of the two problems in turn.

Fifty miles of well watered country.

Conditions to be expected.

Water is reported in small streams and shallow wells which do not run dry in summer.

Requirements necessary.

Reconnaissance, development and distribution will present no difficulty to the engineer field units, but the rapid closing down of points no longer required and opening new points in conjunction with a rapid advance will have to be considered.

The solution lies in supplying the field units with sufficient equipment to enable them to leap frog from one position to another and so have advanced supplies prepared before withdrawing the equipment in rear.

For this purpose each field company will require 12 units consisting of one lift and force pump and one 600 gallon trough; thus allowing three units to each section.

Each section will carry one 2,500 gallon trough for temporary storage of drinking water when required.

The composite field troop responsible for the water supply of the Cavalry Brigade will consist of an amalgamation of a headquarter troop and a field troop, and each of these troops will require two units as above.

Each section of a field company and the headquarter troop of the composite field troop will require an additional mechanical elevator—type Boulton and Paul.

Summary of Equipment.

Field Company.	Elevators, Boulton and Paul	8 No.
	Pumps, Lift and Force	12
	Troughs, waterproof, 2,500 gall	4
	Troughs waterproof, 600 gall.,	12
	Stores for trough, 2,300 gall.	1 set
	Stores for trough, 600 gall.	12 sets
Composite Field Troop.		
	Elevators, Boulton & Paul	2 No.
	Pumps, Lift and Force	4
	Troughs, Waterproof, 600 gall.	4
	Stores for „ „	4 sets

Handing over Water Areas to L. of C. Units.

L. of C. water units will open their own water areas as required, basing same on the water reports of field units; the question of handing over equipment will not arise, as, with surface water available, L. of C. units can make use of their own equipment without loss of time.

RAPID PURSUIT (*cont.*) (SECOND AREA.)

Conditions expected.

Streams and shallow wells running dry.

Deep bore wells a possible source of supply, but none available except at the objective, where a bore of 250′ deep has reached water.

Organization.

1. *Reconnaissance.*

   Extensive reconnaissance and the rapid receipt of reports on the existing surface water are essential.

   Geological reconnaissances will in addition have to be made. Each section of a field company and the composite field troop will carry a Norton Tube equipment for rapid location of water below the beds of dry streams and wells.

2. *Development.*

   The development of surface water will be carried out as in the first phase of the advance; in addition, each section of the field companies and each troop of the composite troop will carry

   2 Spear Points units each consisting of

   20′ of 2½″ piping (one with steel spear point).

(This "Spear Point" will be driven by the Norton Tube equipment). One 2,300 gallon canvas tank for storage.

Consideration of the problem should no water be available during the second phase, either on the surface or within reach of the equipment of Field units.

Amount of Water required.

The strength of the Striking Force is 48,264 men.

" " " 13,466 horses

at a minimum allowance of ½ a gall. a day per man.

" " 5 gallons " horse.

Gallons of water required daily 90,000.

Requirements.

The worst conditions to be considered are a rapid advance up to the objective to be followed by an attack on a prepared position.

Assuming an area of 40 miles without water, and a rate of advance of 10 miles per day across this zone, and allowing five days before water can be obtained by bore wells, the force will have to be supplied for nine days by means of transport, for five days of which a round trip of 80 miles will have to be run.

Solution of Problem.

Water will have to be transported by motor lorry until deep bores have been sunk and the supply obtained from them.

Transport.

Gallons of water to be transported daily = 90,000.

Transport by Water Tank Coy.

87 lorries at 150 gallons = 13,000 gallons.

Transport by Reserve M.T. Coy.

16 Lorries @ 150 gallons	=	2,400
84 Lorries @ 600 gallons	=	50,400
		52,800 gallons.

Total Transport Required.

1 Water Tank Company	13,000 gallons.
2 Reserve M.T. Coys.	105,600
	118,600 gallons.

giving a reserve of 30%.

Special Equipment necessary for Transport.

672—300 gallon iron tanks.

64—150 gallon iron tanks.

for lorries of the two Reserve M.T. Coys.

Organisation.

Initial Water Points.

Two filling points are required, each with storage capacity of one day's supply for half the force, i.e., 50,000 gallons. This will be stored in eight 7,000 gallon canvas tanks; allowing 10 hours for the lorry journey to the forward water point and 7 hours at each end, initial pump capacity when filling direct to lorries must be 8,000 gallons an hour.

Two pumps of 6,000 gallons per hour each, against a head of 250 feet, will be required at each of the two initial watering points.

Forward Watering Points.

These will consist of spill tanks of 7,000 gallon capacity. Each watering point will consist of sufficient tanks to hold a day's supply for one division and a cavalry brigade. Two such points will be required.

Tanks for each point

3 Infantry Brigades	17,310 gallons		3	7,000 gal. tanks.
1 Cav. Brigade	12,660 ,,		2	,, ,,
Div. Art. and Troops	18,410 ,,		3	,, ,,
		Total	8	,, ,,

In order to allow for leap frogging as the advance progresses, two sets of tanks will be required and an additional 100% spare to allow for damage.

Each section of the field company will carry one 7,000 gallon tank and the composite field troop four.

THIRD PHASE.

ORGANISED RESISTANCE OF THE PREPARED POSITION PROTECTING THE OBJECTIVE.

As soon as the rate of advance slows up against increasing resistance it is of utmost importance that all mechanical transport be released for the purpose of bringing up ammunition and stores for the expected deliberate attack—this can only be done by finding a new source of supply close up to the fighting troops.

Bore holes will have to be sunk as rapidly as possible, and the troops supplied from a short distance to their rear, thus releasing the greater proportion of the water transporting lorries for other duties.

Organization of Boring Work.

Each Divisional area requires (at the minimum rate of ½ gallon per man and 5 gallons per horse) 34,000 gallons, and the cavalry brigade 13,000 gallons.

To allow the cavalry brigade to work on either flank, each divisional area must supply 50,000 gallons.

Numbers of Bores Required.

A 6″ bore 350′ deep with water level at 100′ will supply 100 gallons a minute with a compressor lorry air lift plant, or 54,000 gallons in 9 hours. Thus each divisional area will require two bore holes and two compressor lorry plants and can supply the quantity required in 4½ hours.

To construct two bore holes 4 boring rigs are required, to allow for continuous work, and the minimum time to complete will be five days.

One electrical and mechanical company will be required for each divisional area.

Storage.

Storage will be on the same scale as the initial water point—eight 7,000 gallon tanks and transport to units at a distance from the initial waterpoint will be made by lorry transport—the same scale of spill tanks being available if required.

Water Supply on the L. of C.

The problem for the L. of C. water supply consists of supplying the L. of C. posts and the third division, which may have to march up from the base to take part in the final battle for the objective.

Existing supplies are to be found

1. at the base (to be dealt with later).
2. at about 50 miles, the initial water points for lorry transport.
3. behind the fighting troops attacking the objective at 80 miles from the base.

Addition Supplies will be Required.

Two points between 1 and 2 above and one point between 2 and 3.

Each point should be able to supply 2 Brigade groups and the L. of C. units and should have a storage capacity of 50,000 gallons.

The first two groups will consist of eight 7,000 gallon tanks and two portable petrol turbo pumps, delivering 6,000 gallons an hour against 250′ head.

The canvas tanks will be replaced by masonry tanks as soon as labour and material are available.

The third point will have to be supplied from two bore holes which will be sunk by a boring section after it has completed the work in front of the objective and it will have similar storage.

WATER SUPPLY AT BASE.

Requirements.

The base water supply will have to supply the following:—

Base units	13,000	
3rd Division	18,000	(on landing)
Civil population	10,000	
Total	41,000	

Allowing 15 gallons a day, supply must be 62,000 gallons per day.

Solution.

As there is an existing water supply in the town, this will be repaired and reorganised.

Work to be carried out.

(1). Wire off the source of supply—open up and clean the springs and generally improve the collecting area.
(2). Repair the open aqueduct and if necessary cover same to protect from contamination.
(3). Chlorinate water before it enters the pipe system.
(4). Repair existing pipe system and lay new system for the base camp.

Until the work can be completed the base supply will be obtained from the tank barges discharging into 7,000 gallon tanks.

The temporary supply required will be 65,000 gallons a day and will be stored in 10 tanks, this will allow 5 gallons a day for the base units.

Materials required for the permanent supply.

1 Wallace-Tiernan Chlorinator Type MSAM, supplying up to 1,000,000 gallons a day of chlorinated water, using up to 10 gallons of chlorine.

SECTION III.

SPECIAL WATER SUPPLY EQUIPMENT REQUIRED BY FIELD AND OTHER UNITS, AND METHOD OF TRANSPORT.

FIELD COMPANY, R.E.

Headquarters	lbs.
4 7,000 gall. canvas tanks with rope and pickets	920
500 lbs. tar	500
Chest of Implements Norton Tube	120

1 Wagon L.G.S. additional required.

Each Section	lbs.
2 Pumps, Lift and Force with hose and spares	342
1 Elevator, Boulton and Paul with 300′ belt	400
1 Norton Tube equipment	248
2 "Spear Points" 20′ 2½″ piping	200
2 600 gall. canvas troughs with standards	164
1 2,300 gall. canvas troughs with ropes and pickets	180
2 7,000 gall. canvas troughs with ropes and pickets	460
	1,994

1 Wagon L.G.S. additional required.

Composite Field Troop, R.E.

Headquarter Troop.	lbs.
1 Pump, Lift and Force with hose and spares	171
1 Elevator, Boulton & Paul, with 300′ belt	400
1 Norton Tube Equipment	248
2 "Spear Points" 20′ of 2½″ pipe	200
1 600 gall. canvas trough with standards ..	164
2 7,000 gall. canvas trough with ropes and pickets	460
200 lbs. of tar	200
	1,843

1 Wagon L.G.S. required.

1 Troop

as for Headquarter Troop less

1 Elevator, Boulton and Paul, and

1 Norton Tube equipment.

1 Wagon L.G.S. required.

Electrical and Mechanical Coy., R.E.

4 Direct coupled Petrol-Turbo Astor Gwynne 4-stage pumps delivering 6,000 gallons at 250′ head through 4″ pipe.

4 Air compressor Lorry plants. Astor engines, Broom and Wode compressors with air pipe foot piece and discharge gear, capacity 69 cub. ft. free air at 100 lbs. pressure a min.

40 7000 gall. canvas tanks with ropes and pickets total weight 9,200 lbs.

500 lbs. tar.

10 3 ton lorries will be required.

Landing Operations.

54 7,000 gall. canvas tanks with ropes and pickets.
3,000 4 gall. petrol tins empty with wooden handles.
3 25,000 gall. capacity tank barges with pumps and hose.

Base Water Supply.

1 Wallace-Tiernan Chlorinator Type MSAM
4 tons chlorine.

Reserve Equipment and Stores.

2400 ft. run 6" lining for bore holes.
12 Steel driving shoes.
8 Astor Gwynne Petrol Turbo Pumps.
6 Astor Engine Wade Compressor plants.
50 Pumps L. & F.
10 Spear points 20′ 2½" pipe.
80 7,000 gallon canvas tanks complete with ropes and pickets.
20 2300 gallon canvas tanks complete with ropes and pickets.
100 600 gallon canvas tanks with standards.
5000 gal. Tar.

As it is anticipated that operations will be over in 6 months, and as in considering the problem equipment for a rapid advance has been provided, all equipment and stores required have been included in the initial programme and no further requirements will be necessary.

In the event of a third division being required, the question of time has been considered and the existing units have sufficient equipment and stores to prepare the water supply organisation of this division, both on the L. of C. for the march up to the front and in the concentration area for the final attack.

BRIEF HISTORY OF THE ROYAL ENGINEERS WITH CAVALRY IN FRANCE DURING THE WAR 1914-18.

By COLONEL W. H. EVANS, D.S.O.

III. THE CAVALRY CORPS.

1. The Cavalry Corps was formed at Daours early in September, 1916, the five Cavalry Divisions being concentrated under the Fourth Army in that area in readiness for the second phase of the Somme Battle. A C.R.E. (Lt.-Col. W. H. Evans) was appointed to the staff of the newly-formed Corps, and also an Adjutant R.E. (Capt. G. E. Grimsdale). The 1st Field Squadron with the dismounted men of the 1st and 2nd Cavalry Divisions were at Carnoy employed on the construction of a cavalry track from Carnoy towards Leuze Wood and on waterpoints at Carnoy. The 2nd Field Squadron with the dismounted men of the 3rd Cavalry Division were near Fricourt employed on a cavalry track from Montauban to Longueval and Flers and on the construction of a Corps Headquarters Camp at Billon Farm. The 2nd Indian Field Squadron with the dismounted men of the 1st and 2nd Indian Cavalry Divisions were at Fricourt employed on a cavalry track from Fricourt to Delville Wood and on waterpoints at Fricourt. Prior to the attack on September 15th the Divisions were concentrated as follows:—1st at Carnoy, 2nd at Bray, 3rd at Daours, 1st Indian at Morlancourt and 2nd Indian at Fricourt, and the 1st Indian Field Squadron helped with the work being done by the 2nd Indian Field Squadron. During the infantry attacks the cavalry tracks were pushed on as far as possible, and owing to the bad weather a great deal of maintenance work was necessary. After the attack of September 25th the Corps moved to Regnere Ecluse for the winter: the 1st Cavalry Division to N.E. of Hesdin: 2nd remaining between Bray and Fricourt, with the Field Squadron working under the XIV Corps: 3rd to west of Hesdin: 1st Indian to near Crecy: 2nd Indian to Daours, the Field Squadron being left at Fricourt for work under the XIV Corps on Artillery O.P.'s and Railways.

2. On October 4th, 1916, the 3rd Field Squadron went forward to near Couin, in the Reserve Army area, for work on waterpoints near Colin Camps and on a cavalry track, which was not used: they were withdrawn on October 31st. On October 7th the 1st Field Squadron were moved to Albert: they constructed a cavalry track from Ovilliers to Courcelette and a Corps headquarters camp west of Albert: they were withdrawn on November 10th. The

2nd Cavalry Division were withdrawn on November 5th, prior to which date their Field Squadron had constructed waterpoints for three Cavalry Divisions on the Ancre near Albert. The 2nd Indian Field Squadron were withdrawn in the middle of October. By the beginning of November the Divisions had settled into their winter areas: 1st round Samer (Squadron, Doudeauville); 2nd west of Hesdin (Squadron, Douriez); 3rd south of Montrieul (Squadron, Les Puits Berrault); 1st Indian south of St. Valery-sur-Somme (Squadron, Boismont); 2nd Indian north-east of Tréport (Squadron, Embreville). Owing to transportation difficulties it was proposed to send as many Divisions as possible to the Department of the Orne, but this project was abandoned. The winter was spent in providing a certain amount of hutting and stabling, horsedips, etc.; a good deal of training was done and officers were sent to Bridging Courses at Aire and Field Company Commanders' Courses near Hesdin. It was decided to withdraw boat wagons from Field Squadrons, and on February 5th the Cavalry Corps Bridging Park was formed near Boismont, consisting of three Bridging and one Park Sections. The two Indian Divisions and their Field Squadrons were re-named the 4th and 5th early in 1917, and the Canadian Field Troop was finally absorbed into the 5th Field Squadron. During the winter each Division supplied Pioneer Battalions, usually with a few R.E., for work with Infantry Corps and on new railway lines.

3. On February 10th, 1917, a preliminary reconnaissance was carried out for cavalry tracks east of Arras. And on March 11th detachments from the 1st, 2nd and 3rd Field Squadrons with dismounted men from their Divisions (under Capt. Davidson, Majors Richards and Shannon) commenced work on these tracks; Lieut. E. Rait Kerr was dangerously wounded while working on the 3rd Cavalry Division track and was awarded a bar to his Military Cross for gallantry. At the same time other detachments from these Divisions constructed waterpoints near Aubigny, Bailleulmont and Gouy respectively. An advanced Corps Headquarters was also constructed at Duisans. The 25th Infantry Division (changed later to 17th) were attached to the Corps for operations and waterpoints put up by them near Berlencourt. On March 19th, 1917, the 4th and 5th Cavalry Divisions moved up to join the Fifth and Fourth Armies respectively, a Brigade of the 4th Cavalry Division having already moved forward a few days previously: the 4th Field Squadron were employed on waterpoints near Sapignies and a cavalry track near Bullecourt: the 5th Field Squadron accompanied their Division in the advance of the Fourth Army and were employed on filling craters, road work and constructing reserve defence lines, being located at Tertry. On April 6th, 1917, Corps Headquarters moved up to Duisans and for the attack on

April 9th the 2nd and 3rd Cavalry Divisions moved east of Arras, operating under the Third Army; the 1st Cavalry Division operating under the First Army north of the Scarpe. The Park Section of the Bridging Park were employed to carry up wire and pickets after the 2nd and 3rd Divisions. On April 11th the cavalry were withdrawn and by April 20th Corps Headquarters were back at Regniere Ecluse, the Divisions being disposed thus:—1st east of Hesdin (Squadron at Wail); 2nd round Henu, north east of Doulens; 3rd east of Crecy (Squadron at Wadicourt); 4th round Marieux, east of Doulens; the 5th along the Omignon Valley. A detachment of the 1st Field Squadron was employed on constructing at Corps Reinforcement Camp near Frevent.

4. On May 9th the Corps, with the 2nd, 3rd and 4th Divisions, moved down to the Peronne area, between the Omignon and Cologne Rivers, joining up with the 5th Cavalry Division. A portion of the front line between the Omignon River and Epéhy was taken over from the 59th and 42nd Divisions and all four Cavalry Divisions put in, the order of battle being 5th, 4th, 2nd and 3rd: Corps Headquarters took over from the III Corps at Catelet and the Divisions were disposed along the Omignon and Cologne Rivers. The C.R.E. was allowed three temporary Field Engineers to assist him in the work of the Corps area (Lieuts. A. J. Hingston, A. E. Hughes and G. Buswell); Nos. 281, 282 and 565 A.T. Companies R.E., No. 180 Tunnelling Coy. R.E., No. 3 Reinforcement Coy. R.E. and No. 4 Pontoon Park were attached to the Corps. Apart from the ordinary R.E. work connected with the administration of a large area in a devastated zone, a great deal of work was done on improving defences, and the Corps were complimented by the C. in C. and the III Corps Commander, on the state in which they left the defences. Major V. A. Simon, 3rd Field Squadron, and Capt. D. Wise, 2nd Field Squadron, were killed on June 3rd and May 15th, respectively, east of Ronssoy. The dismounted men of the Divisions were formed into the British and Indian Entrenching Battalions (Major Ricardo and Lt.-Col. R. M. Bell) and employed on constructing a reserve defence line known as the "Brown Line." During this period the 1st Cavalry Division were employed with the First Army near Merville; they were employed on reserve positions and communication trenches on the Vimy Ridge.

5. On July 3rd, 1917, the 3rd Cavalry Division moved up to the First Army area and on July 5th the Corps handed over their trenches to the III Corps (34th and 35th Divisions). Corps Headquarters moved to Aire and the Divisions were located thus:—1st, Merville, 2nd, round Magnicourt along the Canche; 3rd, Busnes, near Lillers; 4th, remaining with the Third Army along the Omignon; 5th, north of St. Pol (Squadron at Troisvaux). On July 22nd a Brigade of the 1st Cavalry Division and the 1st Field Squadron

joined the 2nd Army, moving between Watten and Dickebusch; the Field Squadron were mostly employed at the latter place on waterpoints, corduroy roads, etc. On July 26th the 3rd Field Squadron moved to Westoutre to prepare for operations in the Second Army area; they were employed on waterpoints, Corps Reinforcement and Remount camp near Bailleul and advanced Corps headquarters at Dickebusch and later at Poperinghe. On October 4th the 1st and 5th Cavalry Divisions started off by the Elverdinghe and Watou areas, but were at once recalled. On September 1st a Cavalry Corps Horse Show was held, the prize for the best Field Troop going to the 4th Field Squadron (Lieut. S. G. Bennett, Troop Leader).

6. At the end of August, 1917, it was decided to construct huts and stables for the Corps in the area between the Cologne and Omignon rivers and work was commenced on September 16th, the whole of the 4th (at Athies) and detachments from the 2nd, 3rd and 5th Field Squadrons being employed, together with dismounted men from these Divisions: in the middle of October the whole of the 2nd and 3rd Field Squadrons were moved down for hutting work to Brusle and Flamicourt. At the end of October preparations for the Cambrai operations were commenced; a detachment of the 3rd Field Squadron constructed waterpoints for three Divisions at Fins, also an Advanced Corps headquarters there; a track-making Battalion was formed from the dismounted men of the 4th and 5th Cavalry Divisions and trained under Lieut.-Col. R. M. Bell and Lieut. S. G. Bennett, 4th Field Squadron: a bridge for crossing the St. Quentin Canal was prepared by Lieut. H. D. Maconochie, 3rd Field Squadron, and arranged for loading on to two tanks. On November 20th the operations commenced, Corps Headquarters moving from Billers Carbonnel to Fins; the 1st Cavalry Division were employed towards Bourlon Wood; the 5th Cavalry Division, followed by the 2nd Cavalry Division, used the track constructed during the attack by the Indian Entrenching Battalion from Gouzeaucourt via La Vacquerie to Masnierres with the aid of twelve wirepulling tanks; the 4th Cavalry Division were in close reserve at Fins, a brigade with the Field Troop being detailed for work under the III Corps; the 3rd Cavalry Division was in reserve in the Bray area. The specially prepared bridge was used to improve an existing bridge east of Masnierres and facilitated the withdrawal of the Canadian Cavalry Brigade: Lieut. Maconochie was awarded the Military Cross. By November 27th the Corps had moved back to Villers Carbonnel and commenced taking over a portion of the trench line between the Omignon River and Hargicourt, the 2nd Cavalry Division having been left up at Fins.

7. On November 30th, 1917, the Germans counter-attacked in

force south of Cambrai. Corps Headquarters moved to Villers Faucon and the 2nd and 5th Cavalry Divisions came into action between Epéhy and Gouzeaucourt, the 4th Cavalry Division being in support at Villers Faucon and the 1st and 3rd Cavalry Divisions in support of the VII Corps along the Cologne River: later the 1st and 4th Cavalry Divisions took over from the 2nd and 5th. The Field Squadrons were employed on the construction of support lines and strong points. On December 6th the Corps moved back to their winter area, Corps Headquarters moving to Villers Carbonnel: the trench line between the Omignon Valley and Ronssoy was taken over from the VII Corps, the 24th Division being included in the Cavalry Corps. The left sector of the line was taken over by the 24th Division and the right sector by an organisation called the Dismounted Divisions, consisting of two of the Cavalry Divisions in turn; Major A. F. S. Hill, of the 4th Field Squadron, was appointed temporary C.R.E. of the Dismounted Divisions. The C.R.E. was given three extra officers to assist him, Capt. R. G. Wright, Capt. E. O. Pearce, who had joined in September as Hutting Officer, and Lieut. G. Buswell: Nos. 239, 281 and 288 Army Troops Companies R.E. and 258 Tunnelling Company R.E. were attached to the Corps. A great deal of hutting work was carried out, as well as work on defences, including a number of switch lines, dug-outs, etc.; workshops were formed at Brie and all the bridges in the area were prepared for demolition. At the end of February, 1918, the 4th and 5th Cavalry Divisions were withdrawn to the Longpré area, preparatory to being sent to Egypt: the 4th Field Squadron was sent to Ailly-le-Haut-Clocher, where it was broken up: the 5th Field Squadron were retained for work on Corps defences. On March 9th the Corps handed over to the XIX Corps, the 24th Division, after relief by the 66th Division, taking the place of the Dismounted Cavalry Divisions in the line. Corps Headquarters moved from Catelet to Villers Carbonnel, the three Divisions remaining along the Cologne and Omignon Rivers. The Corps were put in charge of the Army Line (the Green Line), Brig.-General Armstrong, Canadian Engineers, being put in charge of the work, the C.R.E. being given a sector to look after with the Field Companies and Pioneers of the 50th Division, the 225th Field Company, Nos. 283 and 288 A.T. Coys. R.E., in addition to the Field Squadrons and a number of Labour Units.

8. Prior to the German attack on March 21st, 1918, the 2nd Cavalry Division had gone down to the Oise to join the III Corps. On the 21st the 3rd Cavalry Division was also sent down to the III Corps area, the 1st Cavalry Division and the 5th Field Squadron put under the XIX Corps, and Cavalry Corps Headquarters moved back to Moreuil. The 1st Cavalry Division were in action several times during the retreat: on the 23rd the Field Squadron blew

up the bridge over the Somme at Pargny and Bethencourt, 2nd Lieut. Baylay being killed: on the 24th they were at Cappy and Cerisy under the VII Corps, and on the 25th at Bussy-le-Daours holding the line north of the Somme about Morlancourt: on this day they again came under the Cavalry Corps, which had arrived at Querrieu. The 2nd Cavalry Division were at Maucourt on the 21st, and the Field Squadron reconnoitred the bridges over the Oise for demolition: on the 23rd Lieut. Kezar's Troop were in action at Jussy with the 3rd Cavalry Brigade, the other troops being detached to the 4th and 5th Brigades and rejoining the Squadron on the 27th. Meanwhile Squadron Headquarters on the 22nd and 23rd prepared 14 bridges about Marucomp and Quierzy for demolition and again two more at Appilly and Bretigny on the 24th, which they blew up on the 25th, the bridge at Pontoise being demolished the same day. On the 29th the Squadron dug posts at Dive Le Franc, handing over to the French, and again the same thing at Ansauvillers, whence they marched north to Boves, on the 30th rejoining the Cavalry Corps. The 3rd Cavalry Division joined up with the 2nd Cavalry Division under the III Corps: on the 26th the Field Squadron assisted the French to blow up some bridges near Pontoise: on the 27th the Division assembled near St. Just, and on the 30th rejoined the Corps at Sains-en-Amienois. The 5th Field Squadron, after retreating daily, were on March 25th joined by two Tunnelling Companies and four A.T. Companies of the XIX Corps, forming the XIX Corps R.E. Battalion, of which Major Buchanan was placed in command, and Capt. Fairclough appointed Adjutant: on the 25th the Battalion blew up a culvert between Estrées and Foucacourt, and on the 26th they dug and manned the Framerville-Varvillers line: on the 27th they retired to the Rouvroy to Framerville line, where they were heavily attacked and had to retire to the Le Quesnil-Beaufort line, Lieut. Matthewson being killed at Rouvroy. The Battalion was reorganised at Cayeux, and again put into the line at Demuin, where they were heavily attacked and had to retire to Hangard, consolidating a position there and being withdrawn on the 31st to near Boves: Major Buchanan was seriously and Lieut. Greathead slightly wounded during the action at Demuin. The Squadron joined the Corps near Glissy on April 1st and were employed on constructing a trestle and a pontoon bridge over the Somme. The 1st Cavalry Division, on April 27th, were hastily transferred from the north to the south bank of the Somme to fill a gap in the line: they occupied this line till May 3rd, the Field Squadron being employed in support and also on preparing some of the bridges about Daours for demolition. On April 1st the 2nd Cavalry Division, with part of the 3rd Cavalry Division, attacked at Hangard Wood, north-east of Moreuil:

the 2nd Field Squadron followed up to consolidate, when Major Swinburne was killed and Lieut. De Meric wounded. On April 3rd the 3rd Cavalry Division went up in support north-west of Gentelles, and the Field Squadron was employed on the Cachy Switch until the 8th. On April 6th Corps Headquarters withdrew to Amiens with the 1st and 3rd Divisions, the 2nd Division moving back to Ailly-le-Haut-Clocher. The 5th Field Squadron were sent to the Base and broken up.

9. On April 10th, 1918, Corps Headquarters moved to Auxi-le-Chateau, and on the 17th to St. Quentin, near Aire, in consequence of the German attack about Merville, the Divisions being located—1st, at Heuchin (Squadron Livossart); 2nd, Blaringhem, 3rd, Pernes (Squadron Sains-les-Pernes). On April 27th the 2nd Cavalry Division moved back to Mont Cavrel, near Montreuil (Squadron at Alette), Corps Headquarters moving on May 5th to Auxi, the 1st Cavalry Division to Bomy, (Squadron Rupigny) and 3rd to Contay in the Fourth Army Area, where the Field Squadron (at Behencourt) with dismounted Cavalry were employed on III Corps rear defences. On the 16th May the 3rd Division withdrew to the Yvrench area (Squadron at Bettencourt-St.-Ouen), leaving a Brigade and a Field Troop working on trenches until July. A good deal of R.E. work was done during the summer for the Cavalry School at Dieppe, where Capt. S. G. Bennett was appointed R.E. Instructor, the Equitation School at Cayeux, where officers from each Field Squadron were sent to attend the courses, the Corps Reinforcement Camp at Abbeville, and the Corps Convalescent Camp near Cayeux. All Squadrons were trained in bridging, and the 1st and 2nd Squadrons drilled with the Inglis Bridge. On May 21st the 2nd Field Squadron went up to Houdain, until July, to work on a reserve line under the X Corps, employing Chinese labour. On May 22nd the 1st Division moved to the Auxi area (Squadron at Gueschart, and later at Villeroy sur Authie). During June the C.R.E. and some officers from Field Squadrons worked on Defences east of Doulens for the C.E., Third Army. On July 3rd the 3rd Field Squadron moved to Dreuil, until July 30th, for work on rear defences, with Chinese labour, under the C.E. Fourth Army. On July 11th the 2nd Field Squadron moved to Willencourt for training in bridging. On July 14th the 1st Cavalry Division moved forward in support of the Third Army to Beauval (Squadron, Gezaincourt), moving back on the 30th (Squadron, Beauvoir Riviére). On July 15th the 2nd Cavalry Division moved up in support of the First Army to Le Couroy (Squadron at Sars-le-Bois), moving back on the 22nd (Squadron, Willencourt).

10. On August 6th, 1918, Corps Headquarters moved to Yzeux, taking the Water Point Section of the Bridging Park, and the Divisions concentrated west of Amiens for the Fourth Army attack

on August 8th. Owing to the secrecy preserved regarding the operations little preliminary R.E. work was possible: the 3rd and 1st Field Squadrons prepared tracks through the trenches for their Divisions and the A.D. Roads, Fourth Army, sanded the pavé roads through Amiens for the night of August 7th to 8th, when the Divisions marched through and concentrated by dawn east of the town, Corps Headquarters moving to Longueau. From the cavalry point of view the attack was a great success, but owing to the rapidity of the advance, very little R.E. work was possible: the 3rd Field Squadron reconnoitred the crossings over the Luce. Corps Headquarters moved forward to Cayeaux-en-Santre on the 8th and to Caix on the 10th, the Bridging Park being ordered up to Cayeux: on the 11th the 2nd Field Squadron employed the waterpoint section at Vrely. On August 12th Corps Headquarters moved back to St. Fuscien, the Divisions withdrawing to along the Somme and Avre east of Amiens. On the 16th Corps Headquarters moved back to Auxi, 1st Division east of Auxi, 2nd between Auxi and Canaples, 3rd Yzeux. On August 20th the 1st and 2nd Cavalry Divisions moved east of Doulens and on August 25th their Field Squadrons were employed on water supply work at Ablainzeville and Miraumont, respectively, Corps Headquarters moving to Hauteclocq (south of St. Pol): the 34th Mobile Infantry Brigade in busses was attached to the Corps for operations on the Third Army front, but the Corps were not used and returned to Auxi early in September, the 1st Division being located east of Auxi (Squadron at Wavans). Meanwhile the 3rd Division moved up west of Auxi (Squadron at Haravesnes), and the 2nd Cavalry Division were split up, 3rd Brigade with a Field Troop to First Army, 4th Brigade to Third Army, 5th Brigade, with a Field Troop, to Fourth Army, Headquarters and remainder of Field Squadron at Gaudiempre and Grenas, north east of Doulens. On September 15th the Corps were set a tactical scheme in the Auxi area in conjunction with Infantry in busses.

11. On September 27th, 1918, the Corps (less 2nd Division) moved down into the Fourth Army area, Corps Headquarters going into camp about Aizecourt-le-Haut (north of Peronne), 1st Division along the Cologne and 3rd along the Omignon Rivers. The 4th Guards Brigade, with a battery of R.F.A., and the Household Machine Gun Brigade, all in busses, were attached to the Corps, as well as the 18th Corps Cyclists: a made-up bridge in three spans, with Weldon trestles, to carry busses, was carried on five lorries, together with a party of sappers under Lieut. Matthews, from 648th Field Company R.E. On several occasions the Corps moved forward to follow up the Infantry attack, but it was not until October 8th that the situation permitted of the employment of Cavalry: on that day the Corps moved forward

across the St. Quentin Canal, Corps Headquarters moving to Estrées: the 1st Cavalry Division were in action about Seraing and Premont, and a troop of their Field Squadron was used to support an attack about Premont: the next day the 3rd Cavalry Division were engaged towards Le Cateau and Corps Headquarters moved forward to Seraing, advancing to Bertry on the 11th. During this battle a great deal of R.E. work was done by the Field Squadrons: the waterpoint wagons of the Bridging Park (3 deep well sets) were used at various villages with excellent results, watering large numbers of horses belonging to all formations: a number of mines and German traps were removed or rendered safe: a good deal of work was done in filling craters, making diversions round craters, etc., the 18th Corps Cyclists assisting in the work. On the 14th, Corps Headquarters moved back to Aizecourt-le-Haut, the 1st Cavalry Division going to Tertry and the 3rd to Manancourt. Meanwhile the Field Troop attached to the 5th Cavalry Brigade had been doing good work during the battle in the neighbourhood of Bohain, while Lieut. Lloyd was lucky enough to be in time to cut the wires laid for firing a large German ammunition dump: this Brigade was withdrawn to Catelet about October 15th, and employed on the construction of a Reinforcement and Remount Camp at Clery.

12. On November 7th, 1918, the Corps (less the 2nd Cavalry Division) moved up to the Lille area, Corps Headquarters going to Seclin and the Divisions west of the Escaut Canal, south of Tournai (Squadrons at Poissonniére and Attiches): preparations were made for operations with the Second Army, two made-up bridges on pontoon waggons, for crossing canal locks, being attached to the 1st Field Squadron, and a Bridging Section from the Bridging Park to each Field Squadron. On November 10th Corps Headquarters moved to Genech and the Divisions crossed the Escaut Canal, going forward into the battle on the 11th, but being stopped at 11 a.m., on account of the Armistice, along the Blaton Canal about and south of Ath. On November 13th Corps Headquarters moved to Tournai, the two Divisions being located east of the Escaut Canal (Squadrons at Wier and Vezon). Meanwhile the 2nd Cavalry Division collected about Cambrai, moving forward to Le Quesnoy prior to leading the advance of the Fourth Army to the frontier, the Cavalry Corps being allotted to the Second Army for the same purpose. The march forward commenced on November 17th the 1st Cavalry Division being on the right, and the 3rd on the left of the Second Army front. Corps Headquarters moved forward via Silly, Braine-le-Comte, Genappe, reaching Namur on the 22nd: here it was decided that the 1st Cavalry Division only should go forward, the 3rd remaining where they were for the present (Squadron, Perweiz). On September 27th

the move forward continued, Corps Headquarters moving via Huy, Ouffet and reaching Stavelot on the 29th, the 2nd Cavalry Division, in front of the Fourth Army, having reached Marche (Squadron, Marloie). On December 3rd a section of the Bridging Park was broken up in order to provide reinforcements for the 1st Field Squadron, who had suffered severe losses on account of influenza. On December 1st the 1st Cavalry Division continued the march into Germany under the Second Army, Corps Headquarters with the 2nd and 3rd Divisions remaining with the Fourth Army. On December 12th the 1st Cavalry Division crossed the Hohenzollern Bridge over the Rhine at Cologne, returning shortly afterwards to their winter area just west of Cologne (Squadron at Modrath). On December 11th Corps Headquarters moved to Spa, and on the 17th the 2nd and 3rd Cavalry Divisions settled into their winter areas south of the Meuse on either side of the Ourthe (2nd Field Squadron at Tilff, 3rd at Schlessin, Bridging Park at Embourg, all near Liège). Towards the end of December Nos. 146, 221, and 574 Army Troops Companies R.E. joined the Corps, the two former being allotted to the 3rd Cavalry Division and the latter to the 2nd. During the advance through Belgium the only R.E. work done was road reconnaissance and removal of German mines. During the winter, apart from the ordinary minor R.E. services, the following works were carried out:—demobilisation camp at Seraing; G.H.Q. Training School near Engis; establishment of various workshops for educational purposes.

13. In conclusion, mention should be made of Captains W. Walker, M.C., R. F. Young, M.C., and R. F. Fagan, who for a long time were Medical Officers to the 2nd, 3rd and 5th Field Squadrons, respectively; also of the following Interpreters:—Bing, who was with the 3rd Field Squadron throughout the war; H. Mayerwaerth, P. Thieux and E. Oliver, with the 4th Field Squadron; and P. Canivet with the 5th. Major J. A. Church, 13th Hussars (R. of O.), was for many months attached to the 4th Field Squadron, and Lieuts. C. T. St. Quintin and N. T. Secombe to the Cavalry Corps Bridging Park.

ERRATA.

On p. 45 *line* 24 *for* Aldershot *read* LUDGERSHALL.
On ,, ,, 28 *for* Westoure *read* WESTOUTRE.
,, ,, ,, 35 *for* Reninghels *read* RENINGHELST.
,, ,, ,, ,, *for* St. Vans Cappel *read* ST. JANS CAPPEL.
,, p. 48 *lines* 15 *to* 19 *Delete from* On December 31st to February 15th, 1916, *and substitute*:—
On December 31st, 1915, the Corps formed a Dismounted Division for duty in the trenches. This Composite Division proceeded to PHILOSOPHE and took over that part of the front line, which included the HOHENZOLLERN Redoubt, east of VERMELLES, until its return to the Corps on February 15th, 1916.

MACAULAY'S EQUATION.

By LIEUTENANTS E. A. L. GUETERBOCK AND P. R. ANTROBUS, M.C., ROYAL ENGINEERS.

In his very clear explanation of the Macaulay method of solving problems on deflections of beams, Captain Womersley mentioned the case of an intermediate couple applied to a beam.

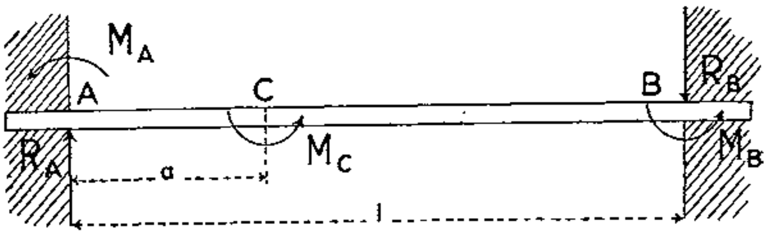


FIG. 1.

The solution by converting the couple into a pair of equal and opposite infinite forces acting at an infinitesimally short distance apart, involves rather long equations which appear to have led Captain Womersley into an arithmetical error in his Example III.

The following is a slight modification of the method which may be found useful in solving this particular problem. It follows so directly from the Macaulay method that many will no doubt be prepared to accept it without proof, but in order to satisfy the most particular, a separate proof is given.

Consider the Fig. 1 above. Take A as origin and the undeflected centre line AB as x axis, and the axis of y downwards.

Using Capt. Womersley's notation, the Bending Moment equation from A to C is :—

$$-EI\ddot{y} = R_A x - M_A \quad \text{(1)}$$

which gives the slope equation on integration :—

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x + \alpha \quad \text{(2)}$$

and the deflection equation on further integration :—

$$-EIy = R_A \frac{x^3}{6} - M_A \frac{x^2}{2} + \alpha x + \beta \quad \text{(3)}$$

where α and β are constants of integration.

From C to B the Bending Moment equation is :—

$$-EI\ddot{y} = R_A x - M_A - M_C \quad \text{(4)}$$

which gives the slope equation :—

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x - M_C x + \alpha_1 \quad \text{(5)}$$

Now this equation may, by simply altering the constant of integration, be re-written :—

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x - M_C(x-a) + \alpha_2 \quad \ldots\ldots\ldots\ldots \quad (6)$$

from which we derive the deflection equation :—

$$-EIy = R_A \frac{x^3}{6} - M_A \frac{x^2}{2} - M_C \frac{(x-a)^2}{2} + \alpha_2 x + \beta_2 \quad (7)$$

Now when $x = a$, (2) and (6) should give the same value for the slope of the beam, and (3) and (7) should give the same value for the deflection and thus it will be seen that :—

$\alpha = \alpha_2$ and $\beta = \beta_2$

Hence the equation (4) can be used as the Bending Moment equation for the whole beam provided that the term $-M_C$ is left out when x is less than a, and the integration carried out in the manner shewn in (6) and (7). Such terms may be enclosed in special brackets.

As a further reminder that equation (4)

$$-EI\ddot{y} = R_A x - M_A - M_C$$

must be integrated in the form :—

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x - M_C \left\{x-a\right\} + \alpha_2$$

it may be written :—

$$-EI\ddot{y} = R_A x - M_A - M_C \left\{x-a\right\}^{\circ}$$

which clearly makes no difference since $\left\{x-a\right\}^{\circ} = 1.$

It may be suggested that this is a trick method, but this is not really the case, as the term $-M_C\left\{x-a\right\}^{\circ}$ is merely a reminder, firstly, of the method of integration, and secondly, that the term is non-existent when x is less than a.

In order to show the advantages of this method, Captain Womersley's two examples are here worked out.

As we have seen, the Bending Moment equation is :—

$$-EI\ddot{y} = R_A x - M_A - M_C \left\{x-a\right\}^{\circ}$$

Integrating, we have the slope equation :—

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x - M_C \left\{x-a\right\} + \alpha$$

and since $\dot{y} = 0$, when $x = 0$, $\quad \therefore \alpha = 0$

Integrating again we have the deflection equation:—

$$-EIy = R_A \frac{x^3}{6} - M_A \frac{x^2}{2} - \frac{M_C \left\{x-a\right\}^2}{2} + \beta$$

and since $y = 0$, when $x = 0$, $\quad \therefore \beta = 0$.

The terminal conditions that $\dot{y} = 0$ and $y = 0$, when $x = l$, give:—

$$R_A \frac{l^2}{2} - M_A l - M_C(l-a) = 0$$

and

$$R_A \frac{l^3}{6} - M_A \frac{l^2}{2} - \frac{M_C}{2}(l-a)^2 = 0$$

These give Captain Womersley's solutions:—

$$R_A = \frac{6a(l-a)}{l^3} M_C \text{ and } M_A = \frac{(l-a)(3a-l)}{l^2} M_C$$

Applied to Example III we have:—

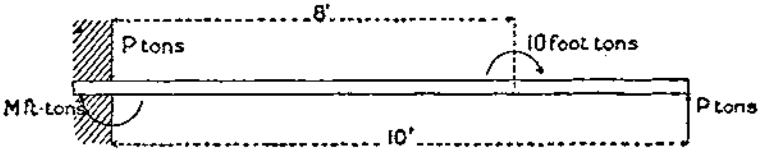


FIG. 2.

$$-EI\ddot{y} = M - Px + 10 \left\{x-8\right\}^0$$

whence $-EI\dot{y} = Mx - P\frac{x^2}{2} + 10\left\{x-8\right\} + \alpha$

and $\alpha = 0$, since $\dot{y} = 0$ if $x = 0$

and $-EIy = M\frac{x^2}{2} - P\frac{x^3}{6} + \frac{10}{2}\left\{x-8\right\}^2 + \beta$

and $\beta = 0$, since $y = 0$ if $x = 0$

Now $y = 0$, when $x = 10$, hence $0 = M\frac{100}{2} - P\frac{1000}{6} + \frac{10}{2}.4$

i.e. $50P - 15M = 6$

And $\ddot{y} = 0$, when $x = 10$, hence $10\ P - M = 10$

Whence $M = 4.4$ foot-tons and $P = 1.44$ tons.

A "SPORTING LECTOR."

By MAJOR A. V. T. WAKELY, M.C., *p.s.c.*, R.E.

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"'Unting is the sport of Kings, the image of war without its guilt and only five and twenty per cent of its danger."
R. S. SURTEES.

THIS short article is rather a collection of anecdotes than an essay of literary or educational merit. The title itself is misleading. It is borrowed from that very fine sportsman, Mr. John Jorrocks, and I can never see myself getting up on the platform in canary-coloured shorts and giving forth in the inimitable style of our friend. On the other hand, I think that some of my experiences and deductions may be of interest and possibly of value to the majority of young officers who read the *Royal Engineers Journal.* Further, I am presumptuous enough to think that my remarks may contain one or two points which some senior officers have not thought of before.

It is hardly necessary to dilate upon the general advantages of fox-hunting as a recreation. Half an hour spent with John Jorrocks will tell the reader all there is to know about hunting as a pleasurable and health-giving occupation. The advantages of hunting as an aid to the training of officers are not so well known, and the object of this little article is to try and point them out, and to show how one can use hunting as a training ground for real soldiering—that is, for war.

As the result of many years' study of hunting, I have come to the conclusion that there is no sport in which the necessary qualities of an officer can be developed and trained like they can in hunting. Let me be more definite, and let me state what some of these qualities are. A few of the more important are capacity for rapid decision, military knowledge, powers of observation, smartness and neatness of turn-out, and tact and a knowledge of human nature.

Rapidity of decision is, perhaps, one of the most difficult things to practise in peace time, but in the course of a day's hunting one will get many opportunities. Every time a fox breaks cover the opportunity occurs. Now, before one can come to a decision one has to "appreciate the situation." In tactics lectures we hear a lot about this, and the phrase is associated in our minds with tactical schemes. Let us put these away for a moment, and consider an appreciation of the situation when we hear a "Tally ho!" from the far end of a big covert.

What is our object and what are the factors? Our object is to see the hunt, to get as near hounds as possible and to stay there. Let us suppose we are on a horse that can jump. There is a fence, perhaps a big one, not twenty yards away. There may or may not be a gate; if there is, there will also be fifty or a hundred people converging towards it. There may be a good scent and hounds may be likely to run fast. We have to decide whether to jump the fence or go for the gate. Is our horse able to jump the fence? Is it necessary to do so? These are a few of the factors. But the chief factor is that of time; generally we have four seconds in which to make up our mind and act. Instant and decisive action must be taken or else we will lose the hunt. Now, in the hunting field such decisions must be taken many times in a day. They arise in many different forms, and the above is only an example. Is there any doubt as to the value of such training to a soldier? Indecision at this moment communicates itself to one's horse. If we take the fence in an indecisive sort of way, a fall is almost a certainty, and, what is worse, both the rider and the horse know that a fall is, to say the least, a likely eventuality. If we go for the gate in a half-hearted way, wavering between the fence and the gate, we will get left and will see no hunt.

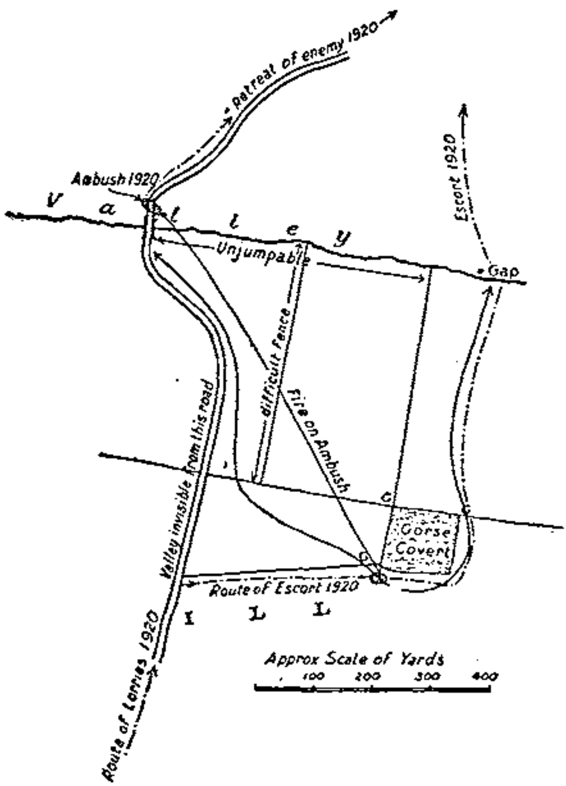
I was discussing this very question not so long ago with an officer who went well with the Staff College Drag. He said that every time he was in two minds he got into trouble—a fall, or at best a scramble. This officer had never ridden to hounds before he went to the Staff College, and he had not realized that what passed in his own mind instantly communicated itself to his horse. Any lack of decision was heavily penalized. I noticed some days after our conversation that he was in the first half-dozen up at the check, and he continued to occupy one of these places on every drag day. This was a remarkable example of will power and decision. Is there anyone who can say this was not good training for an officer's work? Make no mistake about it, any lack of decision on the part of a platoon commander in war, and even in peace training, instantly communicates itself to the men. They feel they are being badly led; they waver, they hesitate and are lost. The moral of it is to train one's self to make quick decisions. Whether these be right or wrong, if they are acted upon with rapidity and with energy they will generally turn out all right.

Hunting provides opportunities for training yourself in acting quickly and in adapting yourself to rapidly changing conditions, and there is just the spice of danger there to sharpen your wits. One very seldom gets a quick thing in the routine of everyday life, but it happens frequently in war. You can get it any day in London if you try to cross Piccadilly Circus during the rush hours, but you don't get so much pleasure out of that as you do out of hunting, and there is great and unnecessary danger! I prefer hunting!

Military knowledge covers a very wide scope, and it is at first sight difficult to see how hunting can help. But, to take only two examples, the use of ground and map reading can, I think, be regarded as quite essential parts of one's military knowledge.

Now, it is a fact that in hunting one covers more ground in one day than in the case of any other sport. So the opportunities for the study of ground are endless. You should always take a map with you out hunting, and you should always watch where you go and be able after the day to mark up your itinerary on the map. This teaches map reading as nothing else can. The use of ground can and should be studied. What ground can you push along over, and where must you take a pull at the horse? How can you cut off a corner to save your horse or to get nearer to hounds as they swing?

I heard, not so long ago, of a very remarkable incident showing how hunting taught the use of ground. A brother officer and myself in 1911, having nothing special to do, made a reconnaissance of nearly every fox covert in Kildare. We found the best line away



Original Sketch 1911 ——→ Best routes away from Fox Covert.

from the coverts in every direction, the easiest places to jump the fences, and the exact position of gates and gaps. We made little sketches of the places, and discussed them in the evenings. The information was absolutely invaluable during the whole of two subsequent hunting seasons, but there was a sequel.

A road ran about 300 yards from a certain covert. The covert was on a hill, and the road, after dropping the hill, crossed a very narrow valley. Owing to the conformation of the hill, the valley was invisible from any point higher up on the road, but the road and the whole valley could be plainly seen from the covert. The bridge in the valley was therefore an ideal spot at which to lay an ambush to catch lorries coming down the road. In 1920 my brother officer had to send escorted lorries along this road. He told the escorting officer that he had carefully reconnoitred this particular spot out hunting some years previously, and that he considered it an ideal place for an ambush. So he told the young officer to get his escort out of the lorries, just short of the covert, go up to it, and have a look down in the valley. Sure enough, the Sinn Feiners were there, lying up for the convoy! The young officer was not slow to act, and he scuppered practically the whole lot. Here is an instance where hunting knowledge probably saved several lives.

If you are keen on riding and hack out to nearly all the meets, you will get plenty of practice in map reading. Personally, I make it a rule to know every bridle path and track within hacking distance of my station. When riding, I eschew motor roads like the plague, and make full use of all tracks in the country. I had an instance of this only a few days ago. A friend and I had to hack about eight miles home after hunting. He proposed going the main motor road, but I was able to lead him by sand-tracks, and he did not know where he was until we got within a mile of barracks. It is, of course, far better for horses to take them along soft tracks instead of tarred roads. Some months ago I brought another friend home from another direction, along tracks he had never been, although he had hunted in the district for twelve years. It is appalling to think of the amount of hard road work done by such people's horses for no reason whatever, except that they never use a map. I learnt the tip from an Irish doctor many years ago, but he always included three or four banks and a few timber stiles in his ride home. Such a ride home is invariably pleasant, but it is not to be recommended as far as one's horse is concerned after a heavy day's hunting.

On another occasion, as a very junior subaltern, my knowledge of the country round barracks stood me in good stead. I was suddenly detailed on parade to lead an infantry brigade on a night march across open country, and I regret to say I had not practised marching on a compass bearing by night, and did not feel very confident about it. Fortunately, the point we had to get to was very near a fox covert two or three miles away, and as I had ridden to it several times and studied the best route on the map, there was no difficulty in leading the troops to the spot without the help of any compass.

The important thing to remember is that you must always bring your map out hunting and use it. I know of countless instances of fellows going miles out of their way because they do not know the country, and will not, for some unknown reason, use a map. If you practise map reading on hunting days you will get very good at it, and some day you will feel yourself quite at home, though the map you hold in your hand be a foreign one.

Smartness and neatness in equipment and dress are things that much could be written about, but a few remarks only are required here. A meet of foxhounds should be just as much a parade for the young officer as a church parade. It is an insult to the M.F.H. to turn up at the meet in incorrect kit, and it is just as much out of place for an officer to turn up in "ratcatcher" after November 1st as it would be to come to one's C.O.'s dinner party in plus fours! Everyone should wear a top hat and a black hunting coat, and as soon as you can ride well enough wear a pink coat. It is incorrect to wear a bowler hat with a hunting coat, and it is incorrect to wear brown breeches with a pink coat, but one sees these combinations not infrequently in the hunting field.

As regards kit, I had an illuminating conversation with a farmer only ten days ago. This farmer had asked us to be very careful not to ride over his wheat. and he said, "You always see the gentlemen in red coats going round the headlands, and they never ride over wheat, but it's them blighters" (this was not the exact word he used) "in bowlers and trilbies that ride down the middle of my wheat." So don't be a "blighter in a trilby"! And if you do carry a red coat, act accordingly and don't ride over wheat. Incidentally you must learn what wheat looks like.

This brings us to the training of one's powers of observation when out hunting. One could write a complete book about this, and it would include everything about the fox and everything about the hounds and how they hunt. But I will only mention here a few of the more obvious things which at any time may affect the ordinary member of the hunt. Learn what wheat, new grass, and beans look like in winter. Again, watch how people open gates. The correct way is to use the hand that is nearest the hinges of the gate. If you do this, you will nearly always open a gate easily without dismounting. Incidentally it requires quick observation to see whether it is necessary to get down to open a gate or not. Nothing is more annoying to those waiting to get through than to see a man fumbling at a gate which cannot be opened from a horse. Always carry a fairly heavy hunting crop with a thong and a lash. It is essential both to complete your kit and to open gates.

Locked gates are a nuisance. To break a lock use your stirrup iron. Set the lock with the catch facing outwards and the hinge of the lock against the gate post and then strike the lock just below the catch with the stirrup iron. Three blows delivered in this way will break the strongest lock, while twenty smites not so scientifically applied will make no impression even on a small padlock. A chain usually defies all efforts, so always attack the lock. Remember that you should not break locks unless it is really necessary, but it often is necessary, and I have personally done in four this season, three of them to get the huntsman through. Incidentally, none of them were on farmers' land.

A very good instance of the value of observation happened to me some years ago. We were riding through a big wood with hounds. I was on hunting leave, so it was some fifty miles from barracks. I saw a large pile of timber such as the sappers use for bridging. Six months later I commanded a detachment of engineers doing brigade training within two miles of the same spot. The Brigade Commander sent for me one evening and said he wanted four footbridges made over a river next day to get the brigade across. I had no material to make them, but suddenly thought of the pile of timber, and told the Brigade Commander that the bridges would be ready. There was just enough light that evening to get on a horse and find the owner of the timber. I borrowed what I wanted for the large sum of two shillings. At dawn next day my men fetched the timber, and we had the bridges made by midday.

Tact and a knowledge of human nature are absolutely vital to a modern leader of men, and the hunting field is one of the best training grounds for these qualities. You make many friends out hunting, and there is a camaraderie about fox hunting which is very pleasant when one comes across it, but you have to look for it under modern conditions. You can talk to your General out hunting, while at any other time an officer of such high rank is almost unapproachable, and the thought of an official interview with him, even when one has done no wrong, is quite enough to make one miserable for days beforehand! Meeting senior officers out hunting is an excellent way of smoothing over difficulties, and paving the way for things one may want from them. Again, during one's hunting expeditions one has many chances of making very useful friends. A man in a pink coat can make friends of all and sundry if he uses the coat in the right way. As an instance, though perhaps a very unusual one, I may be allowed to quote from personal experience. Before the war I used to send my horse by rail to hunt some forty miles away, and I made friends with nearly all the station-masters on the line I travelled by. After summer manœuvres I was told to entrain my company at one of these stations in an ordinary passenger train. On arrival at the station we found that the engine drivers and firemen had gone on strike that morning, and nothing would induce them to function. There was the train, but no steam up and no engine driver, and there was my company, plus twenty or thirty other passengers, looking at the train. A sapper company usually has three or four people quite capable of driving a loco., and mine was no exception, and we did not like the idea of walking the thirty-odd miles to our destination. The station-master, being a personal friend of hunting days, was not averse to falling in with my suggestion that the soldiers should drive the train, so after a trial run up and down to make sure it could be done we started off. We had two bicycles with the company, and we left these with the station master. We dropped the company at its destination, and the two engine drivers took the other passengers on to their various stations. I never heard how much money they made out of it, but there was a "cap" for them! They subsequently left the train in its stable, and rode home on the bicycles. I may remark that this was before the days when rail movements of troops came to be arranged by the Staff with the mathematical precision which we witness nowadays.

Another aspect of the case is this. A keen officer who can ride has many ways of getting into close personal touch with his men, especially if he is in the cavalry or any mounted unit. He can bring his men out for a ride and can make it interesting and exciting for them. Some years ago, as a junior officer, I had charge of about twenty horses. When in camp in a somewhat wild part of the country I used to mount all the drivers on these horses and tell them to follow me. I chose the line very carefully beforehand, so as to have no trouble with the farmers, and it included banks and small fences of all kinds. The drivers and the horses were soon scattered all over the country, some impounded in fields they could not get out of, and some footing it as hard as they could after their horses. No one ever got hurt, and all enjoyed themselves immensely. Incidentally, the good ones were never very far behind me—in fact, they were uncommonly close at times; but I had a good horse! These rides became a weekly routine, and there was great disappointment if, for any reason, the ride did not take place. Those men would have followed me anywhere.

If you are keen on horses and hunting, you will learn everything about your horse, and you should not leave it all to the groom. The knowledge will be very useful later on. When you go to the Staff College—and you should at any rate try to get there—you will be at a disadvantage if you are entirely ignorant of horses and riding. A Company Commander is a mounted officer, and, if you have never been on a horse before, you are liable to cut a sorry figure in front of your men the first time you mount your charger. It is so easy to spot the man who has never hunted. If you hunt, these things come naturally to you, and you can learn all sorts of useful things if you have a horse to play with.

Always learn to saddle and bridle and also how to groom your horse. A short time ago I was on manœuvres, and some of us put our horses up in a stable while we had some food in the pub. It was a night show and we were late, so there were no grooms about. My companion was a first-rate horseman, but he hadn't the foggiest notion of how to saddle and bridle his horse! I did it for him. Such a situation should not be allowed to arise!

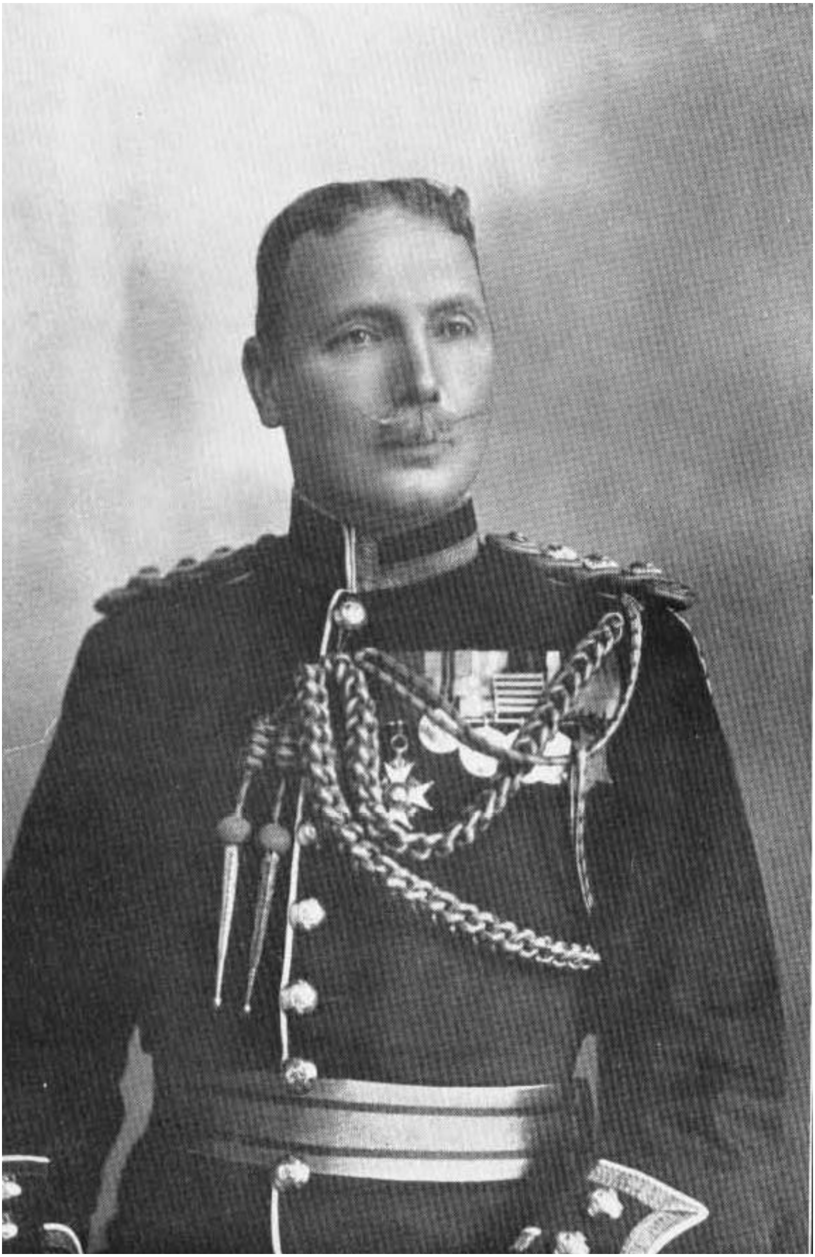
Then there is the story of the Brigade Commander inspecting candidates who had applied for permission to enter for the Staff College examination. You require a riding certificate for that. The Brigade Commander made everyone take their saddles and bridles off and put them in a heap in the middle of the riding school. He gave them five minutes to put everything on again, and not one of them could do it under half an hour! He failed the whole lot! One of the victims himself told me about this.

Another thing to learn is how to catch a loose horse. This is an invaluable trick in the hunting field, but it requires practice. The tip is always to turn towards the loose horse and ride him on your off side and on his near side. The trick was useful to me on manœuvres recently. The General had given his horse to a soldier to hold, and the boy let it go. I was the only one actually mounted at the time, and at once started off in pursuit. It was quite a good ride, and I got the horse after a mile gallop.

I have tried to give above a few instances of the value of hunting as training for officers. But it may be argued that it is not every officer who can afford to hunt. Hunting for the civilian is undoubtedly an expensive amusement, but there are many ways in which the soldier is helped. There is now no difficulty in getting a horse, as a scheme exists whereby troop horses can be hired at 15s. a month, including 4 lb. of oats extra a day. Total cost of the horse is about 25s. a month, if you can share a soldier groom. Most people spend that on cigarettes alone. Then there is your hunt subscription, the most important part of the expenses. Most hunts are very good to soldiers, and at Aldershot we have the Hunt Club. You get the choice of five packs for about £6 6s. per horse for the season. It works out at about 4s. or 5s. a hunt, less than your fare to town! You won't spend much more than the 5s. each hunting day, while, if you go to town every week-end, goodness only knows how much you won't be let in for! And can the pleasure and the value of the two types of amusement be compared? To me it is sacrilege to attempt to do so, therefore I won't try. Kit is certainly expensive, because, as I have already remarked, it must be good. A good saddle and bridle are essential. These will cost about £13, but you can get a good second-hand saddle for £4 or £5. Never go out in a military saddle, it looks too appalling for words, and never in a bridle with the reins buckled on! Your clothes, if new, would cost about £40, as you must have "ratcatcher" kit for the Drag and for hacking, and proper kit for fox hunting. You can, however, get very good second-hand hunting kit from a well-known outfitter near Covent Garden, but you must have your breeches made for you by a good tailor. The best way is to get your hunting kit gradually, and in any case most tailors are fairly long-suffering individuals! If you get good kit to begin with, it will last at least twelve or fifteen years, and the best is not dear in the long run.

Another point worth mentioning is that one should always bring out a supply of small change on hunting days. A sixpence for opening a gate does a lot of good and makes hunting popular with the foot people. If a farm labourer catches your horse his services are dirt cheap at a bob, and he goes away delighted. The "wreckers" of Meath have not, so far as I know, their counterpart in any other hunting country. The methods of these gentry are sheer robbery. I remember one wretched man whose horse got into a place known as the "Poor House Drain." They couldn't get ropes round him, but the horse could just move down the drain, so they dug a ramp for him at an angle to the direction of the drain, so that he could walk out. For this they charged £1, the usual fee for their services! But the man didn't manage his horse properly, and the animal went past the ramp and got into such a position that he could neither move forwards nor backwards. He had to be dug out again, and the wreckers wouldn't start work until another sovereign had been paid. An expensive day's hunting! Fortunately, such disasters do not often happen to the average rider to hounds.

The Editor will get impatient if I write much more! In conclusion, I would urge upon any Commanding Officers who may chance to read these lines that hunting should be treated as part of an officer's training, and that those who are keen should be encouraged in every way to go in for it. That hunting is so regarded in high quarters is not open to doubt, and long may such a state of affairs continue. I would also urge upon senior officers that it is up to them to show young officers how properly to use hunting as a training ground. The great value of hunting is lost if the opportunities given by it are missed for want of telling what they are. If this little article is successful in pointing out how hunting can be used, its object will be achieved.



BRIG GEN A GRAHAM THOMSON CB CMG DSO

MEMOIRS.

BRIGADIER GENERAL A. GRAHAM THOMSON,

C.B., C.M.G., D.S.O.

GRAHAM THOMSON, the son of Surgeon-Major-General Thomson, Honorary Physician to Queen Victoria and King Edward VII, was born in February, 1858, and was commissioned, R.E., in January, 1877.

In 1879, as 1st Lieut., he joined the 17th Fortress Company at Aldershot and proceeded to Malta the following year, where he made his mark in work and sports. He was one of the R.E. Officers' Team which beat the combined Garrison at Association Football; and one of the three 17th Co. Officers who beat all comers at Water Polo. He became a useful Polo player, and had an unusually good barb which he ran in the Races.

At the outbreak of the Egyptian Campaign his Company, being the only R.E. immediately available, accompanied the troops, making the first landing at Alexandria early in July, 1882; and after varied work there and at Ramleh they were among the first troops to be landed at Ismailia. Here for a time he acted as A.D.C. to the C.R.E.; but rejoined his Company when it was called to accompany the Cavalry at the Front. He was present at the battle of Tel-el-Kebir, receiving Medal with clasp and Bronze Star.

At Cairo he was in charge of large working parties of Egyptians improving and remodelling Barrack accommodation, and being essentially just and firm he proved himself the very man for the post. Later, he returned to Malta to bring out the heavy baggage to Abbassiyeh, where, during the trying cholera scourge, he was ever cheery and helpful.

In June, 1884, the 17th Co. left for Suakin to make preparations for the coming campaign, under war conditions, for the enemy were all round Suakin and the Company had to look out for itself.

Here was strenuous work of most varied kinds to be pressed forward in intense heat: ship piers, boat piers, hutments, blockhouses, water supply, light railway, mines, etc.; and here he was equally successful with the native labour parties as he was with the Egyptian.

He was present in the actions of Hasheen and affair at Tamai and with his Company and the Scots Guards held the farthest advanced post of Tambuk on the line to Berber.

On returning to Suakin from home in June, 1885, a crowd of Thomson's old working parties clustered round him with every manifestation of delight at seeing him again—and, indeed, they had a name of their own for him.

Mentioned in Despatches, gaining a clasp, Thomson received the brevet of Major for his Services, immediately on his being promoted Captain.

In November, 1885, Thomson went to the Ordnance Survey until the end of 1890; but as a charming instance of his affection for his old Company, then at Aldershot, he asked to join it in its annual fieldwork course in camp and to do duty as a subaltern, which he duly did, as it was short of one subaltern.

Malta saw him again from October, '91 to December, '96, when he went to the I.G.F's. Office. Thomson served in the South African War from November, 1899, to August, 1902; and at the very unhealthy station of Komati Poort started the first blockhouses of thick sand-bag walling and steel loopholes, and stuck to his work in spite of suffering seriously in health. He took part in operations, as a C.R.E. of Division, in the Orange Free State, including the actions at Vet River and Zand River; also in the Transvaal, including the action at Belfast; and also in Cape Colony, south of the Orange River.

Mentioned in despatches, Brevet of Lt. Col., Queen's Medal with 5 clasps and King's Medal with 2 clasps.

From January, 1903, to April, '08, Thomson was very happy and successful with the Training Battalion at Chatham; and King Edward expressed great satisfaction at all he saw at his inspection.

As Commandant R.M.A., (now substantive Colonel) from September, 1908, to September, 1912, he devoted himself wholeheartedly to the Cadets, knew them all personally and took the keenest interest in their work and play: he procured a new football ground for them and saw it in use before he left. Ever assisted by his devoted wife, Mrs. Thomson, he gave constant parties to the Cadets, and they left a truly pleasant memory behind them.

Thomson went to France, immediately on declaration of War, as Commandant L. of C., and served there till October, 1917, having the rank of Temp. Brig. General from May, 1916; but he had to come home, owing to a serious breakdown in health. However, in February, 1918, he went to Holland for a year in command of our Prisoners of War there, and his unfailing courtesy and kindness were greatly appreciated: indeed, the British Minister at the Hague wrote thanking him for his good work and saying what a great help he had been in bringing about friendly relations between the two countries.

Mentioned five times in despatches, gained 1914 Star and Clasp and C.M.G. He had received the C.B. in 1911.

After retirement in February, 1919, the Thomsons lived a good deal abroad, and in Scotland, but he continued to take active interest in the disabled and invalid soldiers, taking pleasure in doing what he could for them.

He died suddenly after a long illness at Vevey at the age of 68, leaving a fine record of work ably and cheerfully done, and the memory to his many friends of a charming character—unselfish, modest, and ever loyal.

E.W.

BRIGADIER GENERAL E. A. T. TUDOR, C.M.G.

Ernest Augustus Tudor Tudor, who died after a short and sudden illness at Waverley Court, Camberley, on 6th November, 1925, was born at Weston-super-Mare, in April, 1865. He was educated at the Royal Naval School, New Cross, and entered the R.M.A. Woolwich in September, 1882. The course at Woolwich had recently been reduced to two years and, in 1884, after winning his cap in the Rugby XV, he became Senior Under Officer and, in July, on gaining his commission in the Corps, he received the Sword of Honour from the Duke of Cambridge. On completing his course at Chatham he was posted to the Submarine Mining Service and served at home till 1889, when he went to India and took up submarine mining work in Bombay. Here he contracted a very serious illness and was for a long time unable to resume his duties. During his convalescence he visited Hamilton, in Canada, and met his future wife, Miss Edna Sanford, whom he married at St. George's, Hanover Square, in 1898. Meanwhile he had done a tour of service at Mauritius and later he served at Hong Kong, Capetown, Halifax, and other places. He was promoted Colonel shortly before the outbreak of the Great War and was appointed Chief Engineer of the 2nd Army, Central Force, Home Defences, and Chief Engineer London District; afterwards going to France as a Chief Engineer with the rank of Brigadier General. He remained in France until after the Armistice and was mentioned in Despatches and received the C.M.G.

He retired in 1920 and settled at Camberley, and during recent years took a very prominent part in all local activities. He was Assistant Commissioner of the St. John Ambulance Brigade, County of Surrey, and Hon. Secretary of the St. John Ambulance Association County Centre and Assistant County Controller of the V.A.D. under the War Office scheme, also President of the Camberley and Frimley Branch of the Unionist Association. He left three daughters, one of whom is the wife of Flying Officer E. D. H. Davies. His sudden death came as a shock to a very wide circle of friends. He was universally popular, and in his young days and before his serious illness, a man of great energy bent upon getting the utmost out of his life and opportunities.

BOOKS.

THE HISTORY OF THE UNITED STATES ARMY.

By MAJOR OF INFANTRY W. A. GANOE, U.S. ARMY (D. Appleton & Co., New York & London, 1924.)

The history of the development of the American Army, from its birth during the War of Revolution (1775) to the Great War, is of great interest to British readers in that the author describes without reserve the difficulties which confront the military authorities of a nation which will not tolerate universal service nor pay for an effective voluntary army in times of peace.

In Vol. III of the *Letters of W. H Page,* the American Ambassador in London during the Great War does not mince matters when he writes of John Bull "muddling through," and discusses the extravagance and waste due to Great Britain's military system. Major Ganoe's volume shows that "muddling through" must be a characteristic of the Anglo-Saxon race. The United States, however, learnt their lesson, and as Mr. Page writes in a letter to President Wilson: "The prompt passage of the conscription act opened their (British) eyes to our earnestness and efficiency more than any other single event."

The story of the United States Army is one of constant struggle with Congress. It came to such a pass that even when, in the face of imminent danger of war lightheartedly entered into, Congress voted for an increase, sometimes on a lavish scale, it simultaneously enacted a law providing for the reduction of the army to its former numbers on the cessation of hostilities! The danger past, there was heard at once the ever-recurring cry for Economy.

"Economy is certainly a very high political virtue, intimately connected with the power and public virtue of the community. In military operations, which, under the best management, are so expensive, it is of the utmost importance; but by no propriety of language can that arrangement be called economical which, in order that our military establishment in peace should be rather less expensive, would, regardless of the purposes for which it ought to be maintained, render it unfit to meet the dangers incident to a state of war."

So wrote Mr. Secretary of War Calhoun in 1820, in resisting the usual cry from Congress for the reduction of the army. Nevertheless the army, which at the end of the second war with Great Britain had an establishment of 62,000 and a strength of 30,000, and had been reduced in 1815 to 10,000 men and "a Corps of Engineers," was further reduced to only

6,000 men. The condition of the army before 1812 is bluntly described by Lieut. Colonel William Duane (author of a *Handbook for Infantry*, 1812) as follows :—" There is no discipline ; there is even no system ; and there are gross misconceptions on the subject. There appears to have been a disposition to discourage the acquisition of military knowledge."

What was the result of this apathy ? Major Ganoe gives the answer. " During the years after 1812, the army tried to bring itself out of the ignorance and decadence into which it had been tossed after the Revolution. But the only civilians who knew the army's work and understood the nation's need were a limited few like Calhoun. Politics did not know, need to heed nor care to consider the necessity for fighting men. The farce of 1812 had made little impression upon the general public. We had come out all right—that was enough. Just why or how we had ' come out ' was a matter of little concern. That with 527,654 so-called soldiers we had been unable to defeat not over 5,000 British Regulars, that for two years and a half so small a hostile force had brought devastation within our borders and had killed and wounded 5,614 Americans, and that our nation had uselessly spent for all this discord of training over $50,000,000, had not come to be realized by the voter. He was developing the inside of the country without much thought of its edges. It was too much to expect 7,000,000 people to support 10,000 soldiers."

History repeated itself for the next 100 years.

The war of 1812 was long forgotten before the Mexican War of 1846. In the public eye up to that time, and even for years after the Civil War, the Army only existed to drive back the Indians and suppress labour strikes.

The lessons of 1846-8 were ignored, by the Federals at all events, in 1861. It took President Lincoln two years to find, and trust, General U. S. Grant. In the meantime he and his Secretary of War committed every mistake that was possible in their direction of the Army. Had they given General McClellan, who was a good soldier, as free a hand as President Davis (a graduate of West Point) gave to General Robert E. Lee, numbers alone would have told, and the Civil War might have been over in a year.

The accumulated experience of previous wars, to say nothing of the Franco-German war of 1870-1, though it all had been carefully collated by Major General Emory Upton in his report on " The Military Policy of the United States," after a tour of investigation in Europe and Asia, was all forgotten or ignored when the United States found themselves at war with Spain in 1898 ; and, according to Major Ganoe, the situation on the Mexican border was not much better in 1914-16. He writes : " For the third time in 3 years, a great nation of over 100,000,000 people presented a spectacle to the world of being unable to assemble even the semblance of a powerful force. General Funston's predicament (at Vera Cruz) was all the more pitiable when it is considered that, had he received an order to journey in the same path that General Winfield Scott had followed 70 years before (to Mexico City, in the first Mexican War) he would have found that he could not budge for lack of men and transport." The Regular Army actually numbered only 24,000 men in 1914, a smaller strength than at any time since 1861, and this in spite of the great reforms initiated by President Roosevelt and his able Secretary of War, Mr. Root, in 1903-1904, after the Spanish War, the American participation in the International Expedition to Pekin, and the Filipino Insurrection.

The last chapter brings in the Great War, and is the most interesting. It describes the steps taken, but not for a year and ten months after the outbreak of the Great War, to increase the army—on paper—gradually to about half-a-million men in case of the United States becoming eventually involved, and the hurried legislation consequent on that event occurring on April 6th, 1917. Fortunately for the United States—and for the Allies—Congress still had time to put its house in order while the Allies bore the brunt of the German pressure. Thanks to Mr. Root's creation of the General Staff, and to the advice and information placed at its disposal by the Allies, Congress was able to act promptly and effectively. This time no initial mistake was made. Conscription was adopted at once, and it enabled the training of officers and men to be placed on a methodical basis and run on a proper system from the start. Major Ganoe says: "Our greatest improvement over England's haphazard arrangements was the enactment of compulsory and universal service. That we could profit from mistakes of previous bloody wars by attending to Washington's warnings and Upton's examples, and stamp out the fallacy of voluntary service that had wrecked efficiency in our previous wars, had been a hope too sanguine for military experts to entertain. It is not easy for a nation while fighting for the very essence of democracy to wrap itself round with a garment of autocracy. No greater compliment can be paid to the intelligence of our mixed population than that it was able to perceive the nice distinctions between the harsh means and the noble end. It is possibly the first case on record in our history when we have signally advanced in military policy."

The result we know. All male persons between 21 and 30 were made subject to registration and conscription. (Nominally, the manhood of the United States had always been liable for service). Congress fixed the establishment of the Army at about 1,300,000 men. The Regular Army was to be at once recruited to full strength from volunteers, or if sufficient volunteers were not forthcoming, by conscripted men. The pay of all forces, regular, militia and conscripted was to be identical, and the whole army was to be governed by the regulations governing the regular army. All officers above the rank of Colonel were to be appointed by the President, with the advice and consent of the Senate, instead of being appointed by the various States. No person was to be allowed to furnish a substitute. No bounties were to be paid to anyone as an inducement to enlist or re-engage.

June 6th, 1917, was fixed on for "Registration" day. In the meantime, on May 15th, 40,000 civilians, candidates for commissions, had presented themselves for training at sixteen large cantonments ordered to be prepared for that purpose in different parts of the country as soon as war was declared. By a process of elimination about half of these were accepted for commissions on the completion of 90 days' training, about the middle of August. On Registration day, 10,000,000 were registered. The first quota (drawn by lot) of 687,000 men reported for training on September 1st, by which time camps and cantonments had been prepared, and officers were available as instructors. It came as a shock to the authorities and the nation to learn that out of a total of 2,750,000 young men examined by the medical authorities, 46.8 per cent. could not pass the physical tests for front-line soldiers. England was not the only home of the C3 class!

By the beginning of 1918, 1,325,000 men had been enrolled, 42 Divisions had been organized, 8 of which were Regulars, 17 National Guard (organized militia of the various States), and 17 National Army. Six Divisions, each consisting of 975 officers and 27,152 other ranks had arrived in France.

In view of the submarine menace sea transport was always the difficulty, but in May, 1918, 130,000 troops were sent to France, and in July 150,000. At the close of the war, almost 2,000,000 men had been transported overseas.

The war did not last long enough for the Americans to test the efficacy of their arrangements for reinforcements, but there is little doubt that once the question of enlistment was solved by universal service the rest was easy. In former wars it had been the practice to take the short view; enlistment was for 3 or 6, or 9 months, and in some cases for a year or longer. The result had been that men were due for discharge as soon as they reached the theatre of war, or even before they could do so. They had to be bribed by bounties and promises of land grants to extend their service or re-enlist. The Regular Army had been recruited under one set of rules and terms of service, while the militia and "volunteer" armies serving alongside of it were governed by different and various regulations both for enlistment and length of service. Towards the end of the Civil War there were many regiments which had been reduced to a mere skeleton through losses and expiration of enlistments, while all the time new regiments with new officers were being raised. Fortunately Great Britain had taken this lesson to heart before the Great War, and the principle of reinforcing existing units instead of raising new ones had been insisted on, and was adhered to even to the extent of disbanding the fourth battalions of brigades to make up reinforcements for the reduced brigades of 3 battalions. But though we had had our lesson in South Africa, our experience there had not impressed itself sufficiently on our minds to make us realize the necessity for universal service before the Great War. Americans cannot now understand why Lord Kitchener did not insist on universal service on the outbreak of the Great War when men were flocking in thousands to the recruiting offices, and the flow had to be discouraged (in September, 1914). This mistake, hastily committed for reasons which at the moment appeared to justify it, took months to rectify. It was avoided by the Americans, thanks to our experience being placed at their disposal through the agency of a clever and popular military attaché—Colonel George O. Squier.

A good deal is said about the U.S. Military Academy at West Point. It was originally founded for the education of the engineers only, but became a training school for aspirants to all the arms, like Addiscombe for India.

The mention by Major Ganoe of the foundation of the Army Signal School at Fort Leavenworth, Kansas, in 1905, reminds one that the original designation of the Royal Corps of Signals was based, like its initial organisation, on the U.S. Signal Corps. (Incidentally, one nowadays sees officers of the Royal Corps of Signals referred to, even in the Press, as belonging to "Royal Signals," surely rather a stupid abbreviation !)

In his chapter on the renaissance of the Army, Major Ganoe mentions the first autumn manœuvres of the American Army, which were held in Virginia in 1904, joint Army and Navy operations having taken place two years previously on the Connecticut coast. The present writer was one of a number of foreign officers present who were taken charge of by a captain of the General Staff specially detailed for the duty. He had the rare distinction of wearing the Congressional "Medal for Valor," the nearest equivalent of our "Victoria Cross," for gallantry in the Philippines. Shortly afterwards he was specially promoted from Captain to Brigadier-General for his services in that campaign. In 1914-16 he, still a Brigadier-General, commanded the American force, eventually amounting to 75,000 men, in the second war with Mexico, or rather with the insurgent bands of the followers of Villa and Carranza which were running riot all over the country and violating the territory of the United States. The operations on the border having fizzled out with no definite result, in June 1916, the Commander was available when the United States broke off relations with Germany. As Commander-in-Chief of the American Expeditionary Force, General Pershing—for he it was—achieved a record, in that he was the first man ever allowed by a President of the United States, who is the Commander-in-Chief the Army of the United States *ex-officio*, to remain in command of an American Army throughout a campaign !

At Manasses, in 1904, he was described to us as "An outdoor man, a fine leader, but hardly cut out for the office work of the General Staff." Of his achievements, in spite of this supposed disqualification, Major Ganoe says : "All agree that the accomplishments of General Pershing are properly lauded in foreign and domestic accounts. If, as has been said, he did no greater thing than to prevent the infiltration of units into those of our Allies, by his tact and determination, he would deserve all that the public has accorded him. . . . . But he did more, he developed a driving machine that spelled forward movement against the German." All who served alongside of Americans in the war will echo his sentiments.

Major Ganoe's book is written for the American public, and, more fortunate than General Emory Upton's classic report on "The Military Policy of the United States," which was pigeon-holed from his death in 1881 till it was discovered, reprinted and widely circulated by Mr. Secretary Root in 1903, is and will be available for civilians and soldiers to read before the United States embark on another war. It is to be regretted, from the point of view of international amity and the next generation, that it contains not a word of acknowledgment to the Allies, France and Great Britain, for the assistance rendered by them in the organization, arming, training and transport by sea of the American troops. For any record of help from England, it is necessary to turn to Mr. Page or Admiral Sims. Mr. Page, like Colonel House, realized from the outbreak of war that unless the United States came in on the side of the Allies, they would be the next target of the insensate World-Policy of the Germans. He had no hesitation in availing himself of the advice and help which England was only too willing to give, and did give through the Embassy, even two years before the United States broke off relations with Germany. Major Ganoe states, somewhat regretfully, that even after a year of war, the American Expeditionary Force had still to rely on French aeroplanes and field guns.

His peroration has its lessons for us. "When a nation begins the business of preparing for war after it has declared it, much waste and much loss must result. Faults arising from the consequent haste are attributable to no single individual. In retrospect the Great War held more that should shame us now. The training of officers and men had to be scant in a number of instances. Future historians of this conflict will reveal that the inexperience and lack of knowledge incident to haste produced in themselves undue loss. Soldiers had to be placed in the line when many of them had not had time to learn the use of the weapon they were handling. Further, the assignment of officers and men to the multifarious duties of a modern army could not be made with sufficient appropriateness in the time allotted. Laundrymen in the ordnance department, engineers in the quartermasters corps (supply), mechanics in the infantry, electricians in the provost marshal general's department, and lawyers in the Signal Corps felt themselves to be square pegs in round holes. Promotion, too, had to be haphazard, when there existed no agencies for the proper classification of officers and men. . . .

"To the degree that a nation is late in its discipline and training, to that degree must the sufferings of the individual be increased. So must the country's extravagances. Vast sums appropriated for materials on the outbreak of war had to be spent when values had risen to many times the height they had stood before 1917, and when it was impossible to get delivery. In the meantime General Pershing lacked many weapons and machines for effective fighting. It took us over a year to get into real offensive against the enemy.

. . . "To cap all, the selective draft (universal service) revealed the fact that almost half of the young manhood of our country was either defective or unfit for fighting. Had a large percentage of our youth had the opportunity of development, best accorded in military camps, and had such exercises been carried on even for limited periods before the war, no one can doubt that this appalling figure (46.8 per cent.) would have been materially reduced. And, in the meantime, the boy would have become more commercially efficient and a more self-reliant citizen."

. . . "When we were strong, disciplined, trained and well organized, we gained a quick peace. When we were not so constituted, we lost lives and money fruitlessly. It was not war of itself that brought so much horror to our people, as did comfortable sleep in the intervals of quiet.

"It would be manifestly unjust to rail at Congress for its seeming omissions. . . .

"If the public wanted anything intensely enough, the law-maker would have to vote for it. If legislative derelictions have been committed, each one of us as citizens of the republic is to blame, unless we have used our powers legitimately to the contrary."

One's memory goes back at once to Lord Roberts and to the patriotic M.P. who some years before the War resigned a safe seat to stand again in the same constituency as an Independent candidate favouring universal service, and, unsupported by either of the Great Parties, received 400 votes instead of 4,000! (One sees the proof-reader wondering whether "patriotic" is a misprint for "quixotic."!).

The book contains a fair, but inaccurate, index, and a large bibliography of American authorities on which the author bases his narrative. There are no maps whatever, and it is therefore difficult to follow even the slight sketches of the various campaigns described. A good deal of useful information can be obtained from the tabulated appendices, one of which discloses the amazing fact that Regular troops were employed on 328 occasions in "putting down labour strikes" between the years 1881 and 1895 in all parts of the country. About half of these labour troubles occurred in the last two years after the great financial *débacle* in 1893.

After reading Major Ganoe's candid volume it will be interesting to see the volumes of the American Official History of the Great War dealing with the matters under review.

H.B-W.

CAMP AND SOCIETY.

By THE LATE COLONEL H. M. SINCLAIR, C.B., C.M.G. (Chapman & Hall, price 18/-).

After his retirement from the service the late Colonel Sinclair wrote his autobiography for the benefit of his children and other relatives. His widow, wisely judging it to be of sufficient interest, has now published the volume under the title "Camp and Society," omitting such parts as were matters of purely private concern.

Sinclair was an unusually able man. He passed first into, and out of, the R.M. Academy, and second into, and out of, the Staff College, a specially remarkable feat as regards the R.M.A. because, as he himself says, he was not a good mathematician.

He was a grandson of Sir John Sinclair, Bart. His father, after ten years' service in the 4th Madras Cavalry, left the army, went to Oxford and was ordained. He was Vicar of St. George's, Leeds, where his son Hugh was born in 1855, and in 1857 was appointed rector of Pulborough where he remained till his death in 1878.

In 1865 Sinclair was sent to a private school at Malvern Wells, where most of his fellow pupils seem to have been heirs to peerages, and thence to Repton in 1867. Of this last school he gives a very unflattering account. On leaving he went to Frost the crammer for six months and passed into Woolwich in 1872. He was at the "Shop" with the Prince Imperial, and together with four other cadets attended the funeral of the Emperor Napoleon at Chiselhurst. Leaving in 1874 he was at the S.M.E. till 1876. On obtaining his commission Sinclair was posted to Dover and was transferred to the 23rd Field Co., R.E. at Aldershot in 1877. The following year witnessed the occupation of Cyprus by Sir Garnet Wolseley, with a large British and Indian Force. Sinclair was ordered out to the island in October, 1878, and on arrival at Larnaca took over charge of the works which were being carried out by Indian Sappers and Miners who were returning to India. In Cyprus he remained, with intervals of leave, till the spring of 1886, having been for nearly six years Private Secretary to the Governor, Sir Robert Biddulph. The descriptions of Cyprus and the work there are very interesting: still more so are the accounts of trips to Syria and the Lebanon accompanied by Valentine Chirol, then a young journalist, and on another occasion to Palestine.

On his return to England, Sinclair, to his great disgust, was ordered to Athlone, as D.O., where he remained till he entered the Staff College in 1888. On passing out he was, early in 1890, posted to special duty at the War Office on the scheme for the Defences of London, together with Major the Hon. (now Lieut. General Sir) Frederick Stopford and Captain Benson, R.A., for two years. His next appointment was that of D.A.A.G. at York, where he remained three years, and then in 1895 became Staff Officer to the C.E. at Aldershot. In December of that year he went to Ashanti as C.R.E. to the expedition, a bloodless one, returning to Aldershot next year. In November, 1896, he was ordered to India, becoming Executive Engineer, Military Works, at Ferozepore, subsequently Assistant Military Secretary to Sir George Luck, Commander-in-Chief in Bengal, and then, in 1899, A.A.G., Allahabad.

In the winter of that year Sinclair was ordered to South Africa as A.A.G. Transport. His experience in the Boer War was not a happy one. Never given a really responsible appointment, he was moved about from pillar to post, and eventually, after returning to England in 1890, went back to India to complete his tour of service, first as A.A.G., Bombay, and finally as C.R.E., Allahabad. Back in England in the spring of 1902, he was posted to Woolwich as C.R.E. His subsequent appointments were those of A.Q.M.G. at Plymouth, and then Salisbury, and finally Chief Engineer in Scotland. He retired in 1905.

What was probably the most important and thoroughly satisfactory part of Sinclair's work was done subsequently, during the five years he was in command at Longmoor Camp, training Railway Companies for the War.

Whilst on the Staff at Salisbury he married a daughter of Sir John Jackson, the well-known contractor. On his retirement from the service they went to live at Barming House, near Maidstone, which was still their residence when he died.

So much for Sinclair's "Camp" life. The "Society" chapters of his autobiography are certainly not less interesting. He knew more or less intimately a remarkable number of prominent people, amongst others the Duke and Duchess of Teck, Lady Burdett-Coutts, Lord and Lady Granville, Lady Dorothy Neville, Gladstone, Lord Rosse, Lord and Lady Wolseley, Maria, Lady Ailesbury, Henry Irving, and Holman Hunt. Lady Burdett-Coutts was a special friend. Of some of these there are new and good stories. Sinclair had some curious experiences with his acquaintances. When a subaltern in Cyprus he gave an order for a number of wheelbarrows to a small contractor. In after years, he recognized this man as the mysterious multi-millionaire, Sir Basil Zaharoff.

Sinclair was a good linguist. In Cyprus he learnt to speak Modern Greek fluently. This accomplishment stood him in good stead, as, besides being useful to him in his work as Private Secretary, it paved the way to friendships with dignitaries of the Orthodox Church, and opened many doors in Cyprus, Syria and Palestine which otherwise would have remained closed to him. When the Venerable Archbishop of Cyprus was presented to Queen Victoria in 1890, at a garden party at Marlborough House, Sinclair was in attendance as interpreter. Moreover, when in India, he passed the Higher Standard Examination in Hindustani within a year, no mean feat.

His death has been greatly regretted in that part of Kent where he lived so long, and took a special interest in Church affairs. Mrs. Sinclair is to be congratulated on the way she has edited the autobiography. Books of this kind are frequently discursive, "Camp & Society," is less so than usual.

W.P.

ELEMENTARY TACTICS, OR THE ART OF WAR, BRITISH SCHOOL.

By MAJOR R. P. PAKENHAM-WALSH, M.C., R.E., *p.s.c.* (Sifton Praed and Co., 1926,) Price 10/6.

The author has given us a book on tactics and organisation which is well worth buying, not only by officers who have been out of touch for some years with active soldiering and require a book to give them a general line to go on before getting down to the detailed study of the official text books—the *raison d'être* of its production—but which will also be of great assistance to a much larger circle of military students engaged in educating themselves and their subordinates for entrance to the only school in which they can complete their education—the school of war itself. It can be confidently recommended to both regular and territorial officers; to the latter it may almost be said that it will be a Godsend.

Before the Great War there was a plethora of manuals, dating from Clery's *Minor Tactics*, Home's *Tactics* and Wolseley's *Pocket Book* to a host of other publications, more or less of the cramming class, written after the South African War; but to no single one of them was it possible for the seeker after knowledge to turn with any confidence of being able either to fill the gaps left by the official text books, or obtain any help in applying the principles therein enunciated.

Major Pakenham-Walsh expressly states that he has no desire that his volume should take the place of the official text books. It is based on them, and with its ample marginal references will be invaluable in studying them.

The book is divided into three parts. In the first, the principles of war and the mechanism of the Army are dealt with. In the second, the theory of application of the principles of war in various forms of tactical operation are considered, showing how the various arms and services are employed towards the attainment of the objective. In the third, certain examples of operations are worked out in detail on the maps provided.

The third part is especially valuable. In working out the schemes, which are of a progressive nature, administration factors are not overlooked, and the co-operation of the air arm, tanks, signals including wireless, engineers and gas service are carefully considered in the combined operations of the three arms.

Each scheme is developed in detail—scheme, orders, narrative and notes—in a series of consecutive problems. These will be found to be very helpful by officers who find themselves faced with the task of preparing tactical schemes for the training of their units, and who are at a loss to know where to refer for the technique of their preparation and their conduct. The author does not overlook the fact that there are probably more solutions than one of every scheme. He says: "For every problem there are probably several 'correct' solutions. An effort has been made in every case to give a simple solution in agreement with the principles and practice of war as laid down in the official text books of the British Army, and to explain the reasons for the action decided on in each particular case."

There is a brief, but useful, chapter on future developments in war. In the words of the author: "It is the duty of every officer to consider the progress of new auxiliaries, and to foresee how the latter are likely to affect the application of the principles laid down in the text books." He reminds us that: "The surest way to be surprised in war is to imagine that the next war will be like the last."

In conclusion, it may safely be said that any officer who will, after reading the book, take the trouble to work out his own solutions of the schemes and then compare them with those prepared by the author, will have no cause to regret the expenditure of time and the half-guinea at which the volume is offered.

H.B-W.

KEKEWICH IN KIMBERLEY, being an account of the Defence of the Diamond Fields, Oct. 14th, 1899—Feb. 15th, 1900.

By BREVET LIEUT-COLONEL W. A. J. O'MEARA, C.M.G., late R.E., *p.s.c.* (The Medici Society, London & Boston, 1926). Price 7s.

No one is better qualified to write an account of the Siege of Kimberley than Lieut. Col. O'Meara. He was one of the three officers of Royal Engineers who served under Major-General Robert Kekewich throughout the siege, the others being the late Brigadier-General Duncan S. MacInnes, and Lieutenant-Colonel R. L. McClintock. Lt.-Col. O'Meara had been sent out with a batch of special service officers 3 or 4 months before the outbreak of war and had carried out a great deal of valuable reconnaissance work in the Orange Free State. Disguised as a commercial traveller, he had traversed, in a Cape cart or on a bicycle, a large area of country contiguous to the western frontier of the Free State, and, in circumstances of considerable risk to himself, had obtained and recorded a great deal of information which, in the absence of good maps, proved invaluable to the advance of the Western force.

The book is an accurate narrative of events leading up to the outbreak of hostilities, and during the siege—when the author was appointed chief staff officer to General Kekewich. It can hardly be classed as a military history, but it contains much of great value to the military student, in

Can any excuse be found for Rhodes' conduct ? Looking back to the slump in the training of the army before the South African war awoke us out of the sleep of a long peace, one realizes that it was not only the Army which was in fault. The civilian population and its political leaders had not been trained to realize that a knowledge of military affairs is as necessary to the nation as to the army. There had been an awakening in the army, thanks to Lord Wolseley, and this awakening had spread to the Staff College under General Hillyard, amongst whose pupils most of the Army Commanders and Chief Staff Officers of 1914-18 are numbered, but it had still to spread through the army. The nation had forgotten all about war.

It is not, perhaps, surprising to find a man of the calibre of Mr. Cecil Rhodes fretting at the restraint in which he found himself fettered within the perimeter of the Kimberley defences. There he was regarded as a god. The whole of the huge organisation of the De Beers Diamond Mines looked up to him as their chief. It was they who supplied the personnel for the greater part of the volunteer garrison, as well as the material for the defence, and it must be acknowledged that had it not been for De Beers the defence of Kimberley would have been a far more difficult proposition than it was.

On the other hand it is, perhaps, fortunate that Mr. Rhodes was confined in Kimberley, and that his unwilling custodian was a man like Kekewich. Had he been free to exert his dominating will on weaker men either at Cape Town or in Rhodesia, or in London, the effect of his interference in military affairs, of which he knew nothing, might have been disastrous.

As soon as communication with the outside world was cut off, Rhodes came up against the Commander and his staff. He endeavoured to communicate with Cape Town and, through Cape Town, with London, by using his own runners, and, although Kekewich offered to assist him to send his messages through official channels, he repeated the offence, and was found out. He then interfered with the censorship, and boasted of it. Incidentally, he tried to induce Kekewich to carry out an operation which was obviously impracticable and unsound. Naturally he failed, and he resented it. He ought to have been court-martialled. No man could have done more to try to keep on good terms with Mr. Rhodes than Kekewich did. Throughout he showed remarkable self-restraint.

This trait of Kekewich's character was subjected to an even severer trial on the relief of Kimberley. That he was not *persona grata* in certain quarters, and the reason for it, are known to a few. Rhodes and his supporters found fertile ground to sow the seed which widened the breach, with the result that Kekewich was not given a command for a considerable period. Lord Kitchener put matters right, and officers who served in his column in the Northern Transvaal will bear witness to his success as a commander in the field.

Kekewich and his staff officers received one acknowledgement of their services to Kimberley. It is not mentioned in the book. The owner of one of the few " claims " in the diamond mines not already absorbed by De Beers, presented each of them with a valuable uncut diamond found in his claim during the siege. He was a German. Not a word of acknowledgment did they get from De Beers or its chief for saving their property.

Kekewich felt it all very deeply, but he never uttered a word of complaint of his treatment at the hands of Rhodes, and his lips were sealed to his dying day. It is quite time that his memory should be cleared of any suggestion that he was in any way to blame for this unfortunate episode. Lt.-Col. O'Meara has carried out his self-imposed task with great restraint, for he has not recorded all that is known of the behaviour of Rhodes and those others who did their best to ruin Kekewich's career.

Sir Robert Baden-Powell has written a foreword to the book which is worth quoting :—

"A clever brain, a human heart, and a cheery spirit, a lovable disposition, unswerving loyalty, and absolute devotion to duty—supply a make-up for a man which should carry him through most, if not all, of the difficulties of leadership in life.

Robert Kekewich possessed just these qualities in a remarkable degree."

* * * *

"In the event he pulled through successfully, and thus his character and his methods are well worth studying by those who aspire in their turn to happy and successful leadership."

The volume should be read, and readers will have the satisfaction of knowing that the whole of the proceeds of the sale of the book are to be given to the "Past and Present Association" of The Buffs, General Kekewich's regiment, in aid of the regimental charitable fund.

H.B-W.

MILITARY ENGINEERING.

(TECHNICAL TRAINING. VOL. I: MECHANICAL ENGINEERING, 1925). 364 + xxiv pp. 94 plates. 3/6 net. (H.M. Stationery Office).

THE subject of this War Office Manual is of national importance, and of special interest to Military Engineers. The changed conditions of modern warfare have brought Mechanical Engineering into prominence as a vital factor in military operations; from the first outbreak of hostilities, it became generally recognised that the Great War was an engineers' war. This truism was so firmly established that the re-statement of the fact may seem redundant, but in some arms of the service the subordination of the technical officer under regimental or administrative commands would still appear to require re-adjustment. In the senior Service the lessons of war have already been so far forgotten that a recent Fleet Order has entirely deprived Engineer Officers of Military status without giving them the equivalent executive rank enjoyed by their brothers on the Quarter Deck. Representatives of six leading Institutions, speaking on behalf of some 40,000 professional engineers, are exerting their claims for the re-establishment of the more cordial relationships of equality granted to the engineers of the Royal Navy, early in 1915, as a reward for their meritorious service.

If it is admitted, as it must be, that the war was an engineers' war, then too much attention cannot be given to the efficient training of engineers, and it is generally considered that to be efficient in Mechanical Engineering it is essential that a prolonged course of practical training in the workshops should be aimed at, as well as sound technical education. Practical processes are still felt by some to be unsuitable for description on paper, but the mass of text-books and of articles in the technical press bears evidence of an undoubted demand for such literature. It, however, cannot fulfil its *raison d'être* if used as a *substitute* for the workshop practice, but, as a *supplement*, it may be of the highest value in assisting the young engineer to a real understanding of the plant and materials with which he is brought in contact.

So much for the importance of the subject; now to come to the book under review. This is a work upon which much care in selection and abbreviation has been expended, and is in itself a *vade-mecum* of the Military Mechanical Engineer, and it should save him the outlay of quite a small library of text-books on the various aspects of his work, whilst its cost is less than that of any one privately issued text-book.

It is written in clear language and in condensed form, without employment of higher mathematics, and it is illustrated by numerous line drawings of typical examples, but does *not* include working drawings to scale. The condensed arrangement has naturally limited any effort at literary style, and explicitness may sometimes have been sacrificed on the altar of brevity, but, on the whole, the rigorous exclusion of all redundant matter renders the work suitable for the class of readers for whom it is designed and by whom it will be welcomed.

To outline its contents—the volume presents concisely the practice and contents of the workshops, giving little theory, and consequently does not treat of the rudiments of mathematics, mechanics, strength of materials, etc., to any extent, although these are all of importance to mechanical engineers. Part I takes the reader on a visit to the workshops and describes the machines contained and the operations carried on therein. Part II treats of heat engines, describing various types of prime movers, auxiliaries, fittings and their installation, erection and testing. Part III is somewhat obscurely described as "Application," and deals with transmission of power, gearing, bearings, shafting, and general millwrighting.

Such is the outline; the contents will now be considered in some detail, but it may be remarked in passing that this book on mechanical engineering has nothing to say on such matters as railways and locomotives, pumps and water impounding machinery, refrigeration, conveyors, elevators and cranes, steam turbines, marine engines, automobiles and aeroplanes (except as regards petrol engines); yet all these are aspects of the subject which even military engineers cannot overlook and a knowledge of which is required at times—times of emergency only perhaps, but such occasions may be of vital importance.

To return to what the manual *does* contain: PART I—Trades, begins with the conventions used in mechanical drawings, the particulars given being excellent, so far as they go—which is *one* page, obviously inadequate to teach a great deal about drawing. The production of castings is then considered with the effects of crystallization and contraction, and giving as three essential rules of design that corners should be rounded, sections showing the difficulties which confronted a British commander in organising the defence of an open town in a country the inhabitants of which were, for the most part, hostile to the British, though they were British subjects. The details regarding the raising and equipping of a volunteer force, chiefly enlisted from the townspeople and employees of De Beers Mines, and the arrangements for organising the food supply of the troops, civil population and natives, are most instructive; while the story of the friction between Mr. Cecil Rhodes and the Defender of Kimberley has valuable lessons for officers who may find themselves in a similar position.

It is the trouble between Kekewich and Rhodes which caused the book to be written, primarily with the object of clearing the memory of that gallant and fearless soldier from the unjust aspersions cast upon it by those who at the time believed that Mr. Cecil Rhodes could do no wrong.

In his introduction, Lt.-Colonel O'Meara explains that he undertook the work mainly because the partisans of Rhodes, immediately on the relief of Kimberley, and at a time when, by the rules of the service, Kekewich was bound to maintain silence, gave currency to statements which grossly misrepresented his conduct towards Rhodes. To quote the author:—

"Those partisans alleged, *inter alia*, that the friction was due solely to Kekewich's tactlessness and the want of consideration shown to Rhodes, who—it was further alleged—had been treated by Kekewich as if he were an 'ordinary citizen.'"

Rhodes apparently regarded the war as a phase in the struggle between himself and President Kruger. The memory of the Jameson Raid rankled in Rhodes' mind. He told Kekewich, in so many words, that his particular ambition was that at the end of the war he should be able to announce that his own personal interests, as well as those others which he represented, had not suffered damage to the extent of one penny piece. Lieut.-Col. O'Meara states that "the real cause of the difficulties was that Rhodes (a Privy Councillor) had, just before he went to Kimberley, obtained information at Cape Town as to the British plan of campaign. He disagreed with it, in that in his opinion it did not give sufficient importance to the 'strategical importance' of Kimberley. He made no secret of his intention to be 'a factor in the military situation,' and to secure a radical change in the foregoing plan, so far as the Western theatre was concerned. As a soldier, Kekewich could not, and would not, aid and abet Rhodes to force the hands of the military authorities. This was Kekewich's great offence in Rhodes' eyes. One day, in his anger, he shouted at Kekewich: 'You damned soldiers are so loyal to one another that I verily believe that if God Almighty even was in a fix, you would refuse to get Him out of it should the doing so interfere with your damned military situation.'"

The truth was that Rhodes was himself the almighty god in a fix, having been caught in Kimberley by the outbreak of hostilities on his way to Rhodesia. He was trying to move heaven and earth to find a way out of the dilemma in which he found himself.

There never has been—nor will there be—any doubts in the minds of those who knew General Kekewich personally, that tactlessness, or obstruction by vindictiveness had any part in his character.

kept constant, and allowance made for free contraction. Patternmakers are required to possess skill at working in wood and a knowledge of machine drawing, foundry, and machine shop; their materials and tools are mentioned, with the allowances necessary for contraction of various metals on cooling and for machining; their close association with the moulding shop being emphasized. The work of the moulders is treated at somewhat greater length, and hints furnished for the inspection of castings. Under iron founding, the cupola and its working, the mixing of metal, the pouring of molten iron, and fettling, appear. Brass moulding and founding require slight modifications of treatment and are dismissed in a few lines. The operations and plant for smithing and forging are next taken, and then boilermakers' work, with the shop equipment, repairing of tubes, shells, fireboxes, and tube-plates. Heat treatment of iron and steel receives fuller attention and includes hardening, annealing tempering, and casehardening, following which are chapters on oxy-acetylene and electric welding, and the work of the fitting shop in reducing rough castings and forgings to the precise dimensions desired.

Naturally the operations of the machine shop are the subjects of many concise practical remarks on drilling, reaming, turning, cutting speeds of lathes, planers and milling machines, and details of grinding machinery of various types, with warnings of faults likely to be encountered. Quite a considerable amount of data on saws and other woodworking machinery is quoted, with a reminder that serious accidents are particularly liable to occur with this type of plant. Part I of the volume then concludes with some useful appendices showing tables of standard screw threads, wire gauges, and tools required by patternmakers, moulders, smiths, boilermakers, and fitters.

PART II—Heat Engines, discusses internal-combustion and steam plants, the principles on which they work, how to work them, and how to install, inspect, maintain, and test. Taking the internal-combustion engine first, the Otto cycle and the elementary theory of the subject generally are briefly explained, passing on to ignition, speed regulation, lubrication, and instructions of a general nature on the running and care of oil engines, and mechanical starting, giving a table of running faults met with and how they are remedied. A separate chapter is devoted to engines running on heavy oils, *e.g.*, Diesel and semi-Diesel, and their governing, starting, stopping, etc., with a table showing the procedure for maintenance and cleaning operations spread over a period of four weeks. After a brief consideration of the principles and working of gas producers, carburettors for petrol engines receive more congenial treatment, the principles of carburation being set forth with descriptions of such types of carburettors as the White and Poppe, Zenith, Claudel-Hobson, and Holley. The chapter on ignition describes various types of magnetos and has a table of faults, their tracing and remedies, which should be studied together with a table of petrol engine troubles in general, *e.g.*, failing to start, engine stopping, running jerkily, knocking, engine over-heating. The information on petrol engines concludes with a helpful list of points to be specially attended to under the carburettor system, ignition, water circulation, cylinders and pistons, valves, crankcase, and carbon deposits.

Steam engine and boiler principles are next outlined, with the briefest descriptions of common types and their care, working and management, fittings and auxiliaries, the use of oil fuel, natural and artificial draught, valves, and condensers. The lay-out and installation of steam plant include details of pipe-lines carrying steam, materials suitable for the pipes and joints, steam traps (illustrating Sirius and Geipel traps), and lead on to engine testing, which covers the use of indicators, determining the calorific value of fuel, measurement of water evaporated, etc. Finally Part II closes with notes on engine foundations and on the selection of prime movers for the use of engineer services in the field, to assist in which a folding table of the comparative virtues of petrol, oil, heavy oil, steam, and gas engines is inserted.

Part III—" Application " commences with a statement of methods of power transmission, proceeding to give attention to line shafting and its strength and qualities, muff and Universal couplings, plain bearings: their design, fitting, pressures, friction and lubrication; ball, roller, barrel, and thrust bearings; positive, friction, magnetic, and hydraulic clutches and the precautions needed in fitting them; the power and arrangement of belt, rope, and chain drives, and toothed gearing. Indirect transmission systems by electric, pneumatic, and hydraulic means are also noted and their efficiency and applications stated.

A chapter is devoted to the principles and methods of lubrication, viscosity and qualities of oils, with a list of service lubricants which gives their composition, flash points, and viscosities; and another to air compressors: their principles, care, working, and the use of pneumatic tools.

The manual concludes with an outline of factory organization methods for army workshops, with some notes on cost accounts and on repair shops, with examples of forms.

Following a very useful index are 94 pages of illustrations with an immense number of figures which, taken in conjunction with the descriptions in the text, should be of great value.

On the whole, the work is eminently suitable for the purpose for which it has been designed, and no better praise than this is needed. Although it may not cover the vast field of mechanical engineering as practised in our commercial workshops it is really surprising the amount of useful ground treated for the military mechanical engineer, whilst many a member of the profession engaged in civil employment would find that the purchase of the book yielded him the best investment in literature for 3/6 that he had ever had.

MAGNUS MOWAT, *Brig.-General, Reserve of Officers.*
M.Inst.C.E., M.I.Mech.E., M.I.E.S.
Secretary, Institution of Mechanical Engineers.

TEXT BOOK OF TOPOGRAPHICAL SURVEYING.
3rd Edition, 1925.

By Colonels Sir Charles Close, K.B.E., C.B., C.M.G., F.R.S., and H. St. J. L. Winterbottom, C.M.G., D.S.O. (H.M.S.O.). Price 15s.

This text book has now firmly established itself as the best book in the English language on Topographical Surveying, and one which no surveyor should be without.

The issue of a new edition, the previous one having been issued in 1913, is welcome and more than due, as the Great War has stressed the imperative necessity of maps, and has given rise to developments in various directions.

The principal changes may be briefly noted here.

The improvements in wireless telegraphy have resulted in seven pages being allotted to a subject which in 1913 was dismissed in five lines; the usefulness of this method of determining "relative" longitudes has enabled the authors to dispense with all accounts of absolute methods, for which relief surveyors may well be grateful, accurate results having always been highly problematical.

The increased use of rectangular grids has rendered it necessary to devote increased attention to the various orthomorphic projections. An account is included of the methods of fixing graphically the position of resected as well as intersected points.

The use of the Survey of India forms for latitude, longitude and reverse azimuths has been abandoned with "some reluctance" by the authors, as it is an obvious pity that different forms should be used by officers trained in England and India.

The subject of Airphoto Surveys is now included for the first time; first brought into prominence by its utility in surveying areas in enemy occupation, this method of survey has now become firmly established for all surveys of areas which are unsuitable for planetabling, such as, to take one instance, swampy, low-lying country intersected by creeks; also for city surveys and generally for rapid work, with a suitable ground control, its accuracy is marvellous. Developments in this line have been so rapid during the last year or two that the four pages allotted (against nil in 1913), will probably become forty in the next edition; at present, they merely touch on the fringe of the subject. By closer printing the number of pages has been reduced, the book is excellently arranged, clear and well got up, and all that a text book should be. The authors, themselves both distinguished surveyors, are to be warmly congratulated on supplying a book, which is invaluable not only to the beginner but to the expert surveyor.

C. H. D. RYDER.

PORT ADMINISTRATION AND OPERATION.

By BRYSSON CUNNINGHAM, D.SC., BE., M.INST.C.E., F.R.S.E. (Chapman and Hall). Price 13/6.

The author of this volume states that it is impossible to lay down any ideal system of Port Administration, and therefore describes the functions and government of the leading ports of Great Britain and her Dependencies, of the chief maritime nations in Europe, and of the United States.

These ports are simply taken as examples, which shew that in general, each port has evolved its own system of government along lines which are most congenial to its nationality, traditions and bent.

The working of each depends on the class to which the port belongs. Ports are classified in regard to situation—sea ports, river ports, etc. As regards trade; coaling ports, ore ports. As regards function, ports of call, transit ports, ports of destination or entrepôt ports, etc. As regards auxiliary services—barge ports, rail ports, etc.

Systems of port government are also many and varied, but are dealt with under the following heads :—

State Control. This is found satisfactory in the Dominion of South Africa, and undoubtedly has many advantages, but does not commend itself to Great Britain.

Partial State Control of ports is found in numerous countries, at Havre, for example, where the State is responsible for the labour and sea defence work, the docks, dry docks, etc., while the local Chamber of Commerce owns all the sheds, warehouses etc.

This system, in a more modified form, finds expression in the United States.

District or State Control is well exemplified at Boston and San Francisco.

London is an example of Autonomous control which takes the form of a Port Authority with statutory powers. Liverpool and Glasgow are other examples.

Other forms of control are Private, Railway, Municipal etc.

Various organisation diagrams typical of the different types of port control are given.

The chapter on Port Administration deals with a multiplicity of duties and responsibilities of those controlling a port, and how the various financial and engineering problems are dealt with by those in charge.

Rates, dues, charges, warehouse rents and receipts are explained and exemplified. Appendix V is interesting to the layman. It shews, in tabular form, the cost of goods discharged at British ports under various sub-heads, such as Pilotage, Towage, Dock dues, Harbour dues, Local Light dues, Trinity House Light dues, Discharging costs, Tallying, other charges.

A chapter is devoted to Port Labour—one of the difficult and perplexing problems connected with port administration—and others to Port Jurisdiction, Port Belt Lines and Port Bye-Laws.

The volume is full of interesting facts, and though many of these are of greater interest to the specialist in Port Administration than to the general engineer, the latter cannot fail to pick up ideas from the study of the methods employed in the running of such large undertakings as the modern sea-port.

G.C.G.

BUILDERS' ESTIMATES AND PRICING DATA.

By H. A. Mackmin, F.S.I., M.R.SAN.I. (Chapman and Hall). Price 9s. 6d.

This work contains a host of valuable information based on current rates of both materials and labour, and useful tables are included to adjust prices where they vary from the ones given. Constants of labour are given covering a very wide field, and seem on the whole fairly representative of prevailing conditions. A reference is made to the "Constants of Labour" contained in "Hurst's Architectural Surveyors Handbook," with the opinion that they are still the most consistent data of their kind —bearing in mind that allowances must be made for various factors likely to affect them, viz.:—shorter working days, no breakfast interval, workmen's travelling difficulties, etc. Reference is also made to the

"Constants of Labour" contained in "Works Manual (War)," published by H.M.S.O.

Many useful items, some quite new, together with their labour constants, are included, notable examples being:—Pulling down, preparing for re-use and carting away debris, etc., resulting from demolitions and alterations; jointing of almost all kinds of piping, together with jointing material required; reinforced concrete, with shuttering in some detail; plastering in Sirapite, Keens, Parian, Roman and Portland cements, also White Portland Cement or "Atlas White"; hot water, gas, and other pipe work and fitting.

Attention is drawn to the favourable comparison in cost of copper tubing with lead pipe and galvanized iron barrel, especially in H.W. work, where durability, resistance to pressures, and high conductivity are essentials, also for cold water services in soft water districts and exposed situations.

The chapter on Painting, Paperhanging and Glazing is fairly comprehensive, the comparison between lead and zinc paints being especially interesting and instructive.

Some very bold remarks are made concerning "priced schedules" for jobbing work, one being "The builders are put to the expense of measurement, which . . . in some instances amounts to more than the total cost of the item measured."

A reference to approximate estimates based on the "Cube Method" of pricing is also interesting, and a table is given showing how greatly prices vary for the same class of building. Prices for small houses vary as much as from 10d. to 2s. per F.C., indicating how dangerous they can be in the hands of the inexperienced estimator.

The old measure of "bushel" frequently appears in the book, which could with advantage have been replaced by weight or by a cubic measurement, which is much more satisfactory as a rule. There seems to be an error in the cartage table on p. 28. The last four items of this table should apparently equal so many "bushels" and not "lbs."

This work should prove of great assistance to D.O's, M.F.W's and others engaged in estimating, analysing and pricing building work, especially in the case of directly employed labour.

A.M.

THE PRINCE OF POETS.

By BRIGADIER-GENERAL S. A. E. HICKSON, C.B., D.S.O., (R.E. ret.). (London: Gay & Hancock, Ltd., 1926). Price 7/6d.

THOSE R.E. Officers who had the privilege of reading the discriminating articles on the Roman Territorials, contributed to the *R.E. Journal* of some 23 years ago by the author of the *magnum opus* now published, will have a rare treat in investigating a complex subject with an open mind and observing how, in the past, the deductive methods of reasoning pursued by the author on the Territorial system of some 2,000 years back, have been strangely verified by the experience gained before, during and after the Great War of 1914-1918.

The "Prince of Poets," or "What's in a Name?" coming out as it does on the tercentenary date of the death of Francis Bacon, Lord Verulam, is singularly opportune as a mine of wealth and reference book for those Baconian-Shakespearians who wish, if possible, to weigh up the evidence, genealogical, documentary and hereditary, circumstantial mostly, and to reconcile the various opinions as to the duplex âchievements and character of the infant prodigy and divine philosopher, Bacon-Shakespeare.

The modern Eugenist and the Facial Artist will be much interested by a perusal of this unbiassed "Prince of Poets" researchful work, whilst the ordinary person in the street will only marvel at the mass and volume of work accomplished by one or even two individuals in the difficult transition period between medievalism and the new learning.

If all the work involved is due to one man, say Bacon, how could a man, immersed in public affairs as Lord Chancellor, possess the time to study the work of the ancients alike in natural science and philosophy and frame a new system of scientific investigation? Even with the modern aids afforded by the dictaphone, simplified spelling, and broadcasting, the average reader, in mere respect for a great man's memory will deem it kinder not to stretch the marvellous to the ludicrously impossible.

O. E. RUCK, *Colonel* (*retd.*)
Member of the Society of Genealogists.

London, W.C.1.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

No. 52 (*October*, 1925).—In *Armée de Couverture*, General Camon discusses the action of a covering force to a national army, and points out that its mission is twofold, viz.:—

1. To cover the initial mobilisation.
2. To facilitate the eventual offensive.

The use of a natural obstacle as a base of operations is insisted on, and Napoleon's conception of the offensive value of artificial obstacles (*e.g.*, fortifications) is clearly brought out. The network of railways to be found on the frontiers of modern European countries has had a great effect on the action of a covering force in modern war. The importance of seizing the enemy's frontier railway system to as great a depth as possible, thereby facilitating one's own offensive or forestalling offensive action by the enemy, is clearly shown.

Commandant L'Archer begins an important article entitled *La Campagne du Général de Falkenhayn en Palestine* (1917-1918). The description of these operations is compiled from Turkish sources, comment being made on the remarkable lack of German literature on the subject of the activities of the "Yilderim" group of armies. The article deals mainly with the difficulties and mistakes of the German Higher Command, in their efforts to impose their authority on the Turkish military system, and the various conflicting interests on the Turkish side appear clearly and make very interesting reading. The narrative closes with the eve of the British attack at Beersheba on October 31st, 1917.

La Bataille de Courcelles-Méry is completed in this number. Considerable attention is given to the habitual (and admittedly sound) tactics of envelopment and infiltration practised by the Germans in their offensive of 1918. The article deals mainly with the successful defence of Méry on June 10th and the partially successful counter-attack of June 11th, carried out by the only four remaining fresh divisions available at the time. It is easy to see from a study of this operation how essential it is for troops on the defensive to be animated with an offensive spirit, and it is from this theme that Colonel de Ripert d'Alauzier draws most of his conclusions.

Capitaine Damidaux, in his *L'Officier d'État-Major*, displays an intimate knowledge of the qualities required by a Staff Officer. These are grouped under the headings of moral, intellectual and physical qualities, and the somewhat formidable array which are discussed show clearly the necessity for intensive training for the Staff Officer, a necessity which was perhaps not generally realised at the end of the Great War.

Poudres et Explosifs (1914-1918) is concluded in this number. Commandant Duchemin discusses chiefly the interesting question of the German efforts to obtain the necessary ingredients for high explosives once the pressure of the British blockade became felt. The article concludes with suggestions for the future in order that France and her Allies shall not again find themselves unprepared for the enormous demands in "matériel" of modern war.

No. 53 (*November*, 1925).—The object of Lieutenant-Colonel Lucas' article, *Des Méthodes de Commandement*, is to summarise the doctrine laid down in various parts of the French Regulations as far as the general duties of a Commander and his Staff are concerned. The conclusions arrived at are familiar to any officer with experience of command or staff work, and coincide almost invariably with the corresponding doctrine in the British Army. The responsibility of a Commander to make decisions and that of his staff to give effect to those decisions is clearly laid down. The most interesting part of the article consists of a comparison of the theoretical and practical attributes of the staff of a higher formation, in which the writer points out the necessity for a senior staff officer to be prepared to give advice on occasions instead of acting invariably as an automatic machine for giving effect to the Commander's decisions.

La Campagne du Général de Falkenhayn en Palestine is completed in this number, the period comprising the Battle of Beersheba of October 31st, 1917, to Falkenhayn's departure on March 2nd, 1918, General Liman von Sanders having superseded him. The ill-feeling between Falkenhayn and the Turkish Generals shows itself throughout these operations, and the failure of the aggressive measures advocated by the German Commander resulted in the supersession of nearly all the German officers at "Yilderim" headquarters, and the removal of Falkenhayn himself.

Capitaine Welschinger, in *Deux Idoles du Peuple Allemand*, compares the characters and careers of two famous German soldiers, Blücher and Hindenburg. Both were called to the supreme direction of their country's army at an advanced age, but Hindenburg never tasted the fruits of victory like Blücher after Waterloo. The writer attributes the German failure of 1918 to the lack of the faith in the justice of their cause, which was exemplified by Blücher and Gneisenau throughout the Prussian revival of a hundred years before.

Un acte de la Course à la Mer (4-9 *Octobre*, 1914), by Commandant de St. Denis, is a detailed description of the operations of the 13th Division of the 21st Corps during the race to the sea of 1914. The objective of the division was to ensure the occupation of Lille ; at the end of the period it found itself in a defensive position west of La Bassée. These somewhat complicated operations are clearly described and illustrated by three sketch maps.

Colonel Meynier begins a very interesting article, entitled *A propos des raids transsahariens*, in this number. After describing briefly the various efforts to cross the Sahara made between 1916 and 1925 both by motor car and aeroplane, the writer reaches the conclusion that both these machines must now be considered as practical methods of transport in the Sahara. He then points out the need for their employment to convert an impoverished and rebellious area into a prosperous part of the French Colonial Empire. The remainder of the article is devoted to an interesting description of the use of modern weapons (particularly armoured cars and aircraft) in the British desert campaigns against the Senussi (1915-17) and in Dar-Fur (Sudan), in 1916.

Le Logement des Gens de Guerre sous l'Ancien Régime, by Lieutenant Navereau, traces the methods of billeting and accommodation of troops in barracks prior to the French Revolution, and points out the difficulties experienced during the Great War under the existing law governing the billeting of troops.

No. 54 (*December*, 1925).—It goes without saying that Lieutenant-Colonel Grasset's article, *Verdun—Le premier choc à la 72e division*, is both interesting and instructive. In this number the writer deals with the preparatory arrangements on both sides, and the dispositions are given in great detail and are well illustrated by sketch maps. Special attention is paid to the dispositions of the 72nd division in the sector immediately east of the Meuse.

Colonel Meynier's interesting article, *A propos des raids transsahariens*, is completed in this number. A further example of the use of modern weapons in uncivilised countries is given, viz.:—the British campaign in Somaliland in 1920. Aircraft played a very prominent part in these operations, which were not, however, entirely successful, possibly owing to the effect of purely aerial action having been over-estimated. Colonel Meynier concludes his article with a discussion of the capabilities and limitations of the old and new weapons and methods of transport, *i.e.*, infantry, cavalry and camel corps as opposed to armoured cars, mechanical transport, aircraft and railways.

It is claimed that the future of France lies in Africa, and modern methods of communication are essential for this claim to be realised.

The object of Commandant Martin's article, *Les groupes d'Armées Allemands au cours de la Guerre* (1914-1918), is to prove the unsoundness of the original system employed by the German Higher Command, which was to place one Army Commander in command of other armies besides his own. The best known example is that of Von Bülow and Von Klück in 1914. Details are given of the various groupings of the German armies throughout the War.

Rôle Historique des Places Françaises, by Capitaine de Gaulle, outlines the history of the fortresses of north-eastern France since the days of Vauban. After the disasters of 1870, General Séré de Rivières prepared an excellent scheme for the re-organisation of the French system of fortresses, but, apart from Toul, Verdun, Epinal and Belfort, and to a certain extent Maubeuge, his recommendations were neglected. It was largely owing to this neglect that the German sweep through Belgium in 1914 met with such success. Captain de Gaulle concludes his article with the remark that "one door has given entrance to all the disasters which have befallen France throughout her history; it is the door through which the lessons of the past have escaped."

Colonel Baills' *Essai sur l'Emploi Tactique du Génie*, is divided into two parts:—The effect of technical problems on military operations, and the tactical employment of Corps and Divisional engineers. The first part is illustrated by the effect of permanent fortifications on the operations of the Germans in France in 1914; in the second part the doctrine of concentration of engineers, rather than dispersion among the other fighting troops, is in general agreement with the present day doctrine of the British Army.

Les chars au Maroc en 1925, is a report of the activities of the 1st and 2nd Tank Battalions during the operations against Abdel Krim in Morocco in 1925.

Several lessons are drawn from the experiences of the campaign, but it is realised that the special conditions of Morocco called for modifications in the normal organisation of tank units in the Metropolitan Army. One of the main lessons, however, holds good for all forms of warfare, namely, the necessity for compliance with the regulations for the co-operation of infantry and tanks before and during operations. To support the infantry and facilitate their task remains the chief rôle of the tank, under present conditions.

H. A. J. PARSONS.

REVUE DU GENIE MILITAIRE.

(*January*, 1926).—*The Ivory Coast.* An account of the construction of a canal connecting the lagoon, on which stands Grand Lahou, at the mouth of the river Bandama, to Ebrié lagoon, on which is Grand Bassam, the other part of the colony.

The Water Supply of a Camp. A description of the arrangements made to supply a standing camp for 53 officers, 1,760 O.R's. and 370 horses. The authorised scale was 6½ gallons per man and 11 per horse daily. The source of supply could furnish 40,000 gallons in 24 hours, and the distributing system was chosen of such a size as to be able to give 30,000 gallons in 15 hours (from 4 a.m. to 7 p.m.) from a tank holding 3 days' supply.

La Houille Blanche. A précis of the papers read at the third Hydro-Electric Congress held at Grenoble in July, 1925. The Congress was divided into three sections (*a*) administrative, (*b*) financial and economic (*c*) technical, sub-divided into production, distribution and use; The paper includes a description of a laboratory near Grenoble devoted to the study of the production of ·lectric power from water.

Foundations in Sandy Soils. The soils in North Africa are greatly affected by extremes of dampness and dryness. In summer they crack and form fissures up to 40 feet deep, thus making ordinary foundations useless.

If it is possible to keep the degree of dampness of the building constant, for example, by a layer of sand under the foundations, no ill-effects will be found. The only alternative is to build on a reinforced concrete raft.

The Carriage Overland of Ships. A list of various occasions on which ships have been transported overland either as complete ships or in parts, from the time of Cleopatra.

Regulations for the Construction and Use of Septic Tanks.

(*February*, 1926.)—*The Supply of Timber in the War.* The demand for wood until the beginning of trench warfare was almost entirely for fuel. But, in spite of the diminution of civil demands, by April, 1915, commercial stocks were getting exhausted and a general control of timber was organised under the *Direction du Génie* at the War Office.

This system soon proved ineffectual owing to the independent action of the *Intendance*, the Railways, Munitions and other departments, and led to the organisation in 1917 of (*a*) the *Comité Général des Bois*, to control the needs of the various services and their relative urgency, and advise as to means of meeting the requirements, and (*b*) the *Inspection Général du Service des Bois*, to ensure the supply for military purposes and to prepare, co-ordinate and supervise the exploitation of the Allies.

The author claims that the overseas forces acquired much useful knowledge from their contact with the traditional methods of French forestry, particularly in connection with the difficult problem of husbanding their resources.

At the time of the Armistice the requirements meant an annual production of about 200 million cubic feet of wood for work and 50 million cubic ft. for burning.

Before the war, in France there were 24 million acres of forests and in Alsace-Lorraine one million. After the war, in the combat area, i.e., that area occupied by the Germans and 12 miles beyond, there were only 700,000 acres of productive forests. In the interior of France the damage to the forests has not been great, and in general, thanks to the organised cutting, the French forests are in good order, despite the drain on them during the war.

Dealing with any future war the conclusion is reached that the annual production will meet the needs of the Army and of civil life, at any rate at the beginning of a war, without calling on the reserve stock of timber in France, estimated at nearly 2,000 million cubic feet, and that all the qualities of wood required will be available, except perhaps those for aeroplanes.

Crossings of the Euphrates at Deir-ez-Zor in 1924. A description of the methods used to strengthen an existing bridge and provide a ferry, run on an overhead wire rope, capable of dealing with 8-ton loads, over the two branches of the Euphrates.

Calculations for Reinforced Concrete Beams. A description of the method of calculating reinforced concrete beams by means of a slide rule, the invention of M. Rieger, a Czecho-Slovak engineer and teacher. After a description of the rule and the various scales, a number of examples of various problems are worked out in detail.

The Crossing of the Danube at Sistovo on 23-11-16, *by the Austrians and Bulgarians.* An examination of this operation, prompted by the article in the *Revue du Génie* of September, 1925, divided into a consideration of (i) the choosing of the point to cross, (ii) the preparations, (iii) the crossing, and (iv) the morals to be drawn.

(i) The choice of a point to cross a wide stream such as the Danube depends on

(*a*) Historical considerations, *i.e.*, where previous armies have crossed. This is liable to give erroneous information, as other conditions vary.

(*b*) Geographical and strategic considerations, such as the nearness of a railway system (this is not of great importance, as the railways cannot be utilised until the attacking troops have pushed the defenders some way from the river), of roads (of primary importance for the collection of material for the crossing), the proximity of the objective (*e.g.*, enemy's capital or industrial centres).

(*c*) Technical conditions, nature of the banks, position of islands, width of the stream. At Sistovo these were not considered of such account as (*a*) and (*b*).

The choice of the exact point or points of crossing, as opposed to the region in which crossing should be carried out, ought to depend on tactical and technical considerations.

The choice of the region is the responsibility of the supreme command; that of the exact spot should be decided in collaboration between the commander of the formation to effect the crossing and the engineers.

(ii) Choice of the exact sites from which to start. The choice of the sites for collecting materials for the crossing depends on the possibility of bringing up material by road, unloading it and collecting boats, all out of sight of the enemy.

At Sistovo no choice was possible; three spots were forced on the attackers as the only possible ones. Most elaborate precautions were taken to prevent the enemy from discovering the preparations, by camouflage, by elimination of noise in working and by working at night. It is pointed out that these precautions were not specially thought out for this operation; they were laid down in Austrian and German Regulations.

(iii) *The Materials.*

German one-piece boats were used, as well as the excellent Austrian two-piece boats, which were divisible into the " body " (length 11 ft. 4 in.) and the " beak " (length 13 ft. 6 in.), each weighing approximately 8 cwts. The German boats were not as stable as the Austrian on the Danube with its high waves.

For the main crossing at Sistovo and the subsidiary one upstream at Bélène there were available in all 108 boats to carry 3 divisions, a much smaller figure than that used by the Germans in their crossings.

(iv) *The Crossing.*

At Bélène three boats went astray owing to the fog, showing the importance of careful arrangements for directing. At Sistovo a curious arrangement was carried out; the boats left *en échelon,* were dressed after they started and went by compass. It worked very well. The motor boats were not a success; those with oars were more reliable.

To sum up, the attack succeeded for four reasons: careful preparations, complete surprise, fog, a very feeble resistance.

Two days after the crossing, a "Herbert" Bridge, capable of carrying 40 ton loads, was erected, 1,000 yards long, in 23 hours, a remarkable feat.

What lessons can be learned?

For the staff—to give the engineers a free hand to make their preparations; for the latter—to prepare a large enough supply of material without being observed; for extremely exact orders to be issued. If all these have been carried out the programme should go as follows:—Infantry and machine guns go across in light armed boats, followed on rafts by more infantry and some artillery. Then come the rest of the troops on ferries and steam boats; next the building of a bridge, capable of carrying heavy loads.

Points to be noted are the necessity (i) for a larger number of small boats for the first crossing, (ii) for empty boats to be brought back quickly, (iii) for the piloting of the boats to be perfect, even in fog, (iv) for the presence of a large reserve of material, (v) for the flanks of the crossing to be covered by fast armed boats, (vi) for echelons, other than the first, to make use of motor power and to go in large boats, and (vii) for having ready material to make a bridge strong enough to carry, without strengthening, the heaviest loads.

The Work of the Institute of Military Science at Warsaw from 1918-24. The objects of the Institute are to increase the efficiency of the Army and to form bonds between the nation and the army—a difficult task, since Poland had not possessed since 1831 an army of her own or any military literature.

Up till 1922, that is, during the war against the Bolshevists and the subsequent demobilisation, the Institute was perforce limited to the publication of regulations and manuals, co-ordinating civilian science with that of the Army and starting military records and a library.

Owing to the varied nature of the armaments in use, a large number of technical works dealing with them had to be produced. In historical work the only attainments were various studies dealing with the past military history of Poland.

In 1920 a commission was set up to standardise military terms used in official documents. In 1921-22 the influence of the French Military Mission was felt in the increase in scientific studies and translations of foreign books. In 1923 abnormal conditions were over, and the Institute began a methodic course for helping military students by putting before them histories of the Great War and previous Polish Wars. In 1924 the Institute started "Przeglad Wojskowy" to keep Polish Officers in touch with foreign scientific work.

The review, "Bellona," was founded in 1916, and was content at first to cultivate Polish military traditions; after the creation of an army, *Bellona* had to deal with all arms, instruction taking the premier place.

Since then various journals have been started and *Bellona* has been able to deal with more general questions and is modelled on the *Revue Militaire Française.*

March, 1926.—*The Employment of Engineer Troops in the Operations of the IVth Army between 26th September and 11th November,* 1918. The Army Commander laid down that the principal task of the engineers was to keep up the communications, and that the complete success of the operations would depend to a large extent on the speed, governed by the conditions of the roads, at which guns and stores could be brought forward. 13,000 *troops of various descriptions were put at the disposal of the Chief Engineer.*

The article explains how the personnel were employed, how the necessary stores were obtained (almost entirely from the army area) and gives some summary of the results achieved.

Building a Pile Bridge.—A description of the construction of a 200-ft. pile bridge and approaches by the 2nd Engineer Regiment, as part of their technical training in the Department of Herault.

Passage of the Sambre à L'Oise Canal, 4th November, 1918.—The assault bridging methods adopted in the crossing of this canal under the close fire of the enemy, at Etreux.

Several types of bridge were used and are illustrated: (*a*) a duckboard 20-ft. long, 1 ft. 10 in. wide at the ends and wider in the middle; this bridge was found to have considerable lateral vibrations when crossed by men at the double. Such bridges were used for crossing at locks and weirs; (*b*) to cross the canal 60-ft. wide, a bridge with three floating piers either with barrel or cork rafts, the buoyancy of each pier being 420 lbs. Considerable vertical articulation was necessary to allow the bridges to be launched over the tow path; (*c*) smaller two-span floating bridges to cross a small stream 20-25 ft. wide; (*d*) trestle bridges to be built as the attack progressed; (*e*) timber bridges to carry artillery and 3 ton axle loads.

Road Building.—A portion 2½ km. long of a "chemin bicinal" in Haute Savoie was built as a technical exercise by engineer troops with some slight infantry assistance. Details of the road formation, culverts, embankments, etc., are given, together with some interesting notes on the behaviour of the various machines, stone-crushers, compressors, etc., which were used.

A large proportion of the road was on the side of the mountains, and a considerable amount of drilling and blasting was necessary.

Water Supply for Military Establishments.—A *resumé* of a Circular issued by the Minister of Hygiene in July, 1924, relating to the methods to be employed in ensuring the purity of water supplied to barracks, etc., to the keeping existing supplies pure, and for ensuring any future projects should be properly examined before approval.

BULLETIN BELGE DES SCIENCES MILITAIRE.

(1925—Tome II. Nos. 3 to 6 inclusive).

(*Continued*).

An account is given in Nos. 4 and 5 of the incidents of October 8th in connection with the withdrawal of the Belgian Field Army to the new base at Ostend. The main body of this Army was now falling back to the line of the Ghent-Terneuzen Canal. The situation was reviewed at Belgian G.Q.G. on the morning of October 8th ; the latest information to hand led the Belgian High Command to the conclusion that the British 7th Division would probably be able, after all, to reinforce the Belgian Field Army in time to check the further advance of the Germans. In consequence, orders were at once issued with a view to a stand being made on the line of the Durme ; it was still hoped that touch would not be lost with Antwerp altogether.

In the meantime, von Werder, who had been placed in command of the Left Wing of the Germans besieging Antwerp, had received orders to transfer as large a force as possible to the north bank of the Scheldt and to push forward without delay to Lokeren ; the intention of the German High Command was to complete the investment of Antwerp forthwith, with a view to cutting off the line of retreat to the westward of the fortress. The Germans imagined that they had succeeded in bottling up the whole of the Belgian forces and the R.N.D. in the great citadel and were quite unaware that the troops with which they had been in collision at Termonde and Schoonaerde were really parts of the Belgian Field Army ; they fancied that they had been dealing with odd detachments guarding the L. of C.

On the morning of October 8th, units of the Belgian 3rd Division were in the neighbourhood of Lokeren ; accordingly, shortly after von Werder's troops were set in motion on that day, a collision took place between the opposing forces. Von Werder does not seem even then to have realised that it was the Belgian Field Army that he had run up against. The " fog of war " in this region seems to have been as dense as a "London particular."

The " Race to the Sea " was now in progress, and the movements of French 2nd and 10th Armies and the B.E.F. are briefly touched upon in No. 4. Measures had been taken by the British Government for reinforcing the R.N.D. in Antwerp, and a detachment of R.M. Artillery with 16 field guns had been landed for this purpose at Dunkirk. However, the German Right Wing had advanced very rapidly towards the coast and was at this time threatening Lille and Ypres ; the British plans were, in consequence, modified, and the R.M. Artillery did not continue its journey. Sir H. Rawlinson, who was responsible for the British troops sent to the aid of the Belgians, had his Headquarters at Bruges. At 7.45 on October 8th, General Paris telephoned to him and stated that the R.N.D., together with the Belgian 2nd Division and some fortress units, had taken up a position on the Second Line of Defence, which was insufficiently prepared and untenable, under a heavy bombardment, by worn-out and inexperienced troops.

There were many cross-currents at this time ; needless to say, they created dangerous eddies and the situation was much aggravated by a very " divided " command—with strange " links " in it (see No. 5). The Belgian and British views as to the employment of the British reinforcements which had been landed at Ostend and Zeebrugge did not coincide. However, King Albert continued strongly to represent the views of the Belgian High Command, namely, that the dispositions of the British troops in Belgium should be such as to ensure the safety of the line of retreat from Antwerp to the coast. Eventually, the King's representations bore fruit; at 17.45 on October 8th, Rawlinson received a message from Lord Kitchener directing him to make dispositions to assist the retirement of the Belgo-British troops first on Ghent and then on Ostend.

In the meantime, the defence put up by the Belgian 3rd Division at Lokeren was weakening, and as other Belgian troops were now in jeopardy, the Belgian High Command decided to abandon the intention to make a stand on the line of the Durme and a retirement of the Field Army to the left bank of the Ghent-Terneuzen Canal was ordered. Measures were at the same time adopted to cover the withdrawal of the Belgian 2nd Division and the R.N.D. from the entrenched camp.

The last phase of the resistance of the Belgo-British troops on the Second Line of Defence is dealt with in No. 6. Generals Dossin and Paris, having jointly considered the situation, had come to the conclusion that, in view of the violence of the German bombardment, it would not be possible for the force to hold out much longer. A report to this effect was made to General Deguise, but he would not accept the views of the two subordinate generals; he reiterated his demand for a "résistance à outrance."

Prior to his departure from Antwerp, the First Lord of the Admiralty had issued instructions directly to General Paris to the effect that the latter should endeavour to put up a stubborn defence, but he was, nevertheless, to consider himself free, apparently at his own discretion, to cut his way to the left bank of the Scheldt in order to rejoin the force under Rawlinson, or any other British troops. Accordingly, when General Paris telephoned to Rawlinson, as stated earlier, he informed the latter that it was probable that he would be forced to retire at the end of the day; he did not report this conversation to the Belgian authorities, nor did he communicate to them his intention to withdraw the R.N.D. from Antwerp.

The Germans selected the section of the front comprising Forts Nos. 3, 4 and 5 for the break-through, and, having brought their heavy artillery into position, began to bombard these works. A brief reference is made to this artillery action (No. 6).

General Dossin continued to exhibit considerable anxiety in relation to the task set him and sought further instructions from General Deguise. Accordingly, an order—the text of which is set out in the original article—was issued from Fortress Headquarters, wherein were set out the circumstances in which the troops on the Second Line of Defence might withdraw from their positions, and the destinations they should make for. In his turn, General Dossin, at 13.45 on October 8th, issued orders to the Commanders of the Belgian troops under him and also to General Paris indicating the routes by which the several formations and units concerned should retire when it became necessary to abandon their positions. Within an hour of the drafting of General Dossin's order some of the Belgian troops on the Second Line of Defence began to fall back.

German Tactics. The original article, which appears in No. 3, is a compilation based on the regulations for the German Army and certain other works, a list of which is given. The following matters are dealt with in the original article: the details of the new organisation of the German infantry, its training, and the principles for its employment in the battle; the new organisation of the German artillery and the part it is expected to play in the battle; the new organisation of the German cavalry and its rôle in war; the employment of cyclists and armoured-cars is also touched upon; the general principles relating to the employment of field defences are stated; brief references are made to aerial attack and anti-aircraft defence, gas-warfare and tanks. Captain Weber, the author of the article, points out that no attempt is made in the German regulations to conceal the fact that questions of organisation and preparations for war have been approached in the *Reich* from the point of view of the effectives, armament and equipment of a great military Power, and not alone from that of the army of 100,000 men, which is allowed to Germany under the terms of the Treaty of Versailles. Those who wish to keep themselves abreast of what is taking place in the military sphere in foreign lands—there must be many such in the Corps—will find Captain Weber's article exceedingly helpful to them; it gives, so to speak, a bird's-eye view of the new German Army as it has been rebuilt on the lessons of the Great War, as interpreted by its brainy ones.

Infantry Bridge. The original article is contributed by Major Mascart and appears in No. 4. Major Mascart is of opinion that sufficient attention has not been given to the provision in Engineer Parks of material for light infantry bridges for crossing waterways on floating piers. The problem is discussed and particulars, with illustrations, are given of an equipment designed by Major Mascart for a bridge to take infantry in single file. This equipment consists of longitudinal and transverse girders of duralumin and floating supports, similar in appearance to the Blanchard cylinders of long ago—but smaller in size. It is suggested that rubber-covered linen, and not metal, should be used for the floating supports, which might be filled either with straw or a number of air-filled rubber bladders, as used inside the leather jackets of footballs.

W.A.J.O'M.

THE MILITARY ENGINEER.

(Jan.-Feb., 1926).—Theory and Practice with 2nd Engineers. An account of Engineer work in the Great War, written to illustrate the importance of Field Engineers being always prepared for emergencies, and shows how at Chateau Thierry—Soissons and on the Meuse—Argonne, engineering problems seldom worked out as planned, owing to sudden changes in the military situation.

The Army "Air Experience" Course. A description of a short course of flying which officers of all arms should take.

The aim of the course is to enable all officers to appreciate the possibilities of aircraft, to learn what can and cannot be seen from an aeroplane, and to direct an aeroplane over a given route on a map, obtaining the fullest details of the terrain flown over.

Tactical Use of Combat Engineers. Previous articles on the same subject have all been written with a view to arrive at the most satisfactory organisation of Divisional Engineers to enable them to take part in battle as infantry. The writer in this article suggests that engineers should never be used as infantry except in the very last resource, and that by functioning as engineers, either in attack, defence or retreat, they can be of much greater assistance to the infantry than by being thrown into the line to use their rifles.

The 7th Engineers Bridge the Meuse. An interesting and highly instructive article on the Bridging operations during the Meuse-Argonne offensive in November, 1918. The lessons to be learnt from these operations are :—

1. Value of information obtained from reconnaissance and from maps, aeroplane photographs and civilians.

2. Importance of deceiving the enemy of the actual points of crossing by careful preparations at selected points distributed over as large a front as possible.

3. A successful crossing was made at a point which from an engineering point of view presented great difficulties, thus illustrating the factor of surprise.

4. The importance of meteorological conditions. The crossings were assisted by cloudy weather and poor visibility.

The Influence of Bridges on Campaigns. As the campaigns selected are all from ancient history some five hundred years B.C., no useful technical data are obtained, but the article is of interest as it shows the importance of Bridging operations was as great in those days as it is now.

C.G.M.

HEERESTECHNIK.

(*January, February and March* numbers.) Dr. Becker, in his article *On the Measurement of the Velocity of Projectiles by Photographic Means,* describes a number of most ingenious instruments, which he classifies in two main classes: measurement by artificial light, and measurement by daylight. In the latter class the most interesting instrument operates as follows: Two photographs of a projectile are taken on a film which by repeated trial is made to move at such a speed that the two images coincide. On the same film the vibrations of a tuning fork are reproduced photographically, by which means the speed of the film is known exactly, and a simple calculation gives the speed of the projectile.

Major Buhle reviews at length a book by Col. Rimailho, *Artillerie de Campagne.* Col. Rimailho's name is closely connected with the development of the French field artillery, and at the present time he is head of the construction department of the factory of St. Chamond. It is evident that considerable respect is paid in Germany to his opinions.

Major Justrow carries on the wordy battle between himself and Lt.-Gen. Rohne, on the range, muzzle velocity and weight of projectiles; but this is to be the last of it, as far as this magazine is concerned, for the editor is getting tired of it.

Twenty-five pages are devoted to a review of the German Automobile Exhibition held at Berlin in November, 1925; the article deals entirely with the civil aspects, and is accompanied by numerous photographs and diagrams.

Progress in Civil Concrete Practice, is the title of an article by Lt.-Col. Augustin. He gives figures showing the alteration of the analysis of cement in the last few years, and the improvement in its strength in tension and compression as shown by the regulation tests, and in its speed of setting.

Dr. Hanslian reproduces at length the views of a Russian writer on *Gas Shelters, and the Protection of Buildings, etc., against Gas.* The Russians in general seem to place very great value on gas-warfare, particularly in conjunction with the airarm. The needs of a country, says the author, may be divided into three classes: (1) protection of dug-outs, etc., in the field, by means of a suction pump with replaceable filter, worked by hand; (2) protection for buildings, fortresses, etc., by means of petrol or electric motors, the filter in this case being a fixture; and (3) ventilation schemes for factories, telegraph offices, etc., in which fresh air is drawn from pure upper strata of air, so that no filter is required. Calculations then follow as to the amount of oxygen required, and percentages of carbon di-oxide present in rooms, etc. (*To be continued*).

Dr. Stadie writes in terms of high praise of the Russian motor reliability tests, which he considers were arranged better and more practically than any others so far held.

An anonymous article *Coal* deals with the mining, sorting, and use of the mineral in industrial furnaces.

Dr. Becker writes *On the Ballistic Density of Air*, a term which he defines as " an assumed value for the density of the air, which, acting uniformly on the projectile during the whole of its flight would have the same effect on the range as the actual density of the air."

T.H.B.

MILITARWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(Numbers *January to April*).

Captain Fritz Heigl contributes an impartial and well-written article, *The First Tank Battle, Cambrai,* which agrees with the best accounts published in England.

Colonel Robert Pohl, who during the whole war held important staff appointments on the Italian front, writes on *The Conduct of the War by the Central Powers against Italy.* After a brief preface on the relations between Germany and Austria with reference to Italy, he reviews in turn the chief operations on the Italian front, the lion's share being devoted to the offensive on the Isonzo in October, 1917. The immediate motive of the attack was the realisation that under another Italian attack the Austrian defence would fail, so that Trieste and the sea coast would be lost. Ludendorff wrote: "Under the circumstances the use of German troops in Italy for purely defensive purposes would have been useless to us. The G.H.Q. were forced to see the necessity of an attack . . . In spite of the diverse views as to the value of a partial success, the attack on Italy had to be decided upon in the middle of September, to prevent Austria's collapse." Tempting as were the prospects of an offensive from South Tirol, preparations for it required three months; so that winter's approach left no alternative to an offensive on the Isonzo and a break-through between Flitsch and Tolmein. From Tolmein to the south, where the object of the attack on 24.10.17 was to pin down the enemy, the Austrians were in a minority of 2 to 3, but on the front of the break-through, in a majority of nearly 2 to 1. The attack compelled the Italians to give up in two and a half days all that two and a half years and eleven battles on the Isonzo had won for them, and moreover they had to retire to the Tagliamento, 60 kms. back. The exemplary orders for the 14th Army ran: ". . . . By incessantly pressing forward by day and night to leave the enemy no time to prepare a new strong position." The Italian Court of Enquiry stated: "The uttermost exploitation of the unexpected initial success and the tireless pursuit frustrated every attempt at holding a rearguard position." The bulk of the Italian Third Army was behind the Tagliamento early on the 31st; but the Second Army was in the main captured; of the 180,000 prisoners and 1,500 guns taken up to the 31st, the majority—over 100,000 men and 1,000 guns—were cut off on the 30th and 31st near Codroipo and Latisana.

The results of the offensive are well-known, that seven French and five English divisions were transferred from France to Italy, and that the tension on the Western front was relieved.

Lt.-Col. Kiszling describes *The Recapture of the Heights of Runcul Mare; an Infantry Attack with reversed Front in woody mountainous Country*. The Austrian 71st Division, in following up the Rumanians too boldly, were nearly cut-off; but gambling on their greater experience, the Austrians were able to re-group their units, and to make a counter-attack which extricated them from the danger.

The Influence of the Commander in Battle, is the title of a very interesting contribution by Lt.-Col. Ruggera. Unfortunately, it is quite impossible to make an adequate summary of a rather long article.

Major General Nowakowski writes on methods of projection of maps for military purposes, on the difficulties of co-ordinating consecutive map-sheets, and the system of rectangular co-ordinates. The article is not intended for those who have made any study of the subject.

Major Stuckheil writes, *The Second Investment of Przemysl*. Quoting from official documents, published in 1915, he outlines some of the financial and other difficulties, experienced before the war, in maintaining the fortresses of the Austrian Empire in sound military condition, and states that the causes of the fall of Przemysl were primarily insufficient preparations in time of peace. "The greater part of the work" (*i.e.*, of bringing up supplies) "remained to be done in the few weeks between the outbreak of war and the first investment of Przemysl." In the general plans for the supply of the troops in the fortress, a definite limit was set to the rationing . . . . a garrison of 85,000 men and 3,700 horses were to be provided for for three months. We must deem this a very modest figure when we remember that, according to pre-war theory, where possible, the resistance of a fortress should not come to an end until the military resources of the land were exhausted and the continuation of the war was useless." Between the two investments of the place, supplies of all sorts were taken from it for the use of the Army in the field. (*To be continued.*)

Col. Feichtmeier writes on *Night Operations*. "From before the War to the very earliest times it is seen that battles were seldom fought at night, in contrast to which war history shows that the night was utilised to cover movements and preparations, and the battles began with the first light of dawn . . . . The object of this study is to investigate, in the light of actual examples occurring during the war, to what extent the views prevailing before the war were justified." "In the late war both movement and action were carried out by night to a greater extent than in previous wars; but the cause of this was not due to a greater partiality for night work; on the contrary, dislike of night work was greater than ever, for the experience of the war was that a night attack seldom led to a lasting success." The author then briefly reviews nine night operations of the last war, choosing fairly representative examples each account includes a summary of the general conditions, objectives and degree of success attained. Summing up his conclusions, he says, with reference to the attack :—"The difficulties of the night attack do not only demand fresh troops of excellent morale, but troops with special training. The strength of the attacking troops should never exceed one division. The objectives must be limited, and the preparations thorough. Surprise is essential, success depends entirely on it; therefore the infantry open the proceedings alone without support of artillery or of other arms." In regard to the defence, the author says :—"Well-organised defensive fire is the critical factor. Of particular value is frontal fire by machine guns; to the direction and co-ordination of the night lines special care must be paid. Efficient listening and observation posts give ample warning of the attack. Immediate counter attack made by the first line reserves and accompanied by heavy bombing and shouting is demoralising, and being over known ground, is the quickest method of stopping the advance. The counter attack must be made with co-operation of artillery, but all events it must be carried out before dawn." Under the title *The Last Book of the Field Marshal*, Lt.-Col. Glaise Horstenau reviews Conrad's memoirs, in particular the last volume, dealing with the period from October to December, 1914. *Tanks in* 1925 is written by Capt. Fritz Heigl. The chief points on which great light is required are the English Vickers and the French "Char Leger," particularly the new model of the latter provided with "rubber chains."

T.H.B.

MILITAR-WOCHENBLATT.

4th January.—1. *Military political retrospect of* 1925. The army is praised and it is demonstrated that in spite of the Treaty of Versailles it has a *Commander* (though officially he is merely " adviser " to the War Minister), a General Staff, and an increased Police Force. . It is asserted that France will not support general disarmament. The writer gloats over French difficulties in Morocco and Syria and predicts trouble for Britain in Iraq, Egypt and India, while admitting that the English are clever in getting round difficulties by temporarily yielding. Peace and order in Italy depend on the person of Mussolini.

2. *Voyage of Zeppelin L.*59 *to Africa.*—A description of the voyage. When over Khartoum, on its way to succour German troops in East Africa, L.59 was recalled. While dropping bombs on the " fortress of Naples " on the return journey, L.59 was brought down by the gun of a submarine, the crew being burned to death.

11th January.—1. *Influence of the Latest Tanks on Operations.* Attention is drawn to the use of mechanical vehicles during both French and British manœuvres. The performances of the British Medium Mark D are described as astonishing.

2. *Reichswehr.* An article dealing with the new defence force. The difficulties of recruiting are described.

18th January.—*Problem of the Defence of Poland in a Future War.* Polish military organisation and the training of her youth are examined—both are in contradiction to the pacific utterances of her statesmen.

25th January.—1. *War Atrocities.* The necessity to combat the legends of German war atrocities is pointed out.

2. *Why the Minenwerfer is an Infantry and not an Artillery Weapon.* The writer concludes from personal observation and from conversation with officers of the various arms that the infantry must have this weapon directly under its command.

4th February.—*The Disarmament Conference.* The seven main problems, given by the League of Nations for solution by the conference, are discussed. The writer considers that they are framed in such a way as to defeat in advance any attempt to obtain unanimity among the delegates, and this will prevent a successful issue.

11th February.—*Aviation and Locarno.* The writer refers to Treaty limitations on German aviation. He points out that all lines from west to east and from north to south must pass over Germany and that if Germany has to continue to forbid flying over her territory by other countries, the world as a whole will suffer. He hopes the Locarno spirit will be applied to find a speedy solution.

25th February.—*The Legacy of the War Survey Organisation.* The legacy consists of three main discoveries—the taking of aeroplane photographs—the apparatus for plotting on maps accurately from such photos—the development of military geology in trench warfare.

4th March.—The Importance of Anti-Aircraft Artillery. The writer refers to an article of *La France Militaire* of 13th January, 1926, calling attention to the neglect in France of the anti-aircraft gun, owing to the efforts to discover a gun of accompaniment. He deplores the fact that Germany shows a similar neglect although she is open to aeroplane bombardment from all sides, and urges the study of anti-aircraft defence with a view to obtaining good organisation and a better gun. If this is not done the moral of the population may give way in the opening stages of a war.

11th March.—1. *English War Preparation in Belgium before the World War.* The writer declares himself to be in possession of a secret War Office publication entitled "Report on Belgium, south of the Line Charleroi-Namur-Liège, and on Brussels, from the point of view of Aviation, 1914." He examines the contents of this pamphlet, which shows that aeroplane military landing places in Belgium had been reconnoitred and concludes that the violation, by Germany, of Belgian neutrality was merely an excuse on the part of England to enter the war, a course which she, in any case, intended to adopt.

2. *Tank Obstacles.* The tank obstacles used by the Germans during the war are described. The anti-tank gun is considered to be the best form of defence.

18th March.—1. *Defence against Tanks with Ordinary Weapons.* The best weapon at present in the possession of the German army is the field gun. Automatic shot guns, on account of spread of pellets, are effective when vizor is open; if further trials fulfil expectations one shot gun per machine-gun and rifle section will be issued.

The 2c.m. machine-gun mounted on a motor bicycle and organised into a mobile section of 20 to 30 bicycles per division would be very effective, in the opinion of the writer.

2. *The Training of Reserves during the War.* An article of historic interest showing how this question was tackled in Germany.

4th April.—1. *The Infantry Gun.* A battery of 6 guns per regiment is recommended, so that a section may be allotted to each battalion, but the road space occupied by the regiment will be greatly increased. The battery commander would act as artillery adviser on the regimental staff. The tactical requirements of such a gun are discussed in some detail.

2. *Age Tables for the Army.* Tables showing the number of men of various ages. The bulk of the army is between 20 and 27 years old.

18th April.—1. *Armament of Future Warfare.* The writer discusses the question of defence against air, tank and gas attack. He considers that no country can defend itself with success against these weapons, owing to the unsatisfactory development of defensive weapons.

2. *Dornier Red Cross Aeroplane.* This machine is fully described. It is stated that it has been used in recent colonial wars (not specified) with success.

J.R.K.

CORRESPONDENCE.

To The Editor, *The Royal Engineers' Journal.*

SIR,

An interesting article appeared in the March number of the *Journal* about the construction of the bridge over the Tochi at Tal, in Waziristan. The calculations for waterway and depth of foundations in this article call for some comment. They appear to be based on a method laid down in a Circular issued by the Chief Engineer Northern Command in March, 1919, which is briefly as follows:

The velocity of the stream in flood is found by Manning's formula,

$$V = \frac{1.486}{n} \times r^{\frac{2}{3}} \times s^{\frac{1}{2}}$$

in which V = the velocity, n is a constant depending on the nature of the river bed, 'r' is the hydraulic mean gradient, *i.e.*, the sectional area divided by the wetted perimeter, and 's' is the inclination of the water surface; n r and s can be found by actual observations of the river bed when there is no flood.

The 'discharge' is the product of the cross section and the velocity.

To allow for unusual floods, $\frac{1}{3}$ is added to the discharge and the corresponding cross section and hydraulic mean gradient discovered by trial. A new velocity is then calculated.

The 'afflux' caused by the piers of the bridge is found by means of a somewhat complicated formula.

The velocity under the bridge is next found from a formula

$$A_2V_2 = 1.1 \ A_1V_1$$

in which V_2 is the velocity under the bridge, A_2 the reduced area, A_1 the cross section including that due to afflux and V_1 the velocity calculated from the assumed discharge.

(It is not clear why afflux should be taken into account in considering the cross section. Owing to the increased cross section the velocity at the point of afflux must be actually less than V_1).

With the velocity so found, the probable scour is then calculated by using Kennedy's formula $V = md^{.64}$ where d is the depth at which a velocity V causes a condition of neither silting nor scouring, m being a constant depending on the nature of the bed.

If V_1 and V_2 are respectively the velocities under the bridge before and after scour and d_1 and d_2 the corresponding depths, assuming that the discharges remain the same, it can be said that

$$d_2V_2 = d_1V_1, \qquad \text{and} \qquad V_2 = md_2^{\cdot 64}$$

$$\therefore \ d_2^{\,1\cdot 64} = \frac{d_1V_1}{m}$$

d_2 is the probable depth of scour and for safety it is recommended that it be increased by 50%.

In the article referred to, Manning's formula has been wrongly stated as $V = \frac{1.486}{n} \times r \times s^{\frac{1}{2}}$, the index of $\frac{2}{3}$ to r having been omitted. This is a misprint, as the working out is correct for $r^{\frac{2}{3}}$.

In the calculations for afflux the reduction of area has been taken at 10 per cent. whereas it appears from other data to be about 13 per cent.

For calculating the depths of scour the equation at the top of page 5 should read $d_1^{\ 1 \cdot 64} = \frac{6 \times 21}{2.1}$, making d_1 about 12 feet instead of 19.

A manual has recently been brought out in India dealing with roads, namely *Military Engineer Services Handbook, Vol. III*, in which a more detailed and complete system of calculating waterway and depths of foundations is given.

This system appears in the main to be an elaboration of the Chief Engineer's Circular and the question of scour is more completely dealt with. A different formula, Merrimans', is given for calculating afflux, and in calculating the velocity under the bridge, half the afflux is considered in arriving at the sectional area.

It seems that an inherent fallacy exists at the outset in calculating the velocity and discharge, in that the data for finding the sectional area and wetted perimeter are derived from observations of the bed at 'no flood,' and that no account whatever is taken of the deepening of the river bed by scour in times of flood. In Plate IX of the *M.E.S. Handbook*, a sectional view of a pier is given showing 'original bed' and 'scoured bed,' as if no scour took place in a river bed until an obstruction was built in it. It would appear more logical if in calculating the velocity some allowance was made for the increased section of the river bed by its temporary enlargement through scour, which in the case of a well defined bed would be fairly uniform over its width.

The formula on page 45 of the *M.E.S. Handbook*, $DV_2 = D_1V_3$, corresponding more or less to that quoted from the Circular, seems to be vitiated by the fact that D is the observed depth to the bottom of the scoured bed before obstruction, but V_2 is the velocity calculated from the area in which the depth is that observed at a period of 'no flood.' In other words, D does not correspond to V_2.

The question as to whether it is admissible to restrict the waterway of a river bed is an interesting and debatable one. The *M.E.S. Handbook* lays down that it is generally inadvisable, but it can certainly be done with advantage in the case of small river beds in which the stream in flood spreads unevenly over a wide area.

Seeing that the waterway for both the bridges over the Tochi at Shinkai is about 200 feet wide, it would appear that the bridge at Tal, where the discharge is less than at Shinkai, might well have been made one span shorter without very expensive training works.

I am, Sir, your obedient Servant,

A. H. BELL, *Lt.-Col. R.E.*

31, Hertford Street,
Cambridge.

To the Editor, *The Royal Engineers' Journal.*

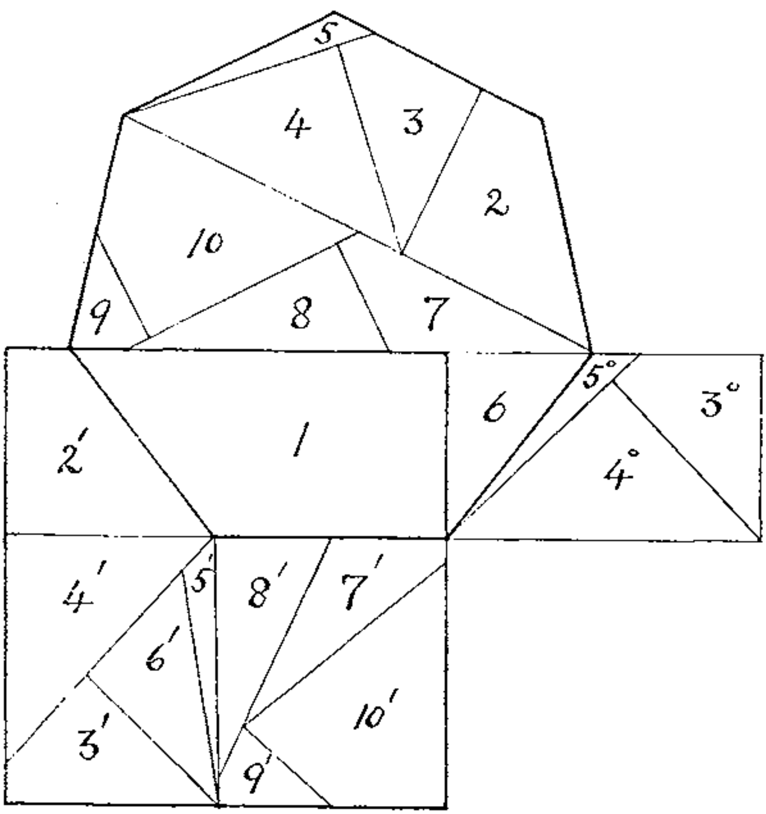
DEAR SIR,

The late Col. Arkwright, R.E., with whom I was in constant correspondence, sent to me, shortly before his death, the enclosed clever dissection of a regular heptagon into a square. He was in the front rank of those who studied the transformation of figures by dissection, and I have thought that you would like to preserve it.

Yours truly,

PERCY A. MACMAHON, *Major.*

Dissection of Heptagon.



COOPER'S HILL WAR MEMORIAL PRIZE ESSAY.

THE second of the triennial prizes presented to the Corps by the Cooper's Hill Memorial Fund is for competition during the year 1926, and the Council of the Institution of Royal Engineers has chosen the following subject :—

"The effect of mechanicalization of the Army on the organization and employment of Divisional and Corps Engineers in the Field."

Essays must reach the office of the Secretary, Institution of Royal Engineers, not later than the forenoon of the 1st September, 1926. Essays must not be signed, but each must bear a pseudonym and the name of the writer enclosed in a sealed envelope must be attached.

The Cooper's Hill Memorial Prize is a bronze medal, a parchment certificate, and a sum of money, about £20.

(*a*) *Qualifications of the Competitors.*—To be a regular officer of the Royal Engineers under the age of 35 on the 1st January of the year in which the award is made.

MONTGOMERIE PRIZE.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded by the Council of the Institution of Royal Engineers in the manner considered best for the encouragement of contributions on professional subjects, by R.E. officers, to the Corps publications. From the beginning of 1920 it was decided that the Prize should be offered to officers on the Active List not above the rank of Substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions :—

(*a*) Descriptions of works actually carried out in peace or war.
(*b*) Inventions.
(*c*) Design (excluding works of defence).
(*d*) Labour organization on work.
(*e*) Scientific investigations generally.
(*f*) Accounts of exploration work and surveys.

ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1926.

Subject selected :—"Survey on Active Service."

The Essay is to take the form of a Report and recommendations on the following points which arise in connection with the particular case outlined in paragraph 2:—

(a) As Director of Surveys, appreciate the situation from the survey point of view and state the policy and programme that you would adopt. Is it likely that more than one scale will be necessary? What projection would you employ and what steps would be taken to begin Survey operations?

(b) Do you consider the resources of the Field Survey Company adequate in personnel to undertake the programme you have outlined? If not, what additional personnel do you consider necessary? What reply would you make to the offer of the Colonial Survey given in paragraph 7? The issue of maps and photographs is to be done by you down to Brigades and Divisional Troops. What arrangements would you make?

2. The Force consists of 2 Divisions and 1 Cavalry Brigade with the normal proportion of Non-Divisional and L. of C. Units. These include 1 Field Survey Company plus Photographic Section and 1 Map Depot. All are at small war establishment. A third Division with additional non-divisional troops is to be sent out later if required.

3. The Base will be a small seaport town of about 10,000 inhabitants in a somewhat backward country. The objective will be 100 miles inland. Landing and advance will be opposed. The attitude of the civil population is uncertain. Operations are not expected to last more than six months, but are expected to include one decisive battle. The enemy is in possession of 3 Batteries of Modern Field Artillery and is plentifully supplied with modern machine guns and rifles.

4. Local topography may be divided broadly into the following zones :—

(i) The coastal part, average width about 20 miles, is heavily timbered (virgin forest) and includes large areas of mangrove swamp. Visibility poor.

(ii) The second zone, 5 miles in width, is composed of small foot-hills rising to the terrace edge of zone 3. The conditions are those of open English park land. Visibility fair.

(iii) Zone 3. Starting at a height of 3,000 feet the country rises progressively to 5,000 feet at the objective. There is little or no timber and the visibility is known to be good.

5. There is no railway and there would be considerable difficulty in constructing one across Zones 1 and 2. Roads are not numerous and are all unmetalled except the main highway to the objective. Country transport includes both carts and pack transport.

6. The Base selected and its immediate environments are fairly well mapped at the scale of 2-inches to the mile. A very bad ¼-inch map, almost blank for Zone 3, contains the only detailed topographical information.

7. The Survey Department of a neighbouring Colony has offered the services of a small volunteer geographical unit raised from its staff. The offer has been provisionally accepted and further details as to what is required have been promised.

Notes on Stores and Equipment.—1. The topographical section armed with revolvers and issued with pantaloons may be mounted if necessary.

2. The stores and equipment for trigonometrical and topographical surveying may be taken as adequate (for the numbers) for any method given in the Text Book of Topographical Surveying.

3. The printing machinery includes 1 double demy flatbed machine (500 copies per hour in one colour) and two proving presses. The camera takes double demy negatives and both helios and vandykes can be made.

Essays must reach the office of the Secretary, Institution of R.E., not later than the 30th November, 1926. Essays must not be signed, but each essay must bear a pseudonym, and the name of the writer, enclosed in a sealed envelope marked with a similar pseudonym, must be attached.

The following are the conditions of the Arthur ffolliott Garrett prize :—

1. The prize, which will take the form of a piece of plate, to be chosen by the the recipient, was instituted by Mrs. Garrett in memory of her late husband, Major Arthur ffolliott Garrett, O.B.E., R.E.

2. Qualifications of the recipient: To be an officer on the Active List of the Royal Engineers, not above the substantive rank of Captain on 1st January, 1926.

3. The essay must not exceed 6,000 words.