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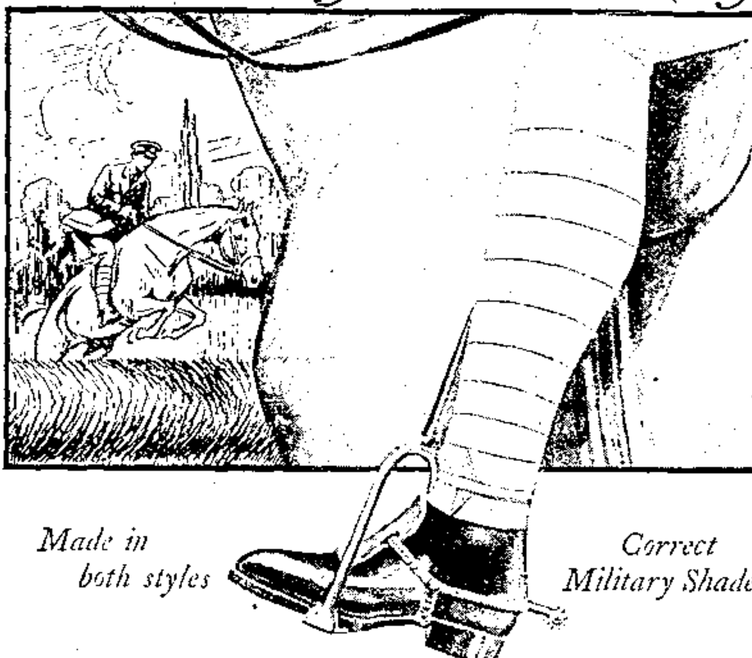

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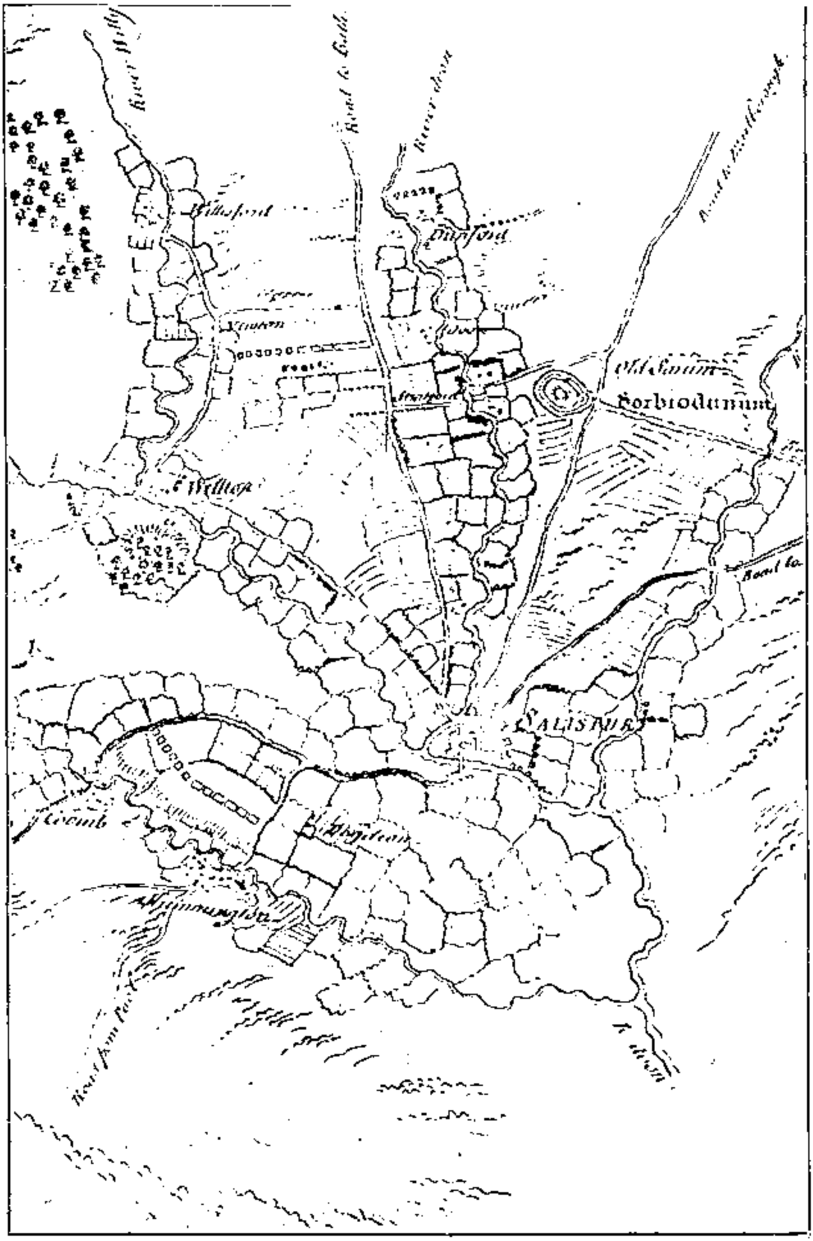
NOTES ON THE EARLY YEARS OF THE ORDNANCE SURVEY.



Portion of a Road Survey from Salisbury to Dorchester by Lieut. W. Roy.
June, 1756. Scale 1" to 1 mile.
"Reconnoitred by Colonel D. Watson, Q.M.G. of H.M. Forces."

NOTES ON THE EARLY YEARS OF THE ORDNANCE SURVEY.

WITH SOME ACCOUNT OF ITS FOUNDERS.

By COLONEL SIR CHARLES F. CLOSE, K.B.E., C.B., C.M.G., F.R.S.

INTRODUCTION.

The Sources of Information.—The period covered by these notes is the hundred years between 1746 and 1846. The Ordnance Survey did not formally exist during the whole of this period; but it is necessary, in order to show how it came into existence, to commence at the date first mentioned. The writer of these notes has been fortunate enough to be entrusted with the custody of a considerable number of letters and documents, hitherto unpublished, covering a large part of the period. The letters and documents were—in the main—collected by Major-General Thomas Colby,* F.R.S., who was Director of the Survey from 1820 to 1846. The writer is much indebted to Miss A. Colby and Miss C. Colby, the daughters of General Colby, for permission to make use of this collection, which includes some original letters written by General William Roy, who may justly be called the founder of the Survey.

Amongst other sources of information should be mentioned a book entitled *The Memoirs of the Mudge Family*, which contains an account of the life of General Mudge, F.R.S., who was Director of the Survey from 1798 to 1820. There is also a valuable addition to the literature of the subject in Mr. George Macdonald's *General William Roy and his Military Antiquities of the Romans in North Britain*, which was published by the Society of Antiquaries in 1917. And there are some old letter-books preserved in the Ordnance Survey Office at Southampton which occasionally throw some light on the early history of the Survey.

Of the sources of information that have already been used in the two little books on the Survey by Capt. H. S. Palmer (1873), and Lieut.-Colonel T. P. White (1886), it is only necessary to mention the various volumes of the *Philosophical Transactions* of the Royal Society; the *Memoir of the late Major-General Colby* by Lieut.-Colonel Portlock, F.R.S., printed in the *R.E. Professional Papers* for 1853–55–56, and the various technical publications of the Survey, ending,

* Pronounced *Cole-by*.

for this purpose, with Clarke's celebrated *Account of the Principal Triangulation*, (1858). The lives of Roy, Colby and Ramsden in the *Dictionary of National Biography* should also be mentioned.

I. ROY AND HIS TIMES.

The Forty-five.—About the middle of the eighteenth century the fortunes of this country were, for a time, in the hands of two young men—Charles Edward, the Young Pretender, grandson of James II.; and the Duke of Cumberland, son of George II. It is an old story how Charles Edward raised the standard of his father in August, 1745, how he and his troops occupied Edinburgh and Carlisle and marched as far south as Derby, were compelled to retreat, and were finally defeated by the Duke of Cumberland, at Culloden, on a misty, drizzly day in April, '46.

The Map of the Highlands.—It is not known what maps were used in this campaign by the Duke of Cumberland and his staff, but it is certain that they were very imperfect and that the Deputy Quarter-Master-General, Lieut.-General Watson, experienced the need for better ones. There were, in fact, no reliable maps available for the use of the Army, either in the operations which terminated in Culloden, or during the subsequent pacification of the country. General Watson therefore determined to make a map of the Highlands and it is from the commencement of this mapping of the Highlands, in 1747, that we should, perhaps, date the first idea of an Ordnance Survey, for the work was carried out, under the orders of the Government, by the Army. We have an authoritative account of the circumstances which gave rise to this undertaking, written by William Roy, and published in the *Philosophical Transactions* of the Royal Society for 1785. The interest of the matter may, perhaps, justify a lengthy extract. Roy says:

"The rise and progress of the rebellion which broke out in the Highlands of Scotland in 1745, and which was finally suppressed by His Royal Highness the Duke of Cumberland at the battle of Culloden in the following year, convinced Government of what infinite importance it would be to the State that a country, so very inaccessible by nature, should be thoroughly explored and laid open, by establishing military posts in its inmost recesses, and carrying roads of communication to its remotest parts. With a view to the commencement of arrangements of this sort, a body of infantry was encamped at Fort Augustus in 1747, under the command of the late Lord Blakeney, at that time a Major-General; at which camp my much-respected friend, the late Lieut.-General Watson, then Deputy Quarter-Master General in North Britain, was officially employed. This officer, being himself an Engineer, active and indefatigable, a zealous promoter of every useful undertaking, and the warm and steady friend of the industrious, first conceived the idea of making a map of the Highlands. As Assistant Quarter-Master, it fell to my lot to begin, and afterwards to have a considerable share in, the execution of that map; which being undertaken under the auspices of the Duke of Cumberland, and meant at first to be confined to the Highlands only, was nevertheless at last extended to the Lowlands; and thus made general in what related to the mainland of Scotland, the islands (excepting some lesser ones near the coast) not having been surveyed.

"Although this work, which is still in manuscript, and in an unfinished state, possessed considerable merit, and perfectly answered the purpose for which it was originally intended; yet having been carried out with instruments of the common, or even inferior kind, and the sum allowed for it being inadequate to the execution of so great a design in the best manner, it is rather to be considered as a magnificent military sketch, than a very accurate map of a country. It would, however, have been completed, and many of its imperfections no doubt remedied; but the breaking out of the war of 1755 prevented both, by furnishing service of other kind for those who had been employed upon it."

The original field sheets of this map are preserved in the King's Library in the British Museum, so far as concerns the greater part of Scotland, namely, that part which is north of the Forth and Clyde. There are a few scattered sheets south of this line. This "original protraction" covers 84 rolls of very varying sizes. The right and left edges of the sheets run roughly parallel to the magnetic north and south of the date of the work, that is, about 17° W. of true north.

The work is clearly an elaborate compass sketch; the roads and some of the streams have been paced, and the mountains have been put in roughly by eye. Near the towns the work is carefully drawn. Cultivation is indicated by open diagonal hatching. The hill-features are shown by rough, faint, brush, sepia shading or *hachuring*; the larger mountains are shown by similar, only darker, shading.

No sheet is dated and no sheet is signed. And this is a pity, because some very interesting men were employed on the work, in addition to Roy; for instance, David Dundas, afterwards Commander-in-Chief; and Paul Sandby, the artist, who was afterwards an instructor at the R.M. Academy.

The British Museum also holds the "fair protraction" of the map, on the same scale and in the same style, but complete for the whole of Scotland except the islands. These fair drawings are folded in 38 sections, numbered systematically from south to north.

The scale of the map is apparently intended to be 1,000 yards to one inch, or 1 : 36,000, a scale which was never again adopted for official maps in this country. This scale lies between the 6-inch and the 1-inch scale, and it is possible that if it had been revived we should have used it in substitution for these scales. A map on the 1,000-yards scale covers about three times the area of ground that a 6-inch map covers on a piece of paper of the same size, and shows very nearly as much detail. The map was never printed, but a reduction on a single sheet was made by Roy before the spring of 1774, when it was engraved, and ultimately published in the *Military Antiquities*. Mr. Macdonald quotes an extract from Roy's will, which is dated 13th November, 1786 :—

"I request that Colonel Dundas will take the pleasure of a most gracious Sovereign with regard to the manuscript map of Scotland remaining in my custody, he having been employed in the execution of that map." The complete large manuscript map and the rolls of the "original protraction" thus passed to the King's Library and thence to the British Museum—a very appropriate resting-place for them.

William Roy.—William Roy was born at Milton Head in Carluke parish, Lanarkshire, on the 4th May, 1726. He was educated at Carluke parish school and afterwards at Lanark. He appears to have held a minor position in the post office at Edinburgh until 1747.

In that year he states that he served as Assistant Quarter-Master under Lieut.-General Watson, then Deputy Quarter-Master-General in North Britain. He was never in the Artillery, as is sometimes stated, and it is not certain that he held any military rank in 1747. He was certainly not Assistant Quarter-Master-General in that year, as stated by Portlock.

Towards the end of the *Colby Memoir* Portlock gives a list of Roy's appointments in the Engineers. His name appears as Practitioner Engineer in the *Army List* of 1756, and he had been so appointed on the 23rd December, 1755. He received a commission in the 53rd Foot on the 4th January, 1756. He became Practitioner Engineer and Ensign of the New Corps of Engineers on May 14th, 1757; Sub-Engineer and Lieutenant, 1759; Captain in the same year; Director and Lieut.-Colonel of Engineers, 1783; Colonel, 1785. In the Army his various ranks were always senior to those he held in the Corps. Thus—he was Lieut.-Colonel in the Army in 1762, Colonel in 1777, Major-General in 1781.

He was D.A.G. in 1764-65, D.Q.M.G. in 1766 and was appointed Colonel of the 30th Foot in 1786.

We may, perhaps, agree with Mr. Macdonald, when he says that during the construction of the map of Scotland, which was in progress from 1747 to 1755, Roy was not in the Army at all; although the map was a military undertaking and Watson employed soldiers on the work. But if Roy was not formally in the Army when he was Assistant Quarter-Master, he worked with soldiers, and was closely identified with the Army, and shortly after the outbreak of the Seven Years' War, when he was not quite 30 years old, he received a commission, as stated above.

Roy was evidently recognized as a capable man, for in 1756 he was employed in making reconnaissances and plans in Great Britain; in June, 1756, for instance, we find him employed in drawing a reconnaissance map, on the 1-inch scale, of the strip of country between Salisbury and Dorchester. In 1757 he took part in the expedition against Rochefort and later was present at the battle of Minden. He was D.Q.M.G. in Germany in 1760–61; then D.Q.M.G. to the Forces in South Britain; then in 1762 D.Q.M.G. in Germany. Then came the peace of 1763.

On 31st July, 1765, Roy was appointed, by Royal Warrant, Surveyor-General of Coasts and Engineer for making and directing Military Surveys in Great Britain, in addition to his appointment as D.Q.M.G. The wording of the warrant is that he was appointed "to inspect, survey and make Reports from time to time of the state of the Coasts and Districts of the Country adjacent to the Coasts of this Kingdom and the Islands thereunto belonging"; this is addressed to the Master-General of the Ordnance, who is to pay Roy an allowance of twenty shillings a day for these duties. The payment continued until Roy's death.*

Although the "Surveys" referred to in the warrant probably implied no more than inspections and investigations, still, Roy did, as a fact, from this time until his death, except for the period of the American War, occupy himself with map-making whenever the occasion permitted, and did not cease to advocate the formal establishment of a National Survey.

The outline of his subsequent career is briefly:—In 1767 he was elected a Fellow of the Royal Society; in 1768 he visited Gibraltar and reported on the defences; in 1783 he was a member of the Committee on the defence of Chatham, and was appointed a member of the board on Fortifications presided over by the Duke of Richmond, Master-General of the Ordnance; in 1778 he read a paper before the Royal Society on *Rules for Measuring Heights with a Barometer*; in 1783 he commenced the triangulation between London and Dover, and in 1784 he undertook the measurement of the base on Hounslow Heath. He was, in 1785, awarded the Copley medal of the Royal Society for this work.

In 1787 he read a paper before that Society on *The Relative Situation of the Royal Observatories of Greenwich and Paris.* On 23rd September, 1787, he met the French Commissioners at Dover; in 1789 his health began to fail and he went to Lisbon for the winter. He died suddenly in his house in Argyll Street, London, in July, 1790, whilst he was correcting the proof sheets of his paper for the Royal Society, entitled *An Account of*

* See *General William Roy and his Military Antiquities of the Romans in North Britain.* George Macdonald Esq., C.B., F.S.A., LL.D., Oxford. Printed for the Society of Antiquaries, London.

the Trigonometrical Operations by which the Distance between the Meridians of the Royal Observatories of Greenwich and Paris has been Determined. The manuscript of his great work, *The Military Antiquities of the Romans in North Britain*, was left ready for printing. The Society of Antiquaries published this, in 1793, in a splendid folio.

Roy's Letters from the Colby Collection.—The earliest letter in this collection is dated 1771. On the 26th October, 1771, Roy, writing probably to Dr. James Lind, says:—

DEAR SIR,

I fear from the unfavourableness of the weather, or some other cause, our operations on Calton hill on Thursday last are not what they ought to have been.—I don't know whether you have already made any calculations from them. Mine were done in a very great hurry and therefore I may have committed some mistake. However, you will no doubt observe, that in the triangle comprehended between the Observatory, Arthur Seat and the Calton hill, all of whose angles were taken, the sum exceeds by some five minutes and some seconds, 180 degrees. . . . The angle taken with my Quadrant on the Calton hill, comprehended between Arthur Seat and Kirk Newtown I found to be 113° 35′ 23″ . . . if an error so great is really made there it must have arisen from some motion in the Quadrant . . . from having only one Telescope. . . .

I am just going over to Sir Wm. Erskine's in Fife. I mean to return on Monday evening and before I go south will have the pleasure of seeing you. In the meantime I am with great regard,

Dear Sir,

Your most obedt. humble servant,

W. ROY.

It is not quite certain what kind of a quadrant was used by Roy, but the fact that he used one is interesting. It will be noted that he states that the instrument had only one telescope. The writer has consulted Mr. R. T. Gunther on the subject. Mr. Gunther is a high authority on old instruments, and his book on *Early Science in Oxford* may be studied with profit by all who are interested in such matters. In Rees' *Encyclopædia* of 1789, a surveyor's quadrant is described; this consisted of a quadrantal board with fixed slot-sights along one margin, and a movable radial alidade, also with slotted sights. The instrument was fixed in the horizontal plane by a ball-and-socket joint on a tripod. There was a diagonal scale for reading by. Roy may have used such a quadrant and may have substituted a telescope for one of the slotted sights.

In the next letter which has been preserved, after some grumbling on Roy's part with regard to the negligence of the Post Office, he refers to the observations which were being carried out (1774–76) by Maskelyne, the Astronomer Royal, to determine the attraction of a mountain of known mass and from this to infer the mean density of the earth. In Maskelyne's words, there were three operations to be performed: "(1) To find by celestial observations the apparent difference of latitude between two stations, chosen on the north and south sides of the hill. (2) To find the distance between the parallels of latitude. (3) To determine the figure and dimensions of the hill." The hill selected was Schiehallien in Perthshire, now spelt Schichallion, the Gaelic form being Sith-chaillionn, *i.e.*, the Hill of the Caledonians.

Mr. Charles Hutton, F.R.S., who computed the results, obtained 5·0 as the density of the Earth, the present accepted value being 5·527. It was Hutton who first, at least in this country, invented contours. His Schiehallien calculations were published in the *Philosophical Transactions* of 1778, and he there says that he "fell upon" the method of "connecting together by a faint line all the points which were of the same relative altitude"; by so doing he "obtained a great number of irregular polygons lying within, and at some distance from each other, and bearing a considerable resemblance to each other";—not the first time that a purely scientific investigation has resulted in a valuable practical discovery.

From William Roy.

Lanark, 26th July, 1774.

DEAR SIR,

. . . Tho' I had left written directions in the Post Office at Edinburgh with respect to the forwarding of my letters, yet by the most astonishing negligence of the people there, I have only received about half my newspapers and very few letters. This appeared to me so strange that I have wrote to London to inform the Secretary of the General Post Office there of the matter. . . . I must therefore beg, My Dear Sir, that you would be so good as to release my letters in the Coffee House, indemnifying the people there. . . .

My intentions were, when I had the pleasure to see you, to return from Shihallan by the way of Edinburgh. . . . I took my leave of Maskelyne on the 15th, but I did not quit Strath Tay till the 18th, having some observations Geometrical as well as Barometrical to make on the neighbouring Mountains.

I am glad to hear that the Sector is at last adjusted. . . . The ground for the Base was so very unfavourable . . . that I advised Mr. Maskelyne to level and measure quite across it between the two stations. Ramsden's Barometers do wonderfully well, that is to say, they are uniformly consistent in their own results; though the rule for ascertaining heights by De Luc's method is defective.

In those days, and, indeed, until sixty years later, geodesists were in doubt as to what datum should be used for the measurement of heights. The conception of a sea-surface swinging up and down from a mean position had not been properly grasped. In consequence, we find Roy, in the following letter, taking "high water neap tide" as his datum surface.

In this letter, also, he writes about his barometer observations. It is remarkable how much time he devoted to this subject, which recurs again and again in his correspondence.

William Roy to Dr. Jas. Lind, Princes Street, New Town, Edinburgh.

Lanark, 5th September, 1774.

. . . I carried one of my Barometers to Glasgow on the 29th, leaving the other here. By three excellent corresponding observations, which differ from each other but a few feet, the station of my Barometer here is above the level of high water Neap Tide (which I take to be the mean height of the Sea) at Glasgow New Bridge 663½ feet. . . .

I have had another long letter from Maskelyne, who is now on the north side of the Hill (Schichallien); nothing is yet fixed with respect to the distance of his two stations. He wants my Telescopic Spirit Level, which I shall endeavour to convey to Perth for his use when I arrive in Town; or I may perhaps send it to your care this week to be forwarded there.

On the 2nd June, 1775, he writes:

There are no accounts as yet from Captain Cook, neither do I hear a single word of Mr. Banks [President of the Royal Society] going any voyage to distant parts of the world. Tho' this morning he sets sail with Lord Sandwich to see the different Dockyards, on which trip he will be absent five or six weeks. . . .

I have been engaged for some time past in making experiments on the expansion of the Mercury, which I have after much plague and trouble ascertained at last. It is progressive and arithmetical. If I can get the paper ready in time it will be given to the R.S., before the Recess; if not, I must put it off until winter.

And on the 15th June:

. . . I have now and then found a degree of superior heat at the Top of St. Paul's, compared with that in the Churchyard. The same happened at Hampstead the other day, when compared with the Temperature in the yard of my house. The smoak might occasion that at St. Paul's, I know not the reason of the last.

Do be so good as try thermometers in the Sunshine, free of reflected heat from walls, and also in the shade. Passing clouds make a very considerable difference, as I found the other day at Hampstead, the difference being 5° or 6°—tho' that in the shade continued unaltered. . . .

American affairs look muddy; we may possibly have something else to do than observe Barometers. . . .

American affairs got "muddier." Already, in fact, we were at war with the Colonies, which formally declared their independence on the 4th July, 1776. We were at war with the French in 1778, with Spain in 1779, and with Holland in 1781, in which year the American war came to an end by the surrender of Yorktown to the American and French forces.

During these years Roy appears to have been occupied with headquarter duties in London, but in exactly what capacity is not known. At the outbreak of war in 1775 he was a Lieut.-Colonel in the Army and a Captain of Engineers. He held the appointment of D.Q.M.G., and was still in receipt of his special pay as Inspector of the Coasts and the Country adjacent thereto, so perhaps it was his business to arrange for local defence schemes. On the 7th November, 1775, writing from London, he says that he is "extremely busy":—

You will be surprised that I have been so long in acknowledging the Receipt of your obliging favour of the 28th September. The truth of the matter is plainly this that, having been for some time past extremely busy, I could not find time to go to the Mitre to meet any of the R.S. to enquire about Mr. Glennie's paper. . . .

I return you many thanks for the drawings of the antient entrenchments you have been so good as say you would permit me to copy.—I will do it with a great deal of pleasure, and the originals shall be carefully returned. I have never seen any one of the pieces you mentioned. The entrenchment at Lornly (for it is not a Camp) I saw a bad plan of, no way satisfactory, perhaps yours may be better.—I had not, when last in Scotland, time to go to see the work itself. Neither have I ever been at Barry Castle, tho' I have often observed it at a distance. . . . The height of Snowden above the sea is 3,568 feet; the vertical distance of the Barometers, the lowermost being on Carnarvon Quay, was 3,555. . . .

Roy's determination of the height of Snowdon was remarkably good; the accepted modern value being 3,560 feet above mean sea-level.

His expression of thanks for "the drawings of the antient entrenchments" shows that even during this busy time in London he still retained the interest in archæology which he first showed in the early days of the map of Scotland. There are, indeed, many who think of Roy chiefly as an archæologist, and remember his name rather as the author of the *Military Antiquities* than as the founder of the Ordnance Survey. Mr. Macdonald's admirable study, already quoted, gives a very clear account of Roy's activities in this field of learning and of the writing of the *Military Antiquities* and construction of the plates, which now constitute its chief value. Mr. Macdonald shows that the manuscript copy of the book was probably presented by Roy to the King's Library before September, 1774.

The American war put an end, for a time, to all Roy's schemes for the systematic mapping of the British Isles. The few letters of this period that remain are full of the war. On the 13th January 1776, he writes:

. . . You see then how matters stand; we are no doubt to have a Body of 17,000 Foreign Troops in America next Campaign, I cannot tell whether any more medical assistance will be necessary, as it has been understood that the lesser Hospital going now out would afterwards be sent to Canada.—The great Hospital still to remain on the coast of the Atlantick. . . .

It is alleged, how truely I cannot say, that Lord S——ch is not so well at C——t as heretofore, owing to his supporting Admiral Greaves, who by all accounts, has behaved with great pusillanimity in his Command.

And on the 22nd February:

There are authentick good news just arrived in 18 days from Boston. Montgomery had assaulted Quebeck in which he with about 90 of his men were killed. Arnold is wounded and taken prisoner with about 300 more. The remainder have retreated to Montreal. We have therefore reason to hope that Quebeck will be safe for the winter, and that now the Succours will arrive in sufficient time to secure it in the spring.

Peace was not signed until 1783, and meanwhile all large survey schemes were necessarily put aside; British official surveys, were, however, about to undergo a change. We are getting to the end of compass sketches and the occasional use of quadrants. The state of mapping at home has its parallel in India. There, Major James Rennell of the Bengal Engineers, the first "Surveyor-General of the East India Company's dominions in Bengal," carried out his surveys with "compass and chain, supplemented by a Hadley's Quadrant for the determination of latitude."* Rennell's work is excellent of its kind, and is intermediate in accuracy between Watson's map of Scotland and Roy's later surveys.

Roy and Rennell.—The great surveys of the British Isles and of India have, from time to time, throughout their history, reacted favourably on each other, and it may be of interest to note the rough similarity that may be traced in the careers of Roy and Rennell. Both began their official lives outside the Army, Roy in the Post Office, Rennell in the Navy; both became Engineer Officers; both were elected Fellows of the Royal Society, and both received the Copley Medal from that Society; both Roy and Rennell felt a deep interest in history and archæology, shown in Roy's case by his *Military Antiquities of the Romans in North Britain*, a work which

* *The Journals of Major James Rennell* (1764–67). Edited by T. H. D. La Touche. Calcutta, 1910.

is still consulted for its plans, and in Rennell's case by his *Geography of Herodotus,* which a high authority pronounces as still of value; both were present at various military actions against the French; and Roy was the founder of the Ordnance Survey and Rennell of the Survey of India.

They must have known each other well. In 1779 Rennell, after returning from India, took a house in Charles Street, Cavendish Square; Roy was then permanently in London, in Argyll Street. Rennell was elected into the Royal Society in 1781, of which Society Roy had been a Fellow for fourteen years. Shortly before Roy's death he submitted to the Court of Directors of the East India Company some proposals for a trigonometrical survey of India, and Rennell supported these proposals.

The Surveys of France.—In 1783, at the end of the war, the surveys of France, both geodetic and topographic, were in a more advanced state than those of the British Isles; and, as the next impetus towards the formation of a national survey in this country came from France, we may, for a moment, glance at the state of affairs across the Channel.

In 1669–70 the Abbé Picard had carried out the first triangulation executed on the soil of France, using the method first adopted by Willebrord Snell in Holland in 1617. Picard's Triangulation consisted of a meridian chain from Paris to Amiens, and his object was to determine the dimensions of the earth. The radius of the earth so determined was used by Newton in 1682 to verify the theory of universal gravitation. Between 1683 and 1718 the two elder Cassinis, father and son, prolonged the chain to Dunkerque on the north, and southward to Collioure.*

The third Cassini, known as Cassini de Thury, with La Caille, revised the arc, which is generally known as the Meridian of France. The revision was carried out in 1739–40. This Cassini began, in 1744, the construction of a topographical map of France, based, no doubt, on triangulation where available. As it is easy to get confused with the dates of the four Cassinis, it may be noted that Cassini de Thury was born in 1714 and died in 1784.

The Surveys of Great Britain in 1783.—At the time of the Peace of 1783 there was in Great Britain no systematic triangulation, if we except the little, rough work that Roy himself had carried out in Scotland. Although the plane-table, in practically its modern form, had been known for at least two hundred years†, it appears that all the official sketches and reconnaissances were executed with the magnetic compass, and the order of accuracy was just that of a

* Revue Scientifique. Article, *La Méridienne de France*, by Colonel Perrier. 8th September, 1923.

† *Early Science in Oxford.* R. T. Günther. Vol. I., p. 372.

military compass sketch. Roy's intention to stiffen up Watson's map of Scotland, with a trigonometrical framework, had never been carried into effect. His efforts to establish a national survey department had been put aside, as a consequence, first, of the Seven Years' War, and later of the war with America. The maps of this country were due to private effort and were inferior in accuracy to those produced by Major Rennell in Bengal. Neither in geodesy nor in topography had our great-grandfathers any reason to be content with the state of affairs at home. But this state of affairs was about to be changed.

(To be continued.)

HANGAR ERECTION IN IRAQ.

By MAJOR R. HAMILTON, R.E.

IN 1921 it was decided to begin the erection of large steel hangars for the Hinaidi aerodrome near Baghdad.

Up to that time only machines of the two-seater type had normally to be accommodated, but the decision to add troop-carrying machines to the Air Force in Iraq, and to form an Aircraft Depôt there, necessitated the provision of a much bigger type of shed than had hitherto been sufficient. Between October, 1921, and the spring of 1923 the following were erected :—

3 " F " type hangars.
1 " H " type hangar.
2 " German " hangars.
2 " Baghdad " hangars.

This work, except the completion of the " Baghdad " hangars, which was done after the unit had left, fell to the lot of the Sapper and Miner Co. at Hinaidi (No. 63 Field Co., Q.V.O. Madras S. & M.), supplemented, as far as possible, by civilian labour, Indian and local. As the work was somewhat outside the ordinary run for a field company and had to be carried out with limited local resources in labour and plant, an account of it may be useful.

A brief description will first be given of the various types of hangar, followed by an account of the methods used and a few details regarding time and labour, and remarks on personnel.

I. DESCRIPTION OF HANGARS.

(*a*) *" F " Type.*

These hangars, as will be seen from the plan and section (*Figs.* 1 and 2) have a main room, 203 ft. by 103 ft. (centre to centre of columns), capable of taking six of the Vickers-Vernon machines, and a " lean-to," 203 ft. by 21 ft., behind. The central doorway is 100 ft. wide with two doorways of 50 ft. width each side ; the clear height under the door girders and inside is 28 ft., the top of the roof being 50 ft. above ground.

The four front columns ABCD support the three girders over the doorways. The roof is carried on 14 trusses, which are bolted in rear to a row of columns along EF ; in front, two trusses are bolted to the columns BC and the remainder to the vertical members of the girders AB, BC, CD.

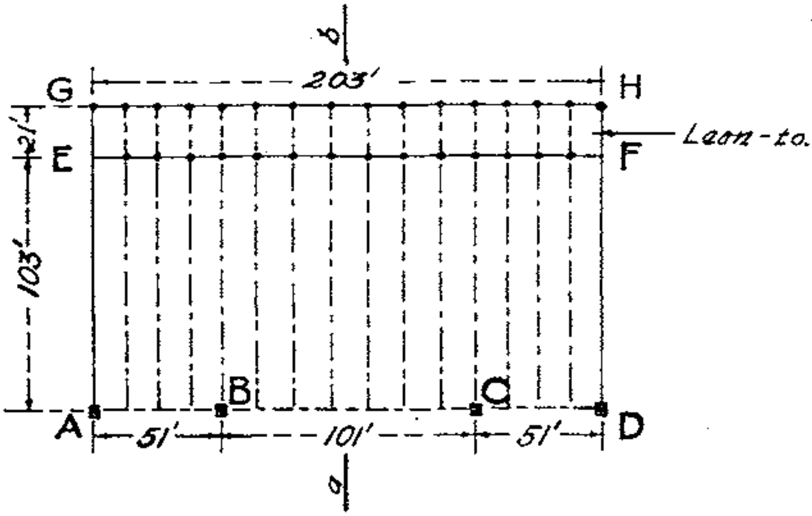


FIG. 1.—Plan of "F" Hangar.

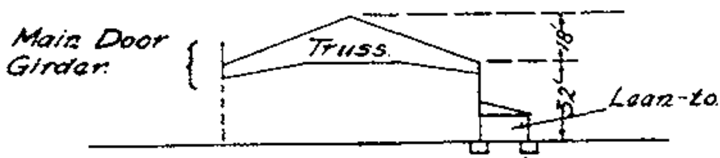


FIG. 2.—Section on *a*—*b* along a Central Truss.

Stability against wind pressure is chiefly insured by the lean-to, the columns along EF being supported from the lean-to columns along GH by the roof-trusses of the lean-to; these latter trusses and the lean-to columns are of very heavy section and the foundations of the latter are heavier than those of the main columns.

The gable ends AE, FD, are each built up of 9 columns and stiffened by a wind girder along them, 28 ft. above ground.

(*b*) *"H" Type.*

The "H" type shed is similar in area and door-space to the "F," but is of entirely different design (see *Figs.* 3 and 4). The heavy columns KLMN support two deep girders (VX, WZ in elevation) which practically carry the entire roof. A series of seven "half-trusses" project from each girder on the inside on the cantilever principle, and are joined together at their ends along the line OP. They are balanced by similar sets of half-trusses on the outer sides, which are attached to light columns along QR, ST. There is a framing of light columns along the back QS, and the lean-to is merely a lean-to and nothing more, built of quite light sections. It will be seen that by this arrangement the roof skeleton is pretty well rigid in itself, and, provided the four main columns are strong enough against bending at the points V and W, there is little overturning tendency in a wind; as a result, the columns, other than the four main ones, have little strain on them or their foundations.

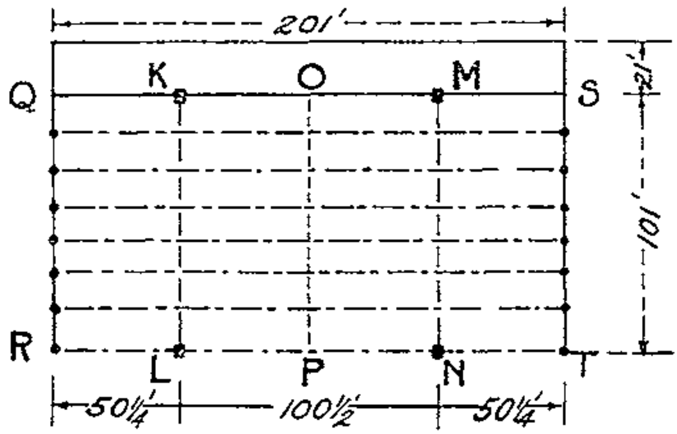


FIG. 3.—Plan of "H" Hangar.

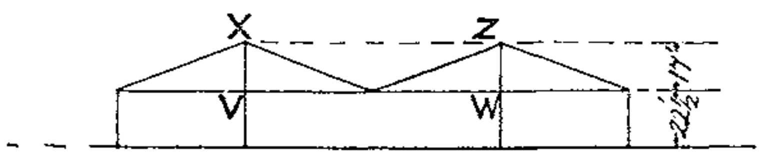


FIG. 4.—Front elevation of "H" Hangar.

"F" and "H" Types Compared.

A comparative table of some of the quantities of materials used in the "F" and "H" hangars is given below; it must be remembered that, while the areas are similar, the clear internal height in the "F" is 28 ft. as against 22½ ft. in the "H," and also that the former was designed for Trafford tiles instead of C.G.I.; the great economy of the "H" type is in the foundations, which are only a fraction of those of the "F."

	"F" Type.	*"H" Type.*
Steel in columns (including wind girders)	44½ tons	14 tons
Steel in girders and trusses ...	69 tons	59 tons
Concrete in foundations ...	345 cub. yds. plus 74 for doors	46 cub. yds.

The purlins and the intermediate framing generally on sides and roof are all steel in the "F" (70 to 80 tons), and timber in the "H," so comparison in this respect is difficult. The former, though doubtless more expensive, is much quicker to erect.

(*c*) *"German" Hangars.*

A German firm had erected a shed at Basra before the war, presumably for storage purposes. The Chief Engineer decided to acquire this and bring it up to Hinaidi to provide additional accommodation for the two-seater squadrons. This shed was a closed-in one, about 230 ft. by 98 ft. The framework of the shed consisted of a series of nine trusses, which were jointed to their supporting columns to form what were practically steel arches (see *Fig.* 5). It was put up at Hinaidi in two halves, so as to make two hangars, 115 ft. by 98 ft., with an open end to each as a doorway. This necessitated duplicating the centre arch, which was carried out in the company's field workshop. Lean-to's were added and the sheds strengthened in other ways.

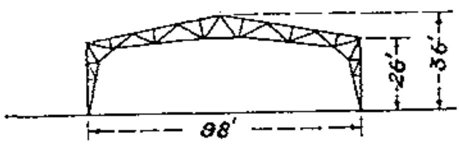


FIG. 5.—"Arch" of German Hangar.

The chief interest of this shed lies in its extraordinary economy of steel, though the shed cannot fairly be compared with the other hangars, as it was not intended for such use as the latter. To take one detail as an example, the purlins were spaced 8 ft. 3 in. apart and had a span of 23 ft. from truss to truss; yet they were only 4 in. by 2 in. "I" beams, weighing about 6 lbs. to the foot; the roof covering was only light C.G.I., yet the lightness of the purlins is remarkable, nevertheless, when compared with those, say, of the "F" hangar—spaced at 3½ ft., spanning 14½ ft., and weighing 9½ lbs. per foot.

(*d*) *"Baghdad" Hangars.*

Finally, two hangars of local design and made up, as regards columns and side-framing, in the E. and M. workshops at Baghdad, and as regards roof members in the field workshop, were erected to supplement the "F" hangars in giving accommodation for the Vickers-Vernon squadrons. Each was a simple double shed with 80-ft. trusses.

II. DESCRIPTION OF WORK.

(*a*) *Preliminary Work on Steel—Transport, Sorting and Straightening.*

When orders were received to start work on the first two "F" hangars, these sheds were represented by some 500 tons of steel

Photo 1.—Raising 100-ft. Girder ("F" Hangar).

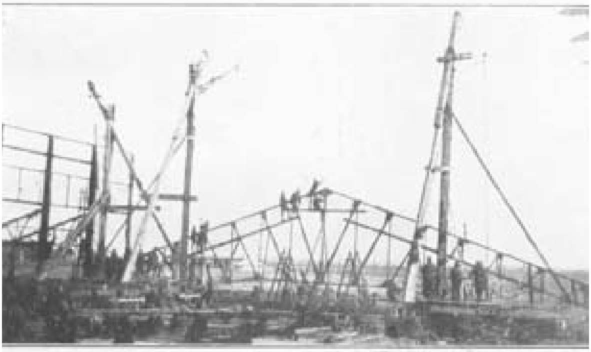


Photo 2.—First Truss ready to lift ("F" Hangar).

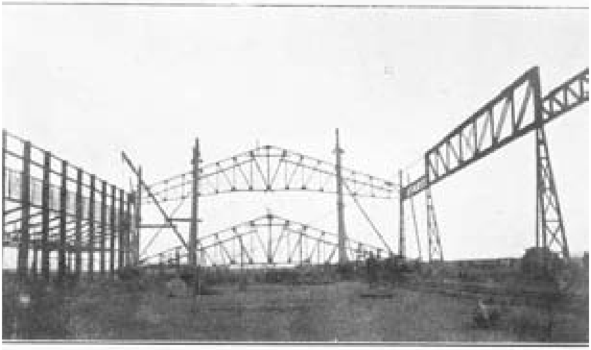


Photo 3.—Second Truss ready to lift ("F" Hangar).

HANGAR ERECTION IN IRAQ

Photo 4.—100-ft. Girder assembled and ready for erection ("F" Hangar).

oto 5.—Straightening a bent column with improvised oven.

Photo 7.—Bolting in 100-ft. Girder ("F" Hangar).

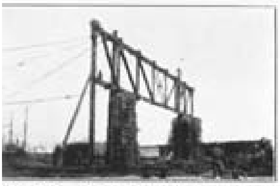


Photo 6.—100-ft. Girder in position ("H" Hangar).

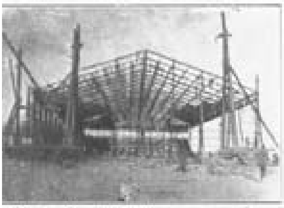


Photo 8.—"F" Hangar nearing completion.

Photo 9.—"H" Hangar nearing completion.

GIRDER PHOTO's

lying on the bank of the Tigris, where it had been previously unloaded, also by the Sapper Company, from barges. The pieces varied in size from columns 40 ft. long and weighing 2 tons, down to short lengths of angle iron apparently almost infinite in number and variety. They were most thoroughly mixed up and also, due to bad loading in ship or barge, were most of them bent, even many of the heavier columns. By no means the least problem to be faced, therefore, was the transport of the steel to the site, nearly three miles away, and getting it sorted and straightened.

The transport was done almost entirely on the Cantonment light railway. The steel was loaded either in bogey trucks or on "swivel trucks," the latter being made to take columns by mounting a U-shaped bracket, pivoted on its centre, on the frame of an ordinary tip-truck. As waiting to make up trains would have involved much delay, trucks were hauled away as soon as loaded by harnessing mules to them, from one to four, as necessary, arranged tandem fashion.

The sorting of the steel, though a very long and tedious job, calls for little comment except to emphasize the enormous value of really thorough, unmistakable, marking. The "H" hangar had been already erected once at East Fortune; it had been very thoroughly marked before dismantling and a "demolition book," giving details of the marking, was sent with it. The result was a saving of very many "men-months" as compared with the earlier hangars, in which the marking was very sketchy.

The straightening of the lighter members did not offer great difficulty, the use of a large jim-crow or heating and hammering the member on a straightening slab being usually sufficient.

The heavy columns were a much harder problem. These columns were mostly single R.S.J.'s, sometimes reinforced with flat iron plates along the flange. The principle adopted was to lay a couple of straight heavy columns on the ground on edge and the bent one on top of them on the flat, separated by packing pieces. The bent column was clamped to the lower ones by putting channel irons below the latter and above the former and connecting them with long bolts (the anchor bolts and channels for the foundations were found very suitable for this). The bent column was then drawn down by screwing up the bolt nuts till the bend had been more than taken out. On releasing it after some hours it would spring back somewhat and probably be straight. This was for mild bends. For worse ones heat was necessary. The same arrangement was used and a small oven of brick and mud, with a pipe chimney, was built round the bend in the column. The oven was then heated up and when the steel was hot enough the column was drawn down into line as before by screwing up the bolt nuts. (See *Photo* 5).

(b) Foundations.

Columns were anchored down to large concrete foundation blocks by anchor bolts and channel irons. Great accuracy in the setting of the anchor bolts was, of course, essential. The following method was found satisfactory :—

A system of pegs is laid out over the site with theodolite and steel tape, arranged so that every pit can be crossed by two lines from peg to peg at right angles; each peg has a nail driven into its head, marking the exact line. All key pegs at the end of rows are made large and set in concrete so that displaced pegs can be reset from them. Wooden templates are made for each type of foundation, with holes drilled in them for the holding-down bolts (usually four). The fixing of these will be clear from the diagrams (*Figs.* 6 and 7).

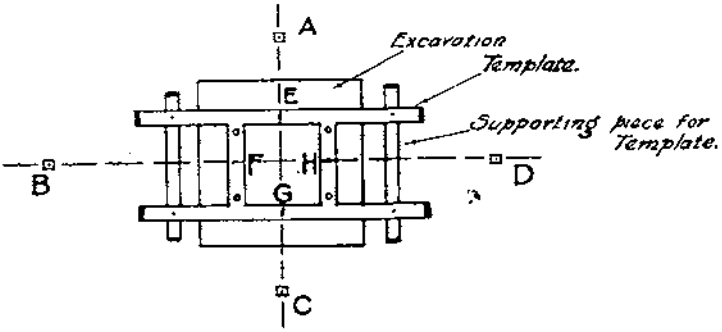


FIG. 6.—Plan of Excavation with Template.

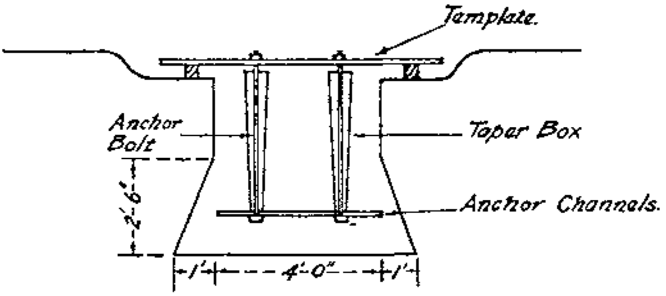


FIG. 7.—Section of Excavation, showing Anchor Bolts, Template and Taper Boxes.

All that is necessary is to get the marks EG and FH under the lines stretched between AC and BD, by means of plumb bobs. For levels, special level pegs are driven in near each pit, set from a central bench-mark. The N.C.O. who is fixing templates levels from this with a mason's level and straight edge, making minor adjustments by turning the nuts on the bolts. Templates, when ready, are checked by an officer and initialled by him.

Before columns are erected a space needs to be left round the anchor bolts to allow some play in them, and also for slight horizontal adjustment of the column if required. This is done by putting tapering wooden boxes round them, as shown in the diagram; these, of course, must be removed when the concrete has set, and to enable this to be done the boxes should be well-greased outside and should be pulled up a little after the concrete has had some hours to set. Otherwise they cannot be removed at all and burning them out is difficult.

Slight adjustment of columns in a vertical direction is allowed for by making the temporary level of the top of the foundation $\frac{3}{4}$ in. below final level and supporting the base of the column on iron wedges and packing pieces. When the whole steel frame is erected and squared, the space below the base-plate and round the anchor bolts is grouted in with a 1—1 mixture of cement and sand. When foundations are complete, nails are hammered into the concrete on the centre lines, and the base-plates of the columns, when erected, are squared with these.

The foundations for the "F" hangar being heavy (419 cub. yds. each), a large daily out-turn was necessary to get them in quickly.

The proportions of the concrete were 4—2—1. The ballast was, at first, broken brick and latterly, shingle, brought by train from the hills. Mixing was done in a mechanical mixer, the ingredients being brought on roller-ways in wooden boxes to a hoist and tipped into the hopper by two men on a platform. Water was fed in by a pipe from a main, and when a "mix" (10 cub. ft.) was ready it was run into a tip-truck and pulled by a mule to the pit where it was needed. The brickbats were broken in a crusher driven by the same engine as the mixer.

The foundations for the third hangar were considerably reduced by adopting the system of making them partly wedge-shaped. It was found that the hard, compact clay soil would easily stand at an overhang of 2/1; pits for the concrete were therefore made with vertical sides at the top and sloping outwards at the bottom, the base being made slightly bigger than that of the original foundation and the top, of course, much smaller (see *Fig.* 7). The labour of undercutting was cheap in comparison to the value of the concrete saved.

(c) *Erection of Columns.*

The only point in which this differs from raising an ordinary spar is in the necessity for letting the base-plate down from above on to its four anchor bolts. The following was found to be the easiest and quickest way:—Wooden packing pieces were placed on the concrete, thick enough to keep the base of the column above the bolts. The column was laid with the edge of its base on the packing pieces, and a small steel collapsible gyn was set up over the foundation so as to be just clear of the column when upright. The column was pulled into a vertical position from a derrick or a neighbouring column, and it was then kept upright by guys, while its base was raised clear of the packing pieces by the gyn, and lowered on to its anchor bolts when the packing pieces had been removed.

A column was plumbed by hanging a heavy metal weight on a wire from a bracket or wooden cross-piece fixed near the top of the column, the weight being steadied in a bucket of water. Distances from wire to column at top and bottom could then be measured by foot-rule and compared.

(*d*) *Erection of Girders.*

The heaviest girders to be raised were the main door girders in the "F" hangars, 100 ft. by 11 ft., weighing 10 tons, and the main girders of the "H" hangars, 100 ft. by 15½ ft., weighing 12½ tons.

Each girder was raised by two wooden derricks, extra height being obtained when necessary by mounting the derricks on cribs resting on earthen revetted platforms.

The chief lesson learnt was the necessity (if the plant used is in any way doubtful) for some safety arrangement which will both avoid disaster if anything gives way, and will also enable the weight to be taken temporarily if adjustments to derrick or tackle become necessary. In the case of the "F" hangar girders (the strength of the derrick spars not being too great) this was provided for by safety tackles from the girder columns themselves, passing through the web of the girder to the lower boom. In the case of the "H" hangar this precaution was at first omitted and the end of one girder was dropped when within an inch or two of position by the failure of a winch. After this, light timber cribs were built up under each end of the girder as it rose.

When bolting girders into their columns, and in all jointing work of this kind, constant use has to be made of drifts made from round steel bars forged to a taper. A determined and experienced man with a hammer and drift will make the corresponding holes in two members coincide sufficiently to get bolts in, when at first they show no inclination at all to do so.

(*e*) *Erection of Trusses.*

The heaviest trusses, those of the "F" hangar, were 103 ft. long by 22 ft. high, weighing 4 tons, the peak when in position being 50 ft. from the ground.

It appeared that the rapidity of erection of the "F" hangars would be largely governed by the speed with which the trusses (14 to a shed) could be put up. To enable this to be done as quickly as possible two movable gantries were made. The base of each was a platform about 23 ft. by 23 ft., consisting of a frame of 12-in.

by 12-in. timber decked in and mounted on four metre-gauge railway trolleys running on two parallel lines of rail (see *Fig.* 8 and *Photo* 2).

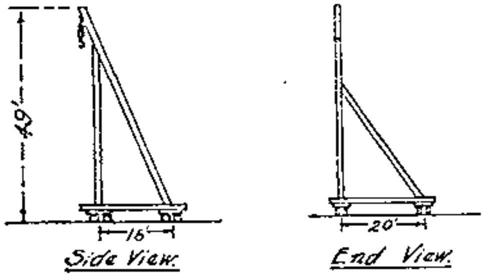


FIG. 8.—Gantry for lifting Trusses ("F" Hangar).

On this base was erected a long sloping spar resting on a vertical timber column and strutted and braced sideways to the other side of the platform to give stability. The fall of the tackle was passed round a winch on the platform. One gantry had a second arm mounted for raising the back columns, and both had light jibs for lifting the steel purlins on to the truss when the latter was up. These machines took some time to make, but were very effective, and as they were used for three hangars (42 trusses) in succession, they were probably well worth while.

In the case of the "German" and "Baghdad" hangars, where the weight of the trusses and the height to be lifted were less, two ordinary spar derricks were used; each of these had two horizontal lifting poles lashed to it some 3 ft. from the ground so that it could be lifted and moved along from one truss to the next without lowering.

A mishap that occurred to the first truss of one "F" hangar is instructive. The peak of the truss, after erection, was supported by guy ropes; after some hours one of these gave way, so that the truss fell over sideways, badly twisting the back column to which it was attached. The guy in question was of 3-in. cordage in very good condition; it was discovered, however, that on its way to its anchorage it had been bearing against the edge of a steel column; the truss had oscillated in the wind and also, probably, through coolies knocking against the guy ropes in passing, and this action of rubbing against the steel had frayed through the rope till it could no longer stand the strain. After this steel wire guys were always used.

(f) Covering of Roof and Sides.

Corrugated galvanized iron was used throughout, fixed by hook-bolts, screws or clips. Hook-bolts were used in the "F" hangars and were the most satisfactory.

As before, the problem was chiefly one of time. The sheets had their top row of holes punched on the ground and the bottom row when in position on the roof. Intermediate rows were put in at leisure after the roof was otherwise complete.

Sheets were generally raised by packing them in large wooden trays and hoisting them with a tackle by hand, or by harnessing a mule to the fall. For the German hangars the trays were made to slide up long inclined timber planks.

A shortage of hook-bolts occurred at one time, but it was found possible to turn out several hundred a day in the field workshop out of ¼-in. round iron, nuts of this size being already available from small bolts. The iron was cut to a gauged length, gripped in a wire strainer (bushed to fit the iron) in a vice, and the end held in another wire strainer and bent over; the hook-bolts were then passed to stock and die men for screw-threading.

(g) *Erection of Doors.*

This part of the work required probably more accuracy than anything else. The "F" hangar sliding doors are 28 ft. high, and weigh about 2½ tons each, but have to be capable of being moved along by one man.

The door rails had channel iron "sleepers," which were anchored into the foundation with bolts and anchor plates and the whole was embedded in concrete to rail-level. The lower portion of the foundation is concreted beforehand, but the rails and channels should not be concreted in till fully tested by running the doors over them.

The doors were generally raised by pulling them up against a column, the top outer guide being omitted.

It may be remarked that such sliding doors should always have a continuous member along each of their four sides. This was not the case with the "H" hangar doors, which had a vertical and horizontal through-joint (except at the bottom) and were never as satisfactory as those in the "F" hangars.

III. TIME AND LABOUR.

Work on the site of the "F" hangars began on October 24th, 1921, concreting began on November 14th, and steel erection on December 9th; the first hangar was ready for machines on February 15th, 1922, though doors had still to be erected and various "finishing" work done. The second hangar was finished, including doors, by April 17th, 1922.

Work on the remaining hangars was intermittent, depending largely on the supply of material. The third "F" hangar was completed in June, the "H" type in September, the German hangars in October and the "Baghdad" one was nearly complete in January, 1923, when the unit left for Mosul. Perhaps the quickest piece of work was done on the roof of the German hangars; the unloading of the barge containing the trusses (in halves) was begun on September 17th and the trusses were transported to site, assembled and erected, complete with steel purlins, by September 24th. The following table gives the approximate amount of labour in man-days employed on one "F" hangar for the different operations, excluding transport of materials to site.

	Sapper Ranks.	Unskilled Labour.	Civilian Skilled Labour.
Foundations (survey, excavation, concrete) .	570	2450	—
Preliminary work on steel (sorting, straightening, preliminary assembling)	1110	3310	1070
Final assembling and erection of steel and putting on C.G.I.	3240	5440	218
Painting and glazing	240	240	240
Floor (levelling, filling, rolling)	40	800	—
Total ...	5200	12240	1528

The above would be equivalent to an average daily strength of 50 sapper ranks, 15 civilian artificers and 117 coolies for four months (105 days) for each hangar.

The unskilled labour (Arab coolies) was generally of low efficiency.

IV. Personnel.

The organization and supervision of the work mainly fell on the Company subalterns, but two Works officers who were lent to the unit gave invaluable assistance. One, Mr. L. G. Madge, a Civil Engineer, had had experience of similar work in South America (though, as he used wistfully to remark, with much less primitive appliances). The other was Lieut. Morgan Browne, R.A.S.C., M.T., who put up and had charge of the field workshop which was established at the site of the work; Lieut. Browne, who had had a lifetime's experience in almost every quarter of the globe, showed a wonderful fertility of resource in inventing straightening and other devices as well as a remarkable faculty for getting work from people of the most diverse races and tongues.

As regards subordinates, the Indian Officers of the company developed a quite remarkable efficiency in hangar work and could, in the course of time, carry out such an operation as raising a 100 ft. truss with little supervision.

The British Sapper N.C.O.'s were of great value for the more intricate technical work such as straightening columns, the collection and assembly of complicated parts, and repairs to engines.

The work of erection was always carried out by Sapper parties diluted with Arabs, who helped to pull on ropes and lift weights but did not do overhead work, except in putting on C.G.I.

The Sappers worked with the sustained keenness that one counts on from Sappers of all colours and classes. They rapidly developed a complete indifference as to the height above ground at which they might have to work and would walk along slender steel members 40 ft. or 50 ft. up, quite unconcerned.

The unskilled labour (apart from a few Indian labourers available for the earlier months, who worked very well) was entirely Arab and was not too easy to get good work out of, especially working, as they had to, under Indians. The Indian regards the "bedou" as a complete barbarian, who requires physical violence to make him do or even understand anything. The Arab, on the other hand, regards the Indian as belonging to an inferior race, and deeply resents physical violence from him. The Arab further is inclined to regard all work as a most unpleasant, though sometimes necessary, evil, and never contemplates doing more than the actual minimum that will avert hunger. Hence much unpleasantness. In time, however, as the Arab gang leaders and the Sapper I.O.'s and N.C.O.'s became better acquainted, relations improved, especially as it was impressed on the latter that they would be judged by the way their Arabs worked, not by the amount they were hammered. Task work was always given when possible, but this was comparatively seldom.

Civilian skilled labour consisted of Indian artisans and "locals"; the latter comprised a varied assortment of Armenians, Assyrians, Jews, etc., some of whom had worked in America; they were nearly all employed in Lieut. Browne's workshop. Armenians were also sometimes found useful for putting on C.G.I. by petty contract.

Serious accidents to personnel were, happily, few. There were no deaths, except one of an Arab boy who got caught in an engine belt in the workshop. One Sapper broke his thigh by bringing down a steel door on himself when showing some civilian friends round on a Sunday. Otherwise, there were only minor mishaps.

The health of all ranks, British and Indian, was remarkably good. Working on the top of a huge steel cage, a man is fairly thoroughly exposed to the extremes of cold in winter and heat in summer, which Iraq so thoroughly provides. There was, however, practically no sickness. The mental effect of having interesting work to do probably contributed to this.

WHOLESALE DEMOLITION.

By Colonel G. C. Williams, C.M.G., D.S.O.

Until 1914 the military engineer was taught "demolitions" as part of his fieldworks course; but, as far as I know, the subject was confined to the actual technical details of calculating, making up and firing charges. It was not until the Great War that the possibilities of demolition on a grand scale became apparent.

The post-war text-books, *i.e.*, *Field Service Regulations*, the *Manual of Fieldworks*, and *Military Engineering*, Vol. IV, speak of delaying the advance of the enemy by demolitions: but my excuse for this article is that the possibilities of wholesale demolition as a defensive weapon are not generally appreciated.

In October, 1914, the 9th German Army made a deliberate withdrawal from the Vistula back to the Silesian frontier, a distance of 150 kilometres, with the object of disengaging itself from attacks by a greatly superior Russian Army. In this retreat we see for the first time the real use of demolitions on a big scale in civilized warfare. The German plan was the complete destruction of the railway system and the road communications of Poland west and south-west of Warsaw. Ludendorff, in his *War Memories* (page 87), says: "The communications in our rear were subjected to a special examination, for a retreat might only too easily be necessary. Preparations were made for the destruction of the railways, amongst other things, by placing in readiness an immense amount of explosives"; and again, on page 94: "Our first business was to delay the Russians as long as possible and keep them away from the German railways. The destruction of railways and roads had been prepared for in a very wholesale manner. Experience had taught us that a modern army cannot operate more than 120 kilometres from its railheads. If this is true and we are able to destroy the railways as thoroughly as I hoped, we could count on bringing the Russian masses to a temporary standstill, even without fighting, before they reached our frontier. . . . I had the satisfaction of seeing the enemy's advance gradually slow down, and actually come to a standstill at the very distance I have mentioned."

The Germans did not forget the value they had derived from this first attempt at wholesale destruction. For in their deliberate withdrawal to the Hindenburg line in 1917 all railways were utterly destroyed, even to the removal of rails and the cratering of embankments and cuttings: roads were rendered impassable by the blowing of mine craters 30 to 60 ft. in diameter at every cross-road, cutting and embankment; all machinery was removed or broken; there was wholesale destruction of gardens, trees, houses and every form of shelter. And the desired military result, *viz.*, respite from attack, was successfully achieved. The demolition programme was carefully worked out and co-ordinated by the Higher Command; and it took five weeks to prepare before the retreat began. It was a very fine piece of organization and, in its gruesome way, a very artistic effort.

Sir Douglas Haig speaks of it in his Dispatches in this way: "By this time (19th March) our advance had reached a stage at which the increasing difficulty of maintaining our communications made it imperative to slacken the pace of our pursuit. . . . We were advancing over a country in which all means of communication had been destroyed, against an enemy whose armies were still intact and capable of launching a vigorous offensive, should a favourable opening present itself. In such circumstances the necessity for caution was obvious."

The final retreat of the Germans in November, 1918, affords an example of the use of wholesale demolition in a forced retreat. To quote from Sir Douglas Haig's final dispatch: "At the time of the Armistice railheads were on the general line Le Cateau, Valenciennes, Lille, Courtrai; and for many miles in front of them bridges had been broken and track torn up or destroyed by mines." This meant that railhead had dropped 70 to 80 miles behind the fighting troops; and, for lack of communications, the advance of the British Armies was reduced to that of three brigades on each army front, and might, in all probability, have come to a temporary standstill in the course of the next two days.

These examples show that in both deliberate and forced retreats wholesale demolition can play an important part. The European armies of 1914–18 were checked in their advances by demolitions alone, and in one case an army was actually stopped in a distance of 80 miles by the systematic destruction of roads and railways. There is, of course, always the serious consideration of the moral effect on the civil population of carrying out wholesale demolition in one's own or a friendly country; and it no doubt may sometimes prevent the complete fulfilment of the programme of destruction, which the military situation demands. In the instances quoted the Germans were fortunate in being able to carry out their demolition entirely on enemy property.

The preparation for such wholesale destruction takes time and cannot be kept a complete secret. These are serious objections, particularly as we would always wish to keep our intentions from becoming known to the enemy and at the same time prevent the demoralizing thought of retirement from lowering our own moral. However, wholesale demolition is such an effective weapon, as the Germans proved, that ways and means should be found to include it in our armoury and to make full use of it when occasion demands

F.S.R., Vol. II, sec. 87, says: "Orders for a possible retreat should be thought out beforehand, but should not be communicated to the troops before it becomes necessary." This regulation is often read to mean that preparations for a possible retreat should be postponed until the last minute for fear of their demoralizing effect; which is, of course, wrong in view of sec. 144, which reads: "It is the duty of a commander of a force acting on the defensive to include in his plan a scheme for withdrawing his troops in the event of the enemy succeeding in capturing his position."

The scheme for withdrawal will not be complete without its demolition project: and the portions of the scheme, which take time to carry out (including some of the preparations for demolitions), must assuredly be got ready beforehand. This form of demolition is referred to in *Military Engineering*, Vol. IV, as "Deferred Demolition." Preparations for demolitions, though they cannot be completely concealed from one's own troops, need not become known to the enemy until the actual explosions take place; whereas wire, trenches and other such defensive measures are much more difficult to conceal. During the war the sight of lines of rear defences usually produced the reassuring feeling that wise precautions were being taken in case the worst should happen, and such sights never created the impression that retreat was imminent. It only remains, therefore, that troops shall be educated to the fact that no defence scheme is complete without its demolition project. Then preparations for demolitions will never be the cause for alarm or despondency, and will always be made in plenty of time.

It may be argued that with the introduction of more and more tanks, destruction of communications will not be so effective as it was in 1918, for armies will become less and less dependent on road and rail communication. This may be true to a limited extent: but still, in most theatres of war communications (roads, railways or tank-echelons) must needs follow certain lines of advance; and, besides destroying roads and railways, supplies, wells, houses and shelters, it will be possible, by well-placed mine-fields, to delay tanks also.

Having established the principle that wholesale demolition is a defensive weapon to be made full use of when occasion demands, it only remains to learn how to handle it. The success of such a project lies in co-ordinating the work of destruction with the movements of the troops using the communications, shelter, water, munitions and stores, so that their wants are adequately met, while nothing remains for the use of the pursuing enemy. Nay, even more, the enemy must also reap the benefit of delay action mines which will continue to destroy as he rebuilds.

It is by the study of the German demolition projects in their retreats of 1914–17–18, and by means of exercises and schemes in wholesale destruction worked out in peace time by Engineer commanders and by staffs that we shall learn to become proficient in this necessary form of frightfulness.

RECENT DEVELOPMENTS IN OIL-ENGINE PRACTICE.

By LIEUT. J. T. GODFREY, R.E., and LIEUT. K. W. MERRYLEES, R.E.

THE class of oil-engine generally known as the Diesel or Semi-Diesel, but better comprehended, perhaps, under the term "heavy oil-engine," has hitherto required for its running an amount of accessory apparatus which has considerably detracted from its otherwise outstanding merit. This apparatus is comprised, in the high-compression type of engine, of the air-compressor, air-bottles, and valves needed to inject the fuel into the cylinder, and in the low-compression type, of the external heating devices required to start combustion.

Of late years, the method of fuel introduction used in the latter type of engine, and known as "solid injection" has encroached more and more on to the field of the high-compression Diesel. Solid injection was evolved from the vaporizer valve used on engines burning paraffin or other light oils—for example, the Hornsby-Ackroyd. In these machines a pump driven by a quick-acting cam on the half-time shaft forced a charge of fuel through a small hole into a special partition of the cylinder (the hot bulb). Owing to the low-compression pressures then used, the hot bulb had to be heated externally for some twenty minutes before starting up, and was, by its construction, intended to remain at a somewhat higher temperature than the rest of the cylinder during work. Only by means of this excess temperature could ignition take place.

An immediate advance was made by raising the compression pressure to that at which ignition is spontaneous. This necessitated stronger construction of the engine and fuel pump and greater care in the design of the sprayer: efficient combustion depended less on the temperature of the hot bulb and more on the complete atomization of the charge.

The success achieved in these experiments led to the use of the method with still higher pressures, and engines now constructed use solid injection on compression pressures of 400 to 450 lbs. per sq. in. The method is applicable without great difficulty to the highest pressures met with in engines using the Diesel cycle: but there is a tendency among designers towards the use of lower pressures than was the case in earlier years. Solid injection is particularly advantageous in that the risk of pre-ignition is very greatly reduced, owing to the fact that there is no permanent air pressure, tending to force fuel into the cylinder at all times, as in the other system; consequently, the extremely heavy construction required in the cylinder heads of air-injection Diesel engines is rendered unnecessary in the solid injection type.

The blast-air injection type of Diesel had, since its inception, almost a monopoly in the use of crude oils. Solid injection, originally designed for paraffin, is now perfectly applicable to crude oils, even the heaviest being amenable when passed through a heater warmed by the exhaust. It can be easily adapted to burn any of the recognized liquid fuels, including vegetable oils, such as palm-oil and nut-oil, obtainable in the tropics, and it operates with great efficiency on the cheapest of them. Even tar-oil can be burnt by the use of a "pilot" fuel valve of a special dual construction which injects about 7 per cent. of oil of lower-ignition point slightly before the main charge of tar-oil, thus firing the latter. Crude alcohol, too, can be burnt by a similar type of valve, and no signs of erratic action have been noticed in engines working on this fuel. In the Ruston-Hornsby type of 'pilot' fuel valve in the smaller sizes of engine, the "lead" of the priming charge is automatic: this does away with the necessity for two separately-timed injectors.

It will be seen that the solid-injection high-compression engine eliminates the bad points of the two types of engines hitherto used. It is unnecessary either to have a messy blow-lamp applied for twenty minutes before starting, as was the case in one type, or to have the permanently running air-compressor required by the second. The fuel supply system of the former is slightly, and of the second enormously, simplified. Above all, the advantage of immediate starting from cold, a great feature of the air-blast Diesel, is retained, while the efficiency is proved to be on a par with the best ever reached, even on engines with 50 lbs. higher compression pressure, chiefly owing to the elimination of the negative work of the compressor. Another merit, from observation, appears to be that the presence, by accident, of an excess charge of fuel in the cylinder does not lead to dangerous pressures.

The details of present construction are as follows:—

The Fuel Supply (*Fig.* 1):—

The fuel (or paraffin for starting and shutting down) is fed by gravity to the heater, an iron box bolted to the exhaust pipe, and is drawn from the heater by the pump. The pump-plunger is operated by a cam on the half-time shaft, but it also may be operated, or held away from the half-time shaft cam, by a hand lever and cam (C3). The fuel is drawn in through the valve V, and delivered through V2 direct to the atomizer. A constant quantity is drawn in on each stroke of the pump, but the amount delivered to the atomizer is varied by the valve V3. This valve is held open by a lever and cam (C2), controlled by the governor. A portion of every charge is thereby returned direct to the fuel tank. The initial setting is made by the set screw S.

The "Tangye" system differs in that the valve V3 is omitted and the governing is obtained by varying the length of stroke of the pump plunger.

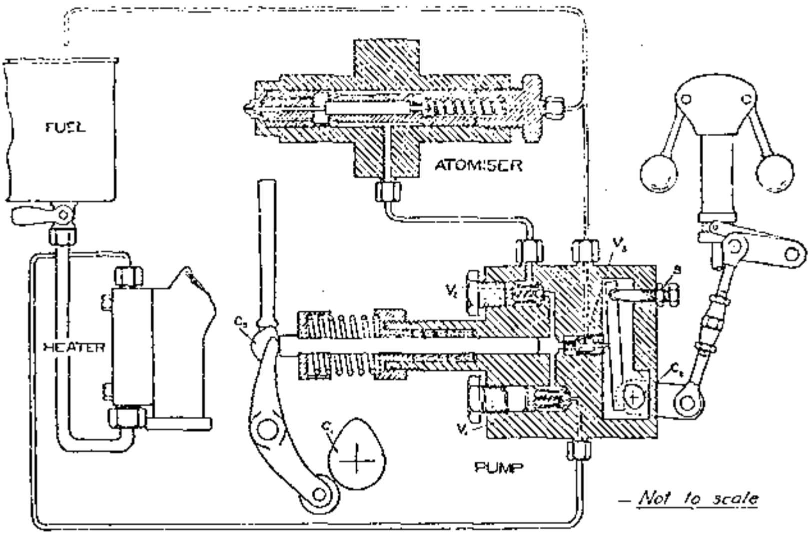


FIG. 1. Diagram of Ruston-Hornsby Solid-Injection System.

The Atomizer (*Fig.* 2) consists of a steel barrel which contains the following items:—

(*a*) *The Nozzle.*—This, in the Tangye pattern shown in *Fig.* 2, has a small round hole through which the fuel is sprayed. The Ruston pattern has a fine slit. The back of this hole is the seating for the needle valve which controls the fuel. When in position this nozzle projects into the combustion chamber of the engine.

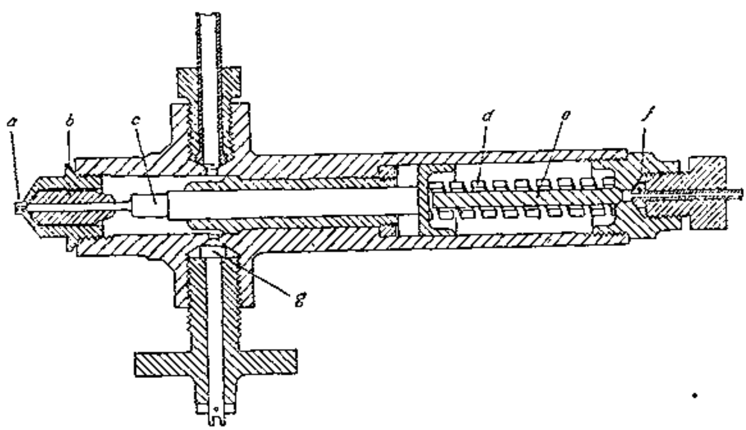


FIG. 2. Fuel Sprayer or Atomizer (Tangye).

(*b*) *The Diffuser.*—This fits close against the nozzle and helps to break up the fuel by passing it through a number of fine longitudinal slots or holes.

(*c*) *The Needle Valve and Piston.*—This is normally held forward on the seating in the nozzle by the spring (*d*), but when the pump forces a charge into the atomizer, the piston is forced back against the stop (*e*) and the charge driven past the now lifted needle valve and through the nozzle.

(*f*) This is a leakage drain for fuel forced back past the piston (*c*). The air release valve (*g*) is opened when the pump and fuel pipes are being filled before starting.

The starting operation is exceedingly simple. The smaller sizes can be swung by hand and the larger by air-blast at 200 lbs. per sq. in. until the speed is sufficient to carry the engine over compression. The air-valve is then shut, the usual half-compression cam disengaged, and the pump plunger dropped by the cam C3 (*Fig.* 1) into the running position on the cam C. The engine will then fire and can be run up to speed, changed over from paraffin to heavy oil, and put on load very quickly.

The range of sizes in which these engines are made is very wide: both the horizontal and vertical types are obtainable. These facts are best expressed in a table of data for a few of the many types:—

TABLE OF DATA.

Type.	Max. H.P.	R.P.M.	Consumption in lbs. per Hour.			Remarks.
			At Continuous Working Load.	At Max. Load.	At Half Working Load.	
Horizontal	16	300	·485	·505	·56	Engines are tested to 20% above working load. These consumption figures are guaranteed plus or minus 5%.
	52	240	·44	·455	·505	
	100	190	·43	·445	·495	
	170	170	·43	·445	·495	
	84C	250	·445	·465	·515	
	104C	240	·44	·455	·505	
	340C	170	·43	·445	·495	
						C = coupled side by side.
Vertical	Max. H.P. per cylinder. 55	300	·44	·455	·515	Made as 1-, 2-, 3-, 4-, or 6-cylinder engines.
	82	275	·43	·445	·505	
	110	250	·43	·455	·505	
	130	220	·43	·445	·505	

Max. size at present obtainable, 750 h.p. for continuous work.

The above consumptions are on fuel oil of not less than 18,000 B.Th.U. per lb., specific gravity not greater than 0·95 at 60° F. Flash point to be greater than 150° F. and less than 215° F. (closed test). The governor-controlled variations of speed are not to be greater than 4 per cent. increase from maxm. to no-load, or 3·84 per cent. decrease no-load to maxm.

Messrs. Tangye, Ltd., who confine themselves to the horizontal type, have kindly supplied figures of a test by Mr. W. A. Tookey, M.I.MECH.E., M.I.A.E., on one of their 70 B.H.P. horizontal engines, showing a consumption at 73 B.H.P. as low as ·389 lbs. per B.H.P. hr. on fuel of 18,200 B.Th.U.S. per lb. net. Their guarantee figures are naturally somewhat higher. On the other hand, as the results obtained at a well-known central power station equipped with two Ruston engines coupled to 250 kw. dynamos, the consumption on full load at 95 r.p.m. is, under working conditions, ·38 B.H.P. hr.

As regards cost, these engines are somewhat more expensive than the hot-bulb type, owing to their necessarily heavier construction, but the running charges would undoubtedly be lower. Compared with the air-blast Diesel, it is probable that their simpler construction would lead to lower maintenance charges.

The advantages for military purposes of this type of engine are self-evident and need only be summarized. There are, firstly, the general merits of high efficiency, ruggedness and long life. There is, in particular, the great gain in simplicity and ease of starting, an important point where changes in personnel are frequent, since, if necessary, only semi-skilled men can take charge. There is the inestimable advantage of an immediate start at any time, power being made available at half a minute s notice, without the necessity for installing either batteries or high-speed petrol engines of short life and a multiplicity of parts.

For small and medium-sized power-station work in military areas these engines are admirably suited in their larger sizes, owing to the reliability and ease of manipulation. It is claimed that a great freedom from cyclic irregularity is obtained, perhaps due to a more accurate control of fuel supply per stroke. Their quick-starting capacity is a great point in this type of work also, where any sudden stoppage of plant on load necessitates the immediate running up of another unit to keep up the bus-bar pressure.

Our thanks are due both to Messrs. Ruston & Hornby and Messrs. Tangye, Ltd., for the permission to make use in this article of the information acquired, and also for the great help given us at their Works.

REPORT ON THE THIRTY-FOURTH CONGRESS OF THE ROYAL SANITARY INSTITUTE, HULL, 1923.

By MAJOR E. D. CARDEN, R.E.

1. INTRODUCTION.

THE parts of the Congress dealt with in this report are those referring more particularly to engineering and the conferences of sanitary authorities.

An account of visits to the cement works of Messrs. G. & T. Earle and to those of the Humber Cement Co. is also given, and of a visit to the Beverley Road swimming baths, where water filtration is employed.

Finally, particulars of some of the exhibits at the Health Exhibition are appended.

2. GENERAL REMARKS.

To a general observer of the proceedings the attention of this 1923 Congress appears to have been particularly focussed on the following urgent problems of the day, namely :—

(*a*) The housing problem.
(*b*) Cancer.
(*c*) Smoke abatement.

With regard to (*a*), the President, in his inaugural address, stated that he regarded the provision of more houses as the greatest need of the nation to-day, and that the progress of public health was set back twenty years, and much of the effort of sanitarians nullified, by the existing state of the housing of the working people.

Whilst the great importance of personal education in hygiene for the general public was insisted on over and over again during the Congress, the President also pointed out, in his inaugural address, that it is of no use attempting to instil the principles of hygiene into people who live in the many dilapidated and insanitary dwellings which to-day exist in the slum areas of all our towns and cities.

It may here be observed that in the Army hygiene and sanitation instruction may bear full fruit, since the buildings occupied by soldiers are suitable for a study of the science of hygiene and for practice of the art of sanitation.

With regard to (*b*), Cancer, the President, in his inaugural address, stated: " The deaths from cancer have now assumed disquieting proportions. This dread disease now claims more victims annually than tuberculosis. At present it accounts for almost one-tenth of our total mortality. I much regret that the outlook in regard to cure is so pessimistic, and that no public health measures are as yet in being to grapple with the disease. I have wondered if it would not be possible for the public health authorities of our large cities and towns to provide means for the education of the public, in regard to the early signs and symptoms of cancer, and, if practicable, to give diagnosis and advice, if not treatment."

With regard to (*c*), Smoke abatement. This question is receiving Government consideration. Two papers were read on the subject, one by Professor J. B. Cohen, "The Smoke Evil," and one by Mrs. M. A. Cloudesley Brereton, "Women's Part in Smoke Abatement."

Prof. Cohen remarked that it was curious that a nuisance so obvious and widespread as coal-smoke had been tolerated with so much indifference. He thought the proper course was to have a fuel expert at the Ministry of Health, and he emphasized the fact that there are many new forms of kitchen range on the market which do much to obviate the evil, so far as domestic smoke was concerned.

Mrs. Cloudesley Brereton confined herself to dealing with how women can help in the matter. She referred to Sir Napier Shaw as the authority for the conclusion that domestic smoke is responsible for about two-thirds of the smoke nuisance. She said that we know, also, that domestic smoke is, in its composition, far more harmful than factory smoke. For coal is burned in a domestic grate at a much lower temperature than in a factory furnace, and consequently the particles that escape as soot are not so completely burned. Factory soot, consisting of practically pure carbon and ash, is hard and "comparatively" harmless; domestic soot contains a large percentage of tar and acid, and is therefore much more actively destructive.

She stated that, although raw coal is cheaper for continuous use than are the alternative fuels derived from coal, yet, when the household budget, as a whole, is considered, the use of raw coal is not cheaper. Items to be taken into consideration are: storage space for the fuel and its rental, labour in dealing with it, cleaning expenses, and, besides, damage to health and property.

3. PRESIDENTIAL ADDRESS TO THE ENGINEERS' AND SURVEYORS' CONFERENCE.

Mr. Elford, M.I.C.E., (Wandsworth) said:—

The construction and maintenance of roads had both a direct and an indirect bearing upon public health.

Road dust was a serious menace to health; the efforts of engineers in recent years had practically eliminated that nuisance. Other important services connected with the work of the Royal Sanitary Institute were water supply, sewerage and sewage disposal, the removal and disposal of domestic trade refuse, provision and laying-out of public open spaces, administration of Public Health Acts and Building Bye-laws, erection of schools and infectious disease hospitals, town-planning and housing.

Those which still presented the most difficult problems were sewage disposal, particularly the sludge, refuse disposal, and housing.

4. "Portland Cement, Its Manufacture and Uses."

By G. V. Maxted, M.I.C.E.*

The author, in his opening remarks, referred particularly to the advent of the rotary kiln and the British Standard Specification as being largely responsible for the present-day reliability of cements manufactured. By reference to a map of England he showed how the industry had grown, and how the rotary kiln had gradually superseded the older types of kiln. Portland cement was first made in this country in Yorkshire, about the year 1870, but the actual home of the industry was centred in the rivers Thames and Medway.

In 1880 the annual output was about 700,000 tons. In 1923, if all works were operating at their full capacity, the annual output would be about four million tons.

The raw materials are not now solely chalk and clay; modern grinding plant enables us to use limestone and shale. The approximate proportions of raw materials used are 3 of chalk to 1 of clay.

The stages of manufacture may be classified as follows:—

(1) Quarrying and digging raw materials; (2) crushing, grinding and mixing; (3) burning; (4) grinding the burnt clinker into finished cement; (5) storage of the finished cement and packing in sacks or casks for transport to market.

Stage 1. Quarrying and Digging Raw Materials.

As this operation can only be carried out in daylight, mechanical means must be utilized to keep pace with the remaining operations of the works.

Every ton of cement requires nearly two tons of raw materials.

Stage 2. Crushing and Grinding.

The chalk from the digger is brought in 6-ton truck-loads and tipped into a crusher, capable of taking 24 tons at a time. From the crusher, the material, now about the size of hens' eggs, passes into a

* See also Section 5.

rotary screen, pieces too large to fall through the openings in this screen passing into a supplementary crusher, where they are crushed again to the proper size ; all then pass into a common elevator which lifts the crushed material into a silo, or overhead storage bin, beneath which the grinding mills are placed. Hand labour is thus minimized and a continuous process assured.

The grinding mill used is generally a combined ball-and-tube mill, of, say, 40 ft. length by 7 ft. diameter and taking about 500 h.p. to operate. The mill is divided into two or more compartments, in the first of which, at the entrance of the rough material, large steel balls are used as the grinding media, in the other compartments smaller steel or hard cast-iron balls are made use of, and sometimes in the finishing chamber a special kind of flint pebble, about the size of large hens' eggs, is used.

In the "wet" process, that mostly used in this country, this material is ground with water, or liquid clay ; in the latter case the resultant mixture is called "slurry ;" it is of approximately the correct chemical analysis.

The slurry is thoroughly mixed in a washmill, and here the chemist analyses and alters the mixture as required. After leaving the washmills the liquid slurry receives one more and final grinding in "wet" tube mills and is then stored ready for the next process.

Stage 3. Burning.

The earliest rotary kiln dates from about 1901, when a kiln of this type was erected at Swanscombe, in Kent.

The earlier kilns did not exceed 70 ft. in length and 6 ft. in diameter, kilns to-day go up to 230 ft. in length and 10 ft. 6 in. in diameter in the burning zone, giving an output of about 1,500 tons of cement per week. The earliest rotary kiln produced about 250 tons a week. The large kilns require about 75 h.p. to operate them.

The principle of the rotary kiln is as follows :—It is placed at a slight incline, falling towards the hot or clinkering end, generally about 1 in 25.

The liquid slurry is fed, in measured quantities, into the upper end, and the kiln, slowly revolving, carries the slurry down the kiln towards the clinkering zone.

At its first entrance into the kiln, the slurry meets the outgoing gases, which are then at a temperature of about 800° to 900° Fahr., and all the moisture is driven off.

As the slurry passes down the kiln, the temperature rises, and next the CO_2, which is about 38% of the materials when dry, is driven off ; it then reaches the clinkering zone, where the temperature is about 2,800° Fahr. The material is there thoroughly and uniformly burnt, and falls out at the lower end, white-hot, into the cooler, which is placed below the kiln.

The kiln is fed with powdered coal, which is first dried and then ground to a fineness of about 5% on a 100-mesh sieve, in suitable mills, generally of the combined ball-and-cube type. Crude oil could be made use of instead of powdered coal.

In the cooler the white-hot clinker passes through large volumes of cold air (which pass through the cooler into the kiln to support combustion) and, as it issues from the cooler, which is just like the rotary kiln in construction, but much smaller, its temperature is so reduced that it can be held in the hand. The combustion air, therefore, on its passage through the cooler, robs the clinker of its heat, and its temperature is therefore materially raised before it passes into the kiln for combustion; the adjustment of the kiln temperature is a matter of great importance. The kiln operates day and night, as it would involve considerable loss to allow it to cool down.

Dust is baffled off before it can get up the chimney and into the atmosphere, but the heat in the waste gases is not made use of at present in this country, though in America it is used for raising steam. It would also be possible to use it for drying the moisture out of the slurry, prior to its entering the kiln—a proposal which holds out great possibilities of a large increase in output, and of which more is likely to be heard.

After the clinker leaves the cooler it is automatically handled either to storage bins over the grinding mills, or to stock heaps, ready for transport later to the grinding mills.

Stage 4. Grinding the Clinker into Finished Cement.

Very fine grinding is a necessity for high-quality cement. Not so long ago, a fineness of 5% residue on a 50-mesh sieve was quite usual, whereas, to-day, the British Standard Specification calls for a fineness of 14% residue on a 180-mesh sieve, or, by comparison, 5% on a 2,500 holes to the sq. in., against 14% on a 32,400 holes to the sq. in.; figuratively speaking, pea-size to flour. Most of the better cements are now offered at 5% on a 180-mesh sieve.

The grinding mills generally used are ball-and-tube mills, or combined mills, as already described.

Grinding mills are preferably placed immediately under the silos or bins into which the clinker is passed after leaving the cooler. These mills are usually run about 132 hours a week, being stopped at week-ends.

From the mills the cement is handled direct to the storage bins in suitable conveyers and elevators, without the intervention of manual labour.

Stage 5. Storage and Packing.

The general storage provision is per six week's full output. The silos are now generally constructed of ferro-concrete, they are planned as cylinders on end, each of 3,000 tons capacity, and should be arranged so that the cement can be automatically withdrawn and passed out to the packing machines.

Automatic packing appliances are now coming into general use. A vacuum or centrifugal pump process, which feeds the cement directly into the bags, from either the silo or small overhead bins, is most common. The machine automatically weighs the bags and discharges them.

In the Bates system the bags are tied before being filled, and the cement is introduced through a small orifice in the bottom corner of the bag, which orifice is automatically closed by the pressure of the cement around its lip.

5. Visits to the Cement Works of Messrs. G. T. Earle at Wilmington and the Humber Portland Cement Co.

These two up-to-date cement works were visited on separate days. They are here reported on together, points of difference being remarked. At the Earle works the chalk arrives by rail, direct to the works for crushing and grinding and mixing with water and clay to form the slurry. At the Humber works, on the other hand, the chalk is quarried by mechanical diggers on the hill, is crushed and ground at works on the spot, whence it is forced wet through a pipe-line down the hill to the main works, air-pressure being used for this purpose. At the main works it is mixed with clay, to form the slurry, in mixers, 3 chalk, 1 clay. At both works rotary kilns, about 200 ft. long, are used.

It was noticed that at Earle's works a ferro-concrete chimney 198 ft. high is used; it has an air-space and is lined with firebrick, its diameter gradually diminishing as it rises; this is achieved by cutting the casing ends as each step is made.

The chimney-top has no collar and is left ragged with the idea of diminishing draughts, which would cause eddies to impede the kiln draught.

The kilns deliver about 7 to 8 tons an hour, and are lined with three different thicknesses of firebrick to accord with the temperatures at various parts of the kiln, 4 in. at the upper end, 6 in. at the centre, and 9 in. at the lower hot end; there are steps at the change between thicknesses, but this is rather the reverse of detrimental, as it gives pauses to allow moisture to be more completely driven off.

The kilns are rotated by means of a heavy spur and pinion gear, meshing with a heavy-toothed ring encircling the kiln about its centre; the remaining supports are rollers similarly arranged.

The rotation is slow, perhaps one revolution in rather less than a minute; 75 h.p. is used.

The clinker, in the form of small pebbles, can be seen dropping out at the lower end of the kiln, and at the Humber works the cooler was well seen ; this also rotates and carries the clinker, which drops into it, to its lower end.

The heat abstracted from the clinker is used to dry the coal-dust before it is blown into the kiln.

During the grinding process, 2% of gypsum is added to slow down the setting qualities of the cement.

In both works the Bates American system of filling sacks has been adopted.

The cement is forced into the sacks by air pressure ; while filling they are hung from the arm of a balance and when the correct weight is reached the sack is automatically released, this action also cutting off the supply of cement to it.

As regards the tests applied to the cement, these are well beyond the British Standard Specification in every particular, and it is suggested that the specification may now be due for revision.

The compression tester at Earle's works is very complete, the pressure being gradually increased by electrically-driven pumps actuating on oil columns. The compression tester at the Humber works was operated by a hand-wheel, but did not register to the figure required for testing to destruction in every case.

Some tests of cement were witnessed as follows :—

Compression Tests.

28	days,	neat cement	...	34 tons on $2\frac{3}{4}$ in. cube
28	,,	3 sand, 1 cement	...	28 ,, ,, ,, ,,
28	,,	,, ,,	...	26 ,, ,, ,, ,,
7	,,	,, ,,	...	23 ,, ,, ,, ,,

Tensile Tests.

					B.S. Spec.
28	days,	neat cement	...	980 lbs. per sq. in.	[538]
28	,,	3 sand, 1 cement	...	730 ,, ,, ,,	[250]
7	,,	neat cement	...	830 ,, ,, ,,	[450]
7	,,	3 sand, 1 cement	...	600 ,, ,, ,,	[200]
7	,,	3 sand, 1 cement	...	690 ,, ,, ,,	[200]

The Le Chatelier expansion test is used ; in this test the cement is set in a short split tube, and to each side of the split a long pointer is attached to exaggerate the opening of the tube as the cement sets.

The tester is placed on a glass plate and filled with the sample to be tested ; after 24 hours it is boiled for four hours to thoroughly set it, and the pointers should then not have opened more than 10 millimetres to be up to Brit. Standard Spec. ; actually, in these cements the opening only amounts to one or two millimetres.

The Vicat setting test is also used ; in this test a sharp pointer is dropped from a height and the depth of penetration into the sample is measured. In this test also the cement proves well above standard.

As regards fineness of grinding, the residue on a 180 × 180 mesh sieve (*i.e.*, 32,000 holes per sq. in.) is 2 to 4 per cent., while the B.S.S. requirement allows as much as 14 per cent.

6. "Continuous Filtration of the Bath-Water of Swimming-Baths."

By T. Thomas (Hull.)*

The author described chiefly the Hull experience of the filtration of swimming-bath water, where, during the last ten years, three continuous filtration plants have been installed. Adoption of continuous filtration has been slow in this country, though successful plants have been in use here for twenty years. Without such a system, water must be changed every day, or every three or four days, whereas when continuous filtration and sterilization by mechanical and chemical means are used, the same water may be in use during the whole of the swimming season of six or seven months.

A Paper read in 1908 by Mr. Robert Angel described the units of the plant at Bermondsey as follows:—

1. Strainer to intercept particles likely to obstruct the pumps.
2. Two steam pumps to deliver the water to the aerator.
3. An aerator to oxygenate the water, situate on the roof of the baths.
4. A filter, provided with the means of cleansing.
5. A heat condenser, capable of raising the water from 50° to 70° Fahr.

The two most notable changes made in present-day plants are the substitution of an electrically-driven air compressor, fixed in the filtration chamber for the cascade form of aerator on the roof, and that of electrically-driven centrifugal pumps for the steam-pumps. The Beverley Road bath installation is described in this Report.

The author of the Paper gave some particulars of this very up-to-date installation. Samples of the water in the Beverley Road Baths were taken for analysis in 1922, after the water had been in continuous use for 6½ months, and after 33,000 admissions of men and youths, and showed that the water was highly satisfactory, the figures generally showing a standard of purity which is not exceeded by many supplies used for drinking purposes.

The author stated that the estimated annual saving by this method in coal and water amounted to £457 at the East Hull Baths, *less* the filtration plant expenses, £302, giving a total of £155.

* See also Section 7.

It was admitted that, in conjunction with the filtration plant, slight chlorination must be used.

The filter is the most important unit; the best filter obtainable will be the cheapest in the long run.

In the selection of the filter the following points must be considered:—

1. Filters built up of flat-ribbed cast-iron plates can be easily handled through corridors, doorways, etc.
2. Filters should be of ample area, the flow of water should not exceed 180 to 200 gallons per sq. ft. per hour of filter bed.
3. Apparatus for agitating filtering material at intervals should be provided.
4. Filters should be provided with pipes of ample area for reversing the flow of water through them for cleaning.
5. Water-gauges should be provided to indicate the level of the water during cleansing of the filters, and a mercury differential gauge to indicate the pressure. This also shows when it is necessary to cleanse the filters.

7. Visit to Beverley Road Swimming-Baths.

These baths were erected in 1905, the contract price was £25,000, the cost worked out at 7½d. a cubic foot, although the average price of such baths was then said to be 1s. a cubic foot. The area of the site is approximately 4,500 yards super, of which 3,200 yards super have been used for buildings.

The accommodation is as follows:—

Men's swimming-bath 100 ft. by 35 ft.
Boys' ,, ,, 60 ,, 40 ,,
Ladies' ,, ,, 65 ,, 34 ,,
Slipper-baths, 48, enamelled porcelain, hot and cold water.

Shower-baths for washing before entering the water are also provided.

Besides this there is a boiler-house, cycle-store, laundry, small staff room and committee room, waiting-hall and refreshment buffet, all on the ground floor. On the first floor are the manager's apartments.

A feature of these baths is that they may be used during the winter as a dancing hall, concert hall, etc. For this purpose a portable floor is placed over the water space, supported by the margins, the dressing-berths being all made collapsible. The gallery is formed of steel girders and concrete.

Floors are of mosaic; the marble mosaic has been found to be slippery to bare feet, so the gangways have been paved with Burt's vitreous mosaic, except in the boys' bath, where a special form of marble mosaic has been introduced. Lighting is electric, with gas emergency pilot lights.

Ventilation is obtained by means of Boyle's air-pump ventilators at the roofs, with suitable low-level inlets.

Heating, both of the building and the water, is by three boilers, which may be used either as steam boilers or simply as water heaters. The method of heating water for slipper-baths is peculiar. In its simplest form, the town water is supplied to a tank on the roof and passes from this tank and through the boilers direct to the baths.

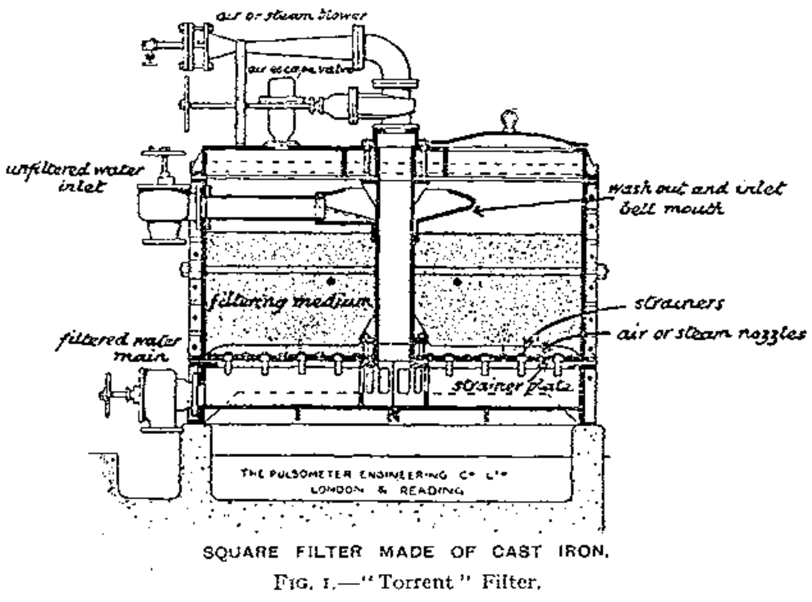
The fuel consumption is rather over half that of more modern systems.

For heating the swimming-baths when filling, two boilers first supply hot water, the third boiler then passes steam through an injector which draws water from the deep end of the bath, and returns it at the shallow end; when the bath is filled, the temperature is maintained in this way.

Continuous Filtration (see *Fig.* 1.)

The "Torrent" patent filter, supplied by the Pulsometer Engineering Co., is used. The method of filtration is the usual one, namely, that of passing the water through a certain thickness of suitable filtering medium. Three filters are used.

The excellence of the system lies in the method of cleansing the filtering medium. This must be cleansed throughout its whole thickness; even if a small portion is left undisturbed it becomes a centre of contamination.



SQUARE FILTER MADE OF CAST IRON.

FIG. 1.—"Torrent" Filter.

These particular filters are square, constructed of cast-iron plates bolted together. A strainer plate is fixed near the bottom of the filter casing, and this plate carries a layer of filtering medium, the lower two-thirds of this medium consisting of crushed granite, the upper third of Leighton Buzzard sand. The total depth is about 2 ft. The bottom of the filter casing is connected to the filtered water main.

The efficiency of the filtration does not depend so much on the thickness and nature of the filter bed as on the thin film of slimy matter which forms on the upper surface of the filtering medium. It is therefore necessary when starting the filter for the first time, or when re-starting it after cleaning, that the filtered water should be allowed to run to waste for a short time to enable the surface of the filter bed to get into condition before the water passes into the filtered water main again.

The cleansing of the filter is effected by reversing the flow; clean water is forced upwards through the filtering medium by means of an electrically-driven centrifugal pump. The process takes about 10 to 20 minutes. Occasionally the filtering medium is further cleansed by forcing steam through it from below. Special brass nozzles fixed in the strainer plate were designed for this purpose, in order that the issuing steam may not pass through the medium by the shortest path but be equally distributed throughout the whole filter. This process is kept on only for a minute or two; the reverse flow of cleansing water may be in action at the same time if required. The capacity of each filter is about 5000 gallons per hour. A certain degree of chlorination of the filtered water is carried out in addition to the filtration, and it is said that it is due to the proper combination of these systems that such successful results have been achieved.

About 3 lbs. of chloride of lime is dropped on to the water all along the side of the men's swimming-bath every evening, and on one evening a week 7 lbs. is used. About 0·5 available chlorine per million by weight is recommended.

The water is aerated as it enters the bath at the deep end by blowing air through with it.

The same water is used in the bath throughout the season. It was seen after four months' use and it then appeared to be quite a clear water.

8. Presidential Address to the Engineering and Architecture Section.

By Alderman W. C. Fenton, F.R.I.B.A., The Right Hon. The Lord Mayor of Sheffield.

The President referred to road construction by clinker-asphalt which has been found to be very satisfactory in the Sheffield district.

On sewage a point of interest was his mention of the pumping of effluent for condensation water.

The address again pointed out the necessity of personal hygiene being a necessary factor behind all public works.

The use of ferro-concrete construction for ordinary buildings, as well as for engineering structures, was much to be encouraged.

He had used ferro-concrete, combined with brick and stone, for ornamentation, and considered it an eminently sanitary form of building, having no hollow spaces for vermin, and being very weather-proof.

9. "REINFORCED CONCRETE IN MUNICIPAL ENGINEERING WORKS."

By G. W. PALETHORPE, M.C., A.M.I.C.E. (Hull.)

This paper was of considerable interest, and much of it is here reproduced, except that some descriptions of ferro-concrete works executed in Hull are omitted.

Some of the advantages of the use of reinforced concrete are as follows :—

1. Much of it is done by unskilled labour.
2. It increases in strength with age, is practically indestructible, requires no painting maintenance, and is easily repaired where damaged.
3. It is practically fireproof, one inch of concrete being sufficient to protect the steel from fire.
4. Being monolithic, it resists vibration, and is therefore useful for engine-houses, mills and factories.
5. Most of the beams and slabs may be considered as fixed or partially fixed, with consequent reduction of bending moments.
6. It is more adaptable than any other material to alteration to meet unforeseen circumstances.
7. Its cost generally compares favourably with that of brick or steel construction ; the saving in first cost may be as much as 30 per cent.
8. It possesses great possibilities for architectural treatment, though successful instances are rare.

Some of the disadvantages of reinforced concrete are :—

1. The weight of a reinforced structure is more than a steel-framed one, and so requires more expensive foundations ; on the other hand, it is considerably lighter than brick construction.
2. The time for construction is longer than for steel.
3. Owing to the time concrete requires to set, it is impossible to have a structure ready for use under a considerable period.

The following notes are given upon the construction of reinforced concrete :—

1. A good line foreman is required who will conscientiously see all details of the work carried out.
2. The steel should have an ultimate tensile strength of 28 to 33 tons per sq. in., and comply with Brit. Standard Spec. for structural steel for bridges. The steel should not be oiled, tarred, or painted, but all loose scale or rust must be removed.
3. Accurate placing of the steel is essential. Supports of beam rods from the bottom of the shielding may be by pre-cast cubes of concrete, which can remain in the work.
4. If pre-cast beams are used, the top side must be distinctly marked, to avoid the risk of putting in beams upside down.
5. Shielding must be substantially and accurately constructed.
6. Long beams should be framed with a camber of about 1/350 span.
7. Column boxes should be built up on three sides, and the fourth side should be gradually built up as the concrete is placed.
8. All shielding for beams should be held in position by means of wedges, so that any movement can be taken up.

   The sides of beam boxes should be capable of being removed from the bottom timber to allow air to get to the concrete before the beam is finally stripped.
9. Use few nails for shielding; it is the most expensive part of the work and must be used again.
10. Immediately before placing the concrete, the shielding should be carefully cleaned out, trued up and coated with soft soap, form oil, whitewash, or some other preparation to facilitate removal of the shielding.
11. The aggregate may be of almost any hard, clean material, such as granite, shingle, stone, gravel, or broken brick, but for reinforced work granite or shingle are the best.

    Concrete should always be proportioned so that the sand and cement are respectively in excess of the voids in the aggregate and sand. The percentage of voids in the aggregate is usually about 40 to 50, in sand about 35; 4-2-1 concrete will generally give the best mixture.

    The aggregate should vary in size from ¼ in. to ¾ in., and the sand up to ¼ in., and 75 per cent. of the sand should pass through ⅛-in. square mesh.
12. The amount of water used is of great importance; the mixture should quake slightly when rammed. The wet mixture will only yield about two-thirds of the combined volumes of the dry materials.
13. The cement should be slow setting, B.S. Specification.

14. The concrete must be well mixed; if possible, use a mixing machine; it must be laid quickly in small quantities and be well rammed round all rods.
15. Each section of concreting should, as far as possible, be done in one operation.

    When work is resumed upon any concrete that has set, the face should be roughened, washed clean, and covered with a layer of cement mortar. The new concrete should then be rammed against the old as hard as possible without injuring it.
16. Care must be taken to avoid disturbing the set of the concrete; no load, such as walking over it or laying planks on it, should be allowed.
17. Reinforcement rods must not be moved in ramming. New concrete must not be laid in the vicinity of vibrating steel-work, which might affect the setting.

    Concrete must be kept moist and covered up in hot weather, and be protected from frost in cold weather.
18. The time for stripping the shielding must be left to those in charge of the work; it varies from 14 to 82 days.
19. Patent water-proofing compounds may cause a loss of strength, 5 per cent. of hydrated lime added to the weight of cement is recommended by some authorities as quite effective.

10. "SOME MODERN MATERIALS AND METHODS OF CONSTRUCTION FOR USE IN BUILDINGS."

By H. D. SEARLES-WOOD, F.R.I.B.A.

A large part of this paper dealt with the use recommended by the author of sand-lime bricks.

These bricks consist of sand and hydrated lime mechanically pressed together and combined under the action of steam pressure. The general size of the bricks is the R.I.B.A. standard—not more than 9 in. $\times 4\frac{3}{8}$ in. $\times 2\frac{11}{16}$ in., and not less than $8\frac{7}{8}$ in. $\times 4\frac{5}{16}$ in. $\times 2\frac{5}{8}$ in.

The fineness of sand used is that which shall all pass a 2,500 mesh per sq. in. sieve and about 85 per cent. retained on a sieve having 10,000 holes per sq. in.

The most suitable lime is a high calcium lime, containing 90 to 95 per cent. calcium oxide, and not more than 0·5 per cent. of magnesium oxide.

The average crushing strength of the bricks when dry shall be not less than the following:—

Engineering bricks	2800 lbs. per sq. in.
Bricks for external work	2000 „ „ „
Bricks for internal work	1000 „ „ „

Hollocrete floors, which are made of pre-cast reinforced concrete beams, formed around a perforated metal hollow core, which is left permanently embedded, were much recommended by the author.

Another interesting construction dealt with in the paper was the Stanton-Hume cast-iron and concrete pipe made by centrifugal action.

A water-jacketted cast-iron mould, lying on a slightly inclined bed, is revolved at a high speed.

Into this mould is discharged the exact quantity of molten metal for one pipe.

A small core is used in the lower end to form the socket.

The iron rapidly solidifies and the pipe is almost immediately drawn out of the mould from the socket end and passed into an annealing furnace.

After passing out of the annealing chamber, the sand core of the socket is removed and the pipes are then tested up to 600 lbs. each. The thickness of the pipe for similar pressure is about 25 per cent. less than would be the case in ordinary vertically cast pipes. The metal produced in this way is extraordinarily dense, its tensile strength varies between 18 to 20 tons per sq. in. After test, a wrought-iron band is shrunk on to the spigot-end to form a bead.

The lining of the pipes with cement mortar, 2 sand to 1 cement, is also done by means of the centrifugal process; after which they are placed in a steam-bath to allow the cement to rapidly harden.

Reinforced concrete pipes are manufactured by the same method. A thin sheet-iron mould is built up, inside which a spiral reinforcement is fixed. These pipes are tested up to 150 lbs. per sq. in. The centrifugal method drives off the water, which prevents later porosity due to water evaporation. The pipes are seasoned for four weeks. A further advantage of the Stanton-Hume pipe is the smooth internal surface produced.

Tests of these concrete pipes have shown them to be capable of withstanding a much greater breaking load than stoneware pipes, something of the order of a 5 to 3 ratio.

The new regulations as to the use of white-lead paint were cited, the most important being that which prohibits dry rubbing down.

The connections and joints of concrete pipes are the great obstacle to their more general use.

Lining iron pipes with concrete was much recommended as an excellent preservative. The use of the correct amount of water in concrete was again urged, an excess of 10 per cent. was said to weaken the concrete as much as 50 per cent.

11. "THE HYGIENIC ASPECT OF ELECTRICITY IN THE HOME."

By Lieut.-Colonel W. A. VIGNOLES, D.S.O., M.I.E.E. [Grimsby].

The author, while referring to the general uses of electricity in the house, and the fact that as an illuminant electric light was pre-eminent, said that, owing to the absence of dirt with this illuminant, the paint and other decorations could be of a lighter colour.

Also that rooms could be lower, with a consequent increase of floor space, if the cubic contents were to remain the same. The lightening of the domestic burden effected by using electricity for ironing and washing was dwelt on.

The domestic vacuum-cleaner was instanced as being the only reasonable system for removing dust from the house; sweeping only stirs up more dust.

The author pointed out that, though electric heating was costly, it must be remembered that the whole of the heat is utilized, no flue being necessary.

He advocated, in a small house, the use of one coal fire, which can be arranged so as to provide the necessary hot water during the winter months, and then to use electricity for the occasional heating required in other rooms, and for providing hot water during summer-time.

The necessity for radiant heat and not only temperature rise was pointed out; electric radiators can supply this want.

Great advances have been made in electric cookers; it is now possible to hire out cookers at rentals of about 10s. a quarter, and, with electricity at a price of 1½d. a unit downwards, electric cooking becomes a serious practical proposition.

It is generally considered that for a household of four, 28 to 30 units of electricity per week would be consumed, if all the cooking were done electrically. At 1¼d. a unit, this would work out at 3s. 1½d. a week.

Houses designed for electric cooking require no flues, a saving in construction.

The actual operation of cooking, whether grilling or roasting, is better done by electricity than by other means. As the temperature can be scientifically regulated as each stage of cooking is reached, this leads to less loss of weight in the meat.

12. "HOT WATER SUPPLY AND SLUDGE DISPOSAL."

By A. J. MARTIN, M.I.C.E., F.G.S.

The author outlined methods by which the calorific value of sludge could be utilized for heating water.

The disposal of the sludge being the chief difficulty in sewage disposal, and the supply of hot water to scattered houses being another difficult and expensive problem, it is proposed to utilize the former to supply the latter want. Samples of Birmingham sludge, dried at 212° Fahr., gave calorific values of 4,120 and 4,893 B.Th.U. per lb. respectively, or one-third that of coal.

Frankfurt sludge, air-dried to 10 per cent. of moisture, gave an effective calorific value of 4,500 B.Th.U. per lb.

Sludge was used in Lancashire boilers at Birmingham during recent coal strikes. It was found, generally speaking, that 1 lb. of sludge would raise 1 lb. of steam.

Sludge has also been used for production of gas for lighting and for gas-engines.

At Chorley it was carbonized in retorts for producing gas for lighting, 7000 cub. ft. of 20 c.p. gas was the yield per ton of sludge.

Gas may also be produced by the spontaneous decompositions of the sludge by the agency of anærobic bacteria, as at Matunga (near Bombay), where it is used for lighting and cooking.

The composition of the gases from sludge varies very much, but generally they are composed of methane about 65%, carbonic acid about 31%, a little nitrogen and practically no oxygen or hydrogen.

The gas from septic tanks is not liberated continuously, it breaks away from the sludge at intervals, so that tests of yield over short periods are of little value.

At Manchester, the yield obtained was 1 cub. ft. of gas per 100 gallons of sewage, or 0·61 cub. ft. per head per day.

The yield at Exeter was estimated at 1 cub. ft. per head per day.

The digestion of the sludge for gas generation is best done in independent tanks, as at Birmingham and other places, and not in the septic tanks themselves; the evolution of gas is not conducive to a clear effluent. The calorific value of the gas from sludge is estimated generally at 650 to 700 B.Th.U. per cub. ft.

The Gas Light and Coke Co. of London is selling gas of 500 B.Th.U. at 9·2d. per therm, or 3s. 10d. per 1000 cub. ft., so that the value of this sludge gas is considerable for the population of a town.

Passing on to the question of supply of hot water to houses by means of this fuel, the author recommended piping the gas to each house, or possibly to a centrally situated block of baths and wash-houses.

Considering the question as to whether an adequate hot water supply could be provided by means of this sludge gas, the author quoted Dr. Herzfeld as having estimated that the average daily consumption of hot water by a family of five, with the usual number of servants in a house rented at £140 per annum, was 80 gallons at a temperature of 140° Fahr., the cold water being supplied at an average temperature of 54° Fahr., say, 10 gallons per head per day. Geyser efficiency was taken as 75%. Taking these figures as a basis, a household of five would need 88 cub. ft. of gas; and 50,000 cub. ft. of gas, produced each day by the sludge of 50,000 people, would heat the water for 570 houses.

It was pointed out by the author that the gas is highly explosive, so that there may be an element of risk in its use, but means could be devised for its safe use.

13. "PERCOLATION IN CHALK."

By G. F. CARTER, M.I.C.E. (Croydon).

This Paper contained useful information on the London chalk basin and contained tables showing the rainfall, evaporation, and chalk percolation as taken by Baldwin Latham's gauges.

The Tables covered the years 1918 to 1922 month by month.

A remarkable figure occurs for July 1920, when the rainfall was 4·84 inches, the highest shown for any month in the Tables, the evaportion was 2·25 inches, whilst the percolation was zero.

For eight consecutive months in 1921, the percolation was zero, but the rainfall was then ranging from 0·17 to 1·99 inches only.

14. "DUST LAYING BY AN EMULSION OF OIL AND BITUMEN."

By Major-General Sir GEORGE K. SCOTT-MONCRIEFF, K.C.B., K.C.M.G., C.I.E., HON. M.I.C.E.

This Paper, in addition to the laying of dust on roads, dealt with the treatment of dust in mines, the successful laying of which would, the author pointed out, alleviate to a great extent the hard lot of the miner's life.

Much of a satisfactory nature has been done already towards this end, and further experiments are now under preparation, aiming at the prevention of explosions, together with their transmission by dust.

Dust, usually created by some of the processes of civilized life, is characterized by want of cohesion between the particles, and increased area of surface tension.

It is in some cases of a combustible character and a fruitful cause of explosion in mines, etc., and also a danger to health.

The remedy usually adopted of treating the dust with water is unsatisfactory because of rapid evaporation, and in mines this remedy is not always permissible because of the condition of the natural strata.

The ideal liquid in mines is one which contains a small quantity of solvent and has a low surface tension.

For work on roads a binding element is necessary to provide cohesion in the dust, and this binding element is found in bitumen, which is capable of being melted into a liquid form, and under certain mechanical treatment can combine with oil to form an emulsion.

Thus, there are three elements involved in the emulsion, *i.e.*, water to act as a conveyer, oil to act as a lubricator, and transmitter of interfacial energy, and bitumen as a binding element.

An emulsion sufficiently stable to be transmitted from the place of manufacture to the place of application, and then locally diluted with water, has been found effective; the proportions at present used are 50% water, 15% bitumen, 35% oil.

In municipalities the use of the emulsion has been found to result in great saving of water for keeping down dust in streets, and on country roads the emulsion, mixed with 9 or 10 times its volume of water and sprinkled by a water-cart in the ordinary way, has been found remarkably effective.

The further application of the principle to factories, shops, refuse heaps and so on, has not yet been extensively tried, but there is little doubt that it will be found to be as efficacious as in the case of roads and mines.

15. "Pure Water Supplies."

Lecture by Sir Alexander Houston, K.B.E., C.V.O., M.B., D.SC.

This lecture dealt firstly with the general water supplies of England:—

The cities and towns of Lancashire and Yorkshire, drawing their supplies from upland and moorland sources.

The deep-well and spring supplies of other places such as Sunderland, Scarborough, Hull, Lincoln, Cambridge, Canterbury, Hastings, Bristol, Lancaster and many others.

The purified water supplies of such places as Reading, Gloucester, Cheltenham, Plymouth, Exeter, Worcester, Northampton, Bedford, Chester and York. The London water supply was dealt with separately.

The author said that England has every reason to be proud of the quality of water supplied to her consumers. He said that we stand as pioneers in all matters that really count in the matter of water purification, for example:—

(*a*) Slow sand filtration.
(*b*) Storage.
(*c*) Lime softening and purification.
(*d*) Excess lime sterilization.
(*e*) Chlorination.

Of the London daily water supply of 250 million gallons, about 60% is derived from the river Thames, 20% from the river Lea and 20% from deep wells. It is interesting to note that the total volume of well-water is not all supplied direct to consumers; over a quarter of it is pumped into the river Lea or New River, mixed with the river water and subsequently filtered. The method of treating the well-water from the Deptford (Twins) Well, which fell off considerably in quality during the drought of 1921, is as follows:—

Briefly stated, the process is one of adding considerably more chlorine to the water than is actually needed for sterilization purposes and then removing the excess of chlorine by means of a solution of sulphurous acid gas. In this way all taste troubles have been eliminated, and there can be no doubt that super-chlorination and de-chlorination methods, although about doubling the cost of the treatment, entirely remove the possibility of taste.

A reason, not known to all, for the immense power of recuperation of purity of the river Thames, was explained in that there are really two Thames rivers, the surface one and an underground one of vastly greater volume which contributes all the way down to the replenishment of the former, with exceptionally pure water, being automatically filtered in the process.

The New River supply was explained as an interesting example of a chlorination difficulty successfully overcome. This river is really part of the water of the Upper Lea diverted along an artificial channel nearly 30 miles in length.

Chlorination was tried, but although successful from a bacteriological point of view, the most serious taste troubles were experienced. At times the New River is intensely susceptible to chlorine taste troubles ; the filter beds tend to absorb the taste-imparting materials, to store them up for a certain period, and then allow them to escape into the filtered water.

After much anxious thought the problem was finally solved by skilfully adapting the dose to the current quality of the river water and the supplemental use occasionally of permanganate of potassium (a great taste preventer or remover).

One other trouble that occurs is growths in the spring which might lead to filtration trouble, though harmless otherwise. Considerable success has been achieved by treating the reservoir water with such algicidal agents as chlorine or copper sulphate, a quite harmless procedure if carried out under suitable supervision. Rapid filters have the power of holding back these growths and are worthy of extended trial. They are now being tested on a practical scale at the Barn Elms, West Middlesex Works.

The river Lea supply is purified by storage and slow sand filtration.

The author enlarged on the value of storage as a means of purification. He said it was Nature's own method of purification. In the first place, most of the solid impurities in the river water are settled out (sedimentation) ; secondly, any sudden chance pollutions of a dangerous character are enormously diluted (equalization) ; and finally, any pathogenic bacteria present gradually lose their vitality and die during the passage of the water through these enormous reservoirs (devitalization).

Speaking of the Thames chlorination treatment, the author said that so long as the cost of chlorine for sterilization falls far short of the cost of coal for pumping, it is likely to be continued indefinitely.

There is little doubt that Thames water is more easily treated by chlorination than New River water.

The dose of chlorine is very small, on the average appreciably less than 1 in 2 millions, yet it has a power of improving the water bacteriologically about a thousand times. The Thames and New River chlorination problems are diametrically opposed in principle. In the latter case, the results are so good during the three-quarters of a year that no treatment is necessary, and chlorination is only practised during the flood months of the year.

As regards the Thames, it is a case of saving pumping charges during dry weather by means of chlorination and reverting to the use of adequately stored water when the Thames is in high flood.

It was noticed in the lantern slides shown that the Paterson Chloronome (see Section 17) is used.

EXHIBITS AT THE HEALTH EXHIBITION.

16. Sack Disinfector.

(Meldrums, Ltd., Timperley, Manchester.)

This apparatus consists of a suspended inverted sack, 2 ft. in diameter by $4\frac{1}{4}$ ft. long, into the top of which steam is introduced through a flexible tubing from a boot boiler heated by a pressure oil lamp or other means. The weight of the complete apparatus is 125 lbs. The steam descends through clothing hung up in the sack expelling equivalent air from its mouth.

The latent heat makes the articles so intensely hot that they dry immediately on removal from the sack.

After steam begins to emerge from the sack mouth, continuance of steaming for :

(*a*) One minute kills all non-spored pathogenic organisms, vermin and eggs.

(*b*) Five and a half minutes destroys anthrax spores, even if enclosed in plugged test-tubes embedded at the centre of a drum of textiles.

The capacity is :—

150 lbs. of textiles in $\frac{1}{4}$ hour.

(*a*) *Close-packed Charge.*—120 single blankets in one hour.

(*b*) *Suspended Charge.*—6 suits of clothes in five minutes.

Fuel consumption is 6 pints of oil an hour or 9 lbs. of coal an hour.

It is estimated that one set per 1000 soldiers is sufficient for disinfection of bedding and clothing.

The complete set can be carried on a push bicycle.

Remarks.

The American Army has adopted the use of this apparatus. The system seems to be simple, effective and presumably economical where large-scale plant is not available.

17. Water Disinfection. "Paterson Chloronome."

(Paterson Engineering Co., Kingsway, W.C.2.)

The chloronome is a device for regulating, measuring and administering chlorine gas to water supplies for their sterilization. The direct use of the gaseous chlorine in place of the usual hypochlorite of lime has many advantages. Hypochlorite is an unstable reagent, of which only 33⅓ per cent. of chlorine is available under the best conditions, which vary according to climate, and the preparation of pastes and solutions is laborious; whereas, when the gas is applied direct, the quantity administered can be adjusted with scientific accuracy.

The chloronome consists essentially of means for conducting the gas from the cylinders, in which it is stored under pressure as liquid chlorine, to the water to be treated. The gas pressure has to be reduced in the process to a constant low pressure, and an exact measurement of the gas passing has to be made.

There are two types of chloronome, the Pulser type and the Manometer type. *Fig.* 2 shows the Pulser type. This is capable of administering 10 lbs. of chlorine per day and sterilizing a maximum of one to three million gallons of water daily. The cylinders of liquid chlorine hold about 70 lbs. each, the pressure at 32° Fahr. being 54 lbs. per sq. in., and at 120° Fahr., 215 lbs. per sq. in. The chlorine passes into the gaseous form on evaporation by the heat abstracted from the atmosphere through the walls of the cylinders.

The gas is first led to a filter, which removes any slight deposit which may be carried by the gas from the exposed coil tubes or the cylinder fittings. After this, two pressure-reducing valves are arranged in series. The gas, at a pressure varying from 80 to 120 lbs. per sq. in., passes through the first reducing-valve, which breaks down the pressure to 20 lbs. per sq. in., then through the second reducing-valve which maintains a constant pressure of 10 lbs. per sq. in. on the regulating valve.

The chlorine gas then passes the regulating valve and flows from the meter (detailed reference to which is made later) through a central pipe down to nearly the bottom of the absorption tower.

This glazed earthenware tower is fitted at the top with a water-distributing tray, and packed with pumice.

A small trickle of water is uniformly distributed over the pumice, and in its downward flow absorbs the measured quantity of chlorine gas.

The chlorinated water flows from the bottom of the tower through a chlorine-resisting rubber or earthenware pipe, and is uniformly distributed through the main body of the water to be disinfected. Many water supplies can be chlorinated by the addition of a quarter part per million, *i.e.*, 2·5 lbs. of chlorine gas per million gallons of water purified, so that an installation purifying 1,000,000 gallons per day may only require to administer 1·66 oz. of chlorine per hour. A positive volumetric measurement of gas administered is therefore

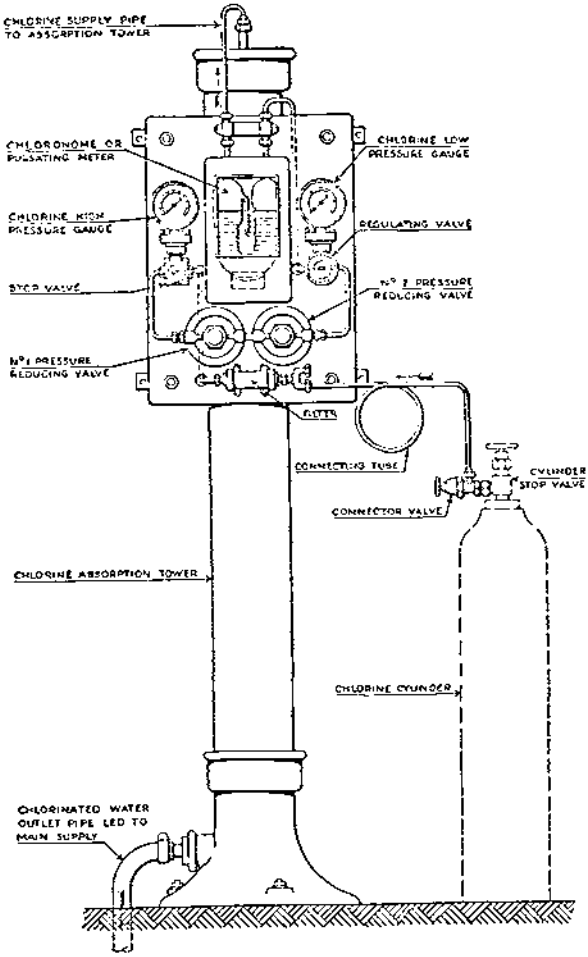


FIG. 2.

desirable. The chloronome pulsing meter consists, essentially, of a U-shaped tube, with a connecting branch between the two limbs (see *Fig.* 3).

The U tube contains sulphuric acid, which acts as an inert seal between the dry chlorine gas in the instrument and the absorbing water supply.

The flow of gas into the inlet limb depresses the column of sulphuric acid until it unseals the small vent pipe, so permitting the passage of the measured quantity of gas from the inlet to the outlet limb; this establishes equilibrium and allows the return of the column of sulphuric acid until it again seals the vent pipe, when a cycle of movement is completed and another downward stroke commences. The rate of pulsation and known volume of the stroke gives the weight of chlorine added.

For deliveries exceeding 10 lbs. of chlorine per day, the Manometer type of apparatus is recommended. In this type, the pulsermeter is replaced by a special fitting containing a silver diaphragm plate, having an orifice of predetermined size. A connection from either side of this diaphragm is led to the two limbs of a manometer tube and the difference in pressure set up by the rate of flow of the gas causes a displacement of the liquid contained in the tubes which are graduated to indicate the flow in lbs. per hour.

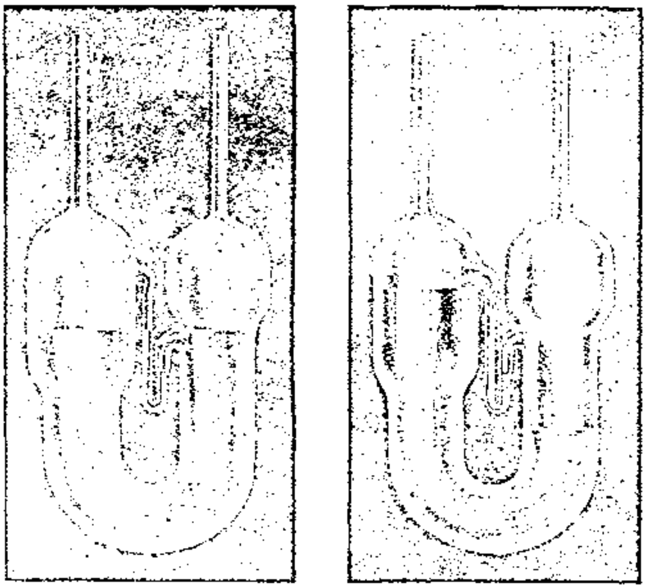


FIG. 3.—Paterson Chloronome Pulser Meter.

For military purposes a portable oufit, comprising a complete pumping, filtering and sterilizing equipment, is fitted on a motor lorry.

The water lifted by a petrol-driven rotary pump, after treatment with a trace of sulphate of alumina to coagulate the suspended impurities, passes into the reaction tank, which allows the bulk of the impurities to be precipitated. A quartz sand filter secures the final purification, and the chloronome administers the correct dose of chlorine to ensure disinfection.

Remarks.

The system is of proved utility. It is used by the Metropolitan Water Board, amongst others.

Water chlorination is recognized as the best sterilizer for military purposes, *vide* the Service water-cart; if the precise dose can be administered as is done by the chloronome, the system of chlorination of water is raised from a rough process to an exact one, and the risk of over-chlorination may be avoided. Also, the bulky and unstable reagent is replaced by sealed cylinders of liquid gas. There seem to be possibilities of the wide application of this system to military purposes. As far as the portable outfit is concerned, this should prove useful for fairly large forces. The system might be applicable in smaller units also. Some special tests would no doubt be necessary in this case, especially as to the robustness of the sulphuric acid pulser, but the problem does not appear to be insuperable.

18. "Lewbart Automatic Disinfector and Deodorizer."

(*Lewbart Manufacturing Co., Ltd., Norfolk Street, Strand, W.C.2.*)

This is a small instrument, $3\frac{1}{2}$ in. diameter and 8 in. long, clipped on to the flush pipe of a latrine, without severing the pipe or using solder, making a water-tight joint by means of a small rubber pad.

A small square hole ($\frac{5}{8}$ in. square) is made in the pipe to allow the trigger to be inserted, and a small hole ($\frac{1}{8}$ in. diameter) to take the discharge of the disinfectant. The action is automatic and foolproof, the descending water actuates the trigger which starts a simple drip-feed, thus releasing a few drops of disinfectant.

The disinfectant enters the pan only after the flush has taken place. The mixture is not further diluted with the water in the pan, but merely floats on the top, and therefore forms a protective barrier.

The container holds sufficient disinfectant for 1,400 pulls of the chain.

Remarks.

The fitting is robust, effective and simple, the movements are so loose-fitting that it is difficult to imagine their becoming jammed or stiff through want of use.

If the joint to the pipe remains water-tight, the fitting should give satisfaction and would add considerably to the cleanliness of latrines. A trial in barracks would be inexpensive; the fitting costs 35s. For military purposes it might be found necessary to construct a heavier fitting and to lock the disinfectant container in some way.

19. "Parks' Valveless W.W.P. Flushing Cistern."

(*Arthur Parks, 31, Mount Ephraim, Tunbridge Wells.*)

A ball cock is used, and the dome is lifted by a downward pull on a rod projecting below the cisterns.

This does away with long levers and chains, is very silent, and the cistern can be fixed in any position.

The arrangement is practical and workmanlike and worth attention.

20. "SILENT HARRIAP W.W.P. FLUSHING CISTERN."

(G. W. Harrison & Co., Napier Lead Works, Laisterdyke, Bradford.)

The forerunners of this cistern are well known and have an excellent name; this latest pattern is remarkable for its fine single casting of antimonial lead, copper being the only other metal used.

It is a cistern which should require the minimum of upkeep, and is to be used in some of the important building schemes now in hand. The price of a 2-gallon iron cistern would be about 23s.

21. "FLAVEL'S 1923 LEAMINGTON GAS-COOKER," AND THE "FLAVEL" BURNER.

(Sidney Flavel & Co., Leamington.)

This gas-cooker, which employs the Flavel burner (described later), has several neat and well-arranged devices.

The burner taps are fitted at the front and are protected by a guard-rail; their levers automatically fall to "turn down" should they become loose.

The grilling burner, which is the only non-Flavel burner used, can be rotated through 90 degrees to convert it to a double boiling burner.

The simmering burner is a Flavel burner with an adjustment for raising or lowering its height to the exact amount required for gentle simmering. The oven burner is so arranged that, when turned off, the ventilating flue in the oven is also closed, thus assisting in the retention of heat in the oven.

The Flavel burner itself is an exhibit of considerable interest. The principle is that of the Bunsen burner, with the addition that in this construction the mixture of gas and air circulates in a peculiar spiral motion, which produces perfect combustion on ignition. It burns with an intensely hot flame and has a guaranteed efficiency of 30% greater than the old-type drilled burners. The principle is simple and is well illustrated by *Fig.* 4.

The flame issues in a complete circle of solid flame. The opening from which the flame issues is machined to precise limits, so that there are no variations in the size of the discharge apertures in the burners.

All gas passages are perfectly smooth and free from obstruction, so that there are no pockets to retard gas and create noise in burning. The air trap constitutes an important part of the burner; by depressing the finger plate when lighting or putting out, these operations can be performed silently.

The mixture can be regulated by the screw shown. The burner was shown in the action of boiling a kettle of water; it was noted that the admission of air to the burner at once increased the volume of steam issuing from the kettle, and closing the air-trap had the reverse effect.

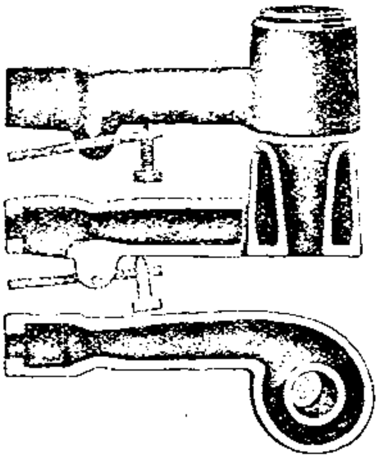


FIG. 4.—"Flavel" Burner.

An independent test in comparison with ordinary drilled burners is said to have resulted as follows:—

Ordinary Burners: 2 pints water boiled in 7 minutes, 22 seconds, gas consumption 2·31 cub. ft.

Flavel Burner: 2 pints water boiled in 7 minutes, gas consumption 1·48 cub. ft.

22. "EASILIT BLOW-LAMP."

(" *Easilit Blow-Lamp Co., 34, Watford Road, King's Norton, Birmingham.*)

This lamp, which appears to have already received some attention at the hands of the Service, is in use by the Post Office. It looks like a successful attempt to solve the difficulty of starting up the usual type of blow-lamp.

The features are an additional burner (at right angles to the main burner), the flame from which impinges on a plate which spreads the flame for giving better distribution of heat for vaporization. The necessity for pouring spirit from a separate can into the usual cup-retainer on the lamp is thus done away with.

The burners are cleaned by automatic cleaning pins, which are inserted through the backs of burners; these pins are drawn inside and away from the flame so that they may not be affected by heat. The usual pricker is therefore not required. The pressure pump is neatly fitted in the handle of the lamp.

The knobs by which the prickers are actuated project somewhat, but do not appear to be unduly fragile; if they are broken off, the lamp can still be used as an ordinary blow-lamp. A branding-iron attachment can be fitted in the blow-lamp flame; this is a great time-saver where numerous articles have to be branded.

23. "IVEX DOMESTIC INVERTED BURNER." (*Fig.* 5.)

(*A. E. Podmore & Co., 34, Charles Street, Hatton Garden, E.C.1.*)

This is a superheated burner similar in appearance to the Alrae burner used in the Service, the chief difference being that the pre-heated air is drawn through three tubes, attached to the corona band, from below the outlet of the products of combustion, to a central mixing chamber above the head of the burner where the gas and air are thoroughly mixed. Each air port is provided with an adjusting shutter. The burner is suitable for interchange of nozzle for bijou, medium, or universal mantle and mundus; the same burner can be adapted for using one or three mantles.

"IVEX"

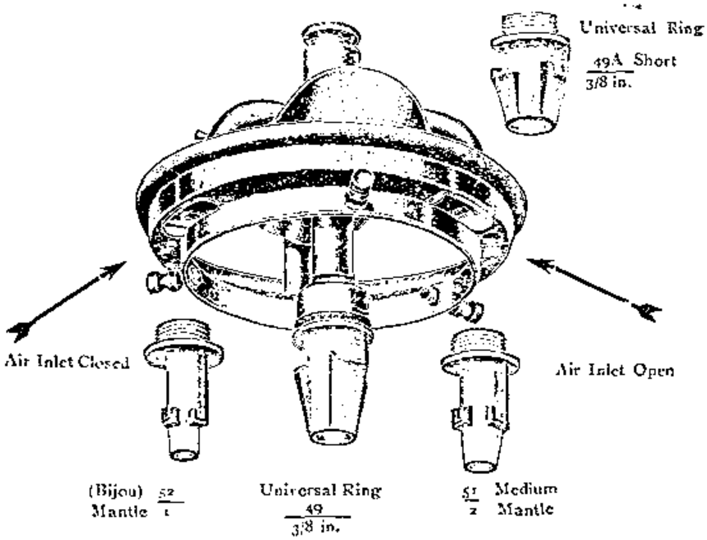


FIG. 5.

ANTI-TANK MINES IN MOBILE WARFARE.

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

THE means of anti-tank defence at the present time comprise artillery, our own tanks, natural obstacles and artificial obstacles. *Engineer Training* specifies anti-tank defence as one of the duties which engineers may be called upon to undertake in the field, and consequently the question of the provision of artificial tank obstacles merits consideration.

Artificial anti-tank obstacles may be divided into :—

(i) Some form of ditch impassable for tanks. If concealed, the ditch develops into a " tank trap."

(ii) Some form of stockade. In order to stop tanks the stockade must be of very strong construction and usually entails heavy concrete work.

(iii) Inundations.

(iv) Land mines.

Of these various forms of obstacle (i) and (ii) both demand either more time, more labour or more transport than would be available in mobile warfare. Inundations are only possible where specially favourable natural conditions exist. Land mines, therefore, remain the only class of tank obstacle which the engineers might generally be able to provide in mobile war.

Very little is at present laid down in our text-books with regard to anti-tank mines. *Tank Training* mentions mine fields as being a source of anxiety to tanks, but gives little further information on the subject. *Military Engineering*, Vol. IV, after saying that anti-tank mines were used in the War of 1914–18, states that the most suitable form of anti-tank mine is now under consideration.

There can be little doubt that, in the event of our being engaged in a war against an enemy armed with tanks, there will be an immediate and insistent demand for every possible form of anti-tank protection. Mines alone can never provide efficient protection, any more than barbed wire alone can be a protection against infantry. The framework of anti-tank defence under present conditions must be anti-tank artillery, but mine fields may prove as important an accessory to these guns as barbed wire has proved to machine-guns.

The question deserves consideration not only from the point of view of our own defence, but also to provide security for our offensive tank forces. It is wrong to think that by exploring possible anti-tank measures we are counteracting the offensive value of our own tanks. It is only by foreseeing the probable anti-tank measures which the enemy may employ that our own tanks can be secured against them.

THE USE OF ANTI-TANK MINES IN THE WAR.

The tank itself was in its infancy at the time of the Armistice. Counter measures to meet any new weapon inevitably follow behind the development of that weapon; and consequently the possible means of anti-tank defence were only explored to a very limited extent during the War.

As we led the way in the development of the tank we might naturally expect to find anti-tank measures developed mainly by the Germans. Actually, they do not appear to have treated the problem seriously until the last five months of the war, when they evinced a feverish activity in seeking counter-measures. Their extreme anxiety on the subject, combined with the rapid development of the final operations of the war, prevented any really effective treatment of the problem.

Anti-tank mines were used both by the Allies and by the Germans. They most usually took the form of shells or trench mortar bombs, provided with a special type of firing mechanism and buried just below ground level. A type of contact-firing mechanism was devised which operated when a tank passed over the mine, but which was not fired by the passage of infantry or transport.

The German mine fields do not appear to have scored any great success against our tanks; in fact, the heaviest recorded allied tank casualties from mines occurred through tanks running over one of our own mine fields laid before our retreat in March, 1918, and forgotten. This disaster occurred at the end of September, 1918. The mine field consisted of rows of buried trench-mortar bombs, each bomb containing 50 lbs. of ammonal. In spite of having been laid seven months previously, the efficacy of the mine field was demonstrated with unfortunate thoroughness. The weight of explosive used was sufficient to blow in the bottom of the machines and cause severe casualties among the crews.

NEUTRALIZATION OF MINE FIELDS BY THE ENEMY.

As the use of mine fields becomes more general, methods of counteracting them will, in turn, come into prominence.

Three methods of destroying mine fields have been suggested:—

(i) By artillery fire.

(ii) By providing tanks with a roller pushed ahead of the machine in such a way as to detonate mines before the tank itself reaches them.

(iii) By a form of plough pushed ahead of a tank.

The destruction of mine fields, the exact location of which is unknown, by artillery fire would demand an expenditure of ammunition which is not likely to be possible in mobile warfare.

Though neither the roller nor the plough has yet been perfected as a mine-clearing machine, it may be expected that some form of mechanical mine-sweeper will eventually be evolved.

Such a machine is only a partial answer to the mine; and its use would not completely neutralize the value of the land mine, any more than naval mine-sweepers have been able to eliminate entirely the value of mines at sea. The necessity for every tank formation being preceded by mine-sweeping tanks whenever operating over ground which might be mined, would constitute a handicap upon the manœuvre power of the tanks, which would itself justify the use of the mines.

The Probable Type of Anti-tank Mine.

For use in mobile warfare it is essential that an anti-tank mine should be light enough to be easily transportable in large numbers. It may be assumed that the use in mobile operations of mines, sufficiently powerful to break through the armour of a tank, and so inflict casualties on its crew, will be precluded by the weight of explosive required. The mines will, therefore, probably be designed to break the tracks of the tank and so render it immobile. For this purpose a mine weighing from 10 to 15 pounds would probably be sufficient.

Other desiderata for the mine are that it should be safe to handle, quick to lay and easy to conceal. There should be no difficulty about ensuring safety in handling. Rapidity in laying and facility in concealing would both be realized by a small mine designed to be laid just under the ground surface, and calling for the minimum of digging. These characteristics do not appear to be difficult to realize.

We may then assume that mines will be available possessing the following characteristics:—

(i) Weight, 10 to 15 lbs.
(ii) Powerful enough to immobilize any tank whose track passes over it.
(iii) Safe to handle.
(iv) Quick to lay and conceal. Say 1 man could lay 1 mine in normal ground in 5 minutes.

From these assumptions we can draw certain data:—

(i) A 3-ton lorry could carry about 400 mines.
(ii) A section of a Field Company, R.E., could lay a field of 500 mines in about 1 hour, presuming the mines are dumped on the site.

(iii) To form an efficient mine field at least one mine per yard of front to be covered is required. This allows of two rows of mines, with mines 6 ft. apart in each row. It may be found that three rows of mines are desirable, requiring $1\frac{1}{2}$ mines per yard of front.

PRACTICABILITY OF SUPPLY OF MINES IN MOBILE WARFARE.

The use of mines while operations are so mobile that formations are moving daily is clearly neither useful nor practicable. The demand for mines will occur as soon as a formation occupies a position with a view to meeting an enemy attack upon it. It may be anticipated that a period of from 24 to 48 hours may be available in which to put such a position in a state of defence.

The previous operations should have given sufficient indication of the probable course of events to permit a supply of mines being available at railheads very soon after the decision to occupy a position is taken. The problem then becomes one of transport forward from railhead. The establishment of a Div. M.T. Co. includes two 3-ton lorries for R.E. stores, but the demands on these lorries for the carriage of normal R.E. stores would be too great to allow their being used for mines. The best solution of the problem would be the allocation to Divisions of lorries specially for the carriage of anti-tank mines. Until this development takes place transport would have to be found either by the Corps or the Division diverting M.T. from its normal duties, or by utilizing the pontoon trailers of the Field Park Company with the Division, provided that they were temporarily available. These latter have a caryring capacity of 42,000 lbs., say 2,800 mines.

The question of transport forward from railhead is, therefore, in doubt. With our present establishment of M.T. it would usually be possible to make 8 or 10 lorries available if the urgency of the need for anti-tank mines justified it.

If we consider a Division holding a front of 5,000 or 6,000 yards, faced with the probability of attack by an enemy with superior strength in tanks, and relying mainly on the fire of twelve Pack Artillery Howitzers for defence against these tanks, it seems likely that its need of additional anti-tank defence will be urgent enough to ensure transport being found for, say, 3,000 mines.

On the basis of the assumptions made, we may consider that a Division could have sufficient mines to cover about half the frontage it is holding. This quantity of mines could be laid by two Sections of a Field Company R.E. in about four hours; and the mine-fields should easily be completed within twelve hours of the arrival of the mines at railhead.

Method of Employing Mines.

The Value and Limitations of Mine-Fields.—In considering the method of employing mine-fields, their value and their limitations must be realized. Their value is two-fold :—

(i) Their physical value, arising from their power of rendering tanks immobile.

(ii) Their moral value, arising from the effect on the nerves of the driver of a tank of the knowledge that he may at any moment drive into a mine-field, be put out of action, and remain an easy target for artillery.

The main disadvantage of mines lies in the restriction which they lay upon the movement of our own tanks, and possibly of other troops, in counter-attack.

The mines under consideration also have the limitation that, though they would be capable of stopping a tank, they would not put either its crew or its armament out of action.

Co-operation.—In selecting sites for mine-fields it is essential to consider how they may affect or be affected by the action of other arms.

Lines on which it is probable that our own tanks may be required to counter-attack must be left clear.

Areas which are likely to be under heavy concentrations of our own artillery fire in the early stages of an enemy attack are not suitable, owing to the probability of a large proportion of the mines being detonated by that fire.

The mine-fields must be sited in conjunction with the siting of anti-tank guns, and must be within their arc of fire to achieve their full effect, since the mine will only stop the tank and the gun is required to put its armament and crew out of action.

A mine-field should normally be under infantry or machine-gun fire to prevent enemy working parties clearing a path through the field, once they have located it. In order to exploit the moral effect of the mines it may, however, be useful to site a few small mine-fields in defiles well forward of the infantry positions, simply with the object of increasing the uncertainty and limiting the enterprise of the enemy tanks in their advance.

Influence of Ground.—On any front there are likely to be certain lines of approach favourable to tanks, and certain sections where woods, marshy ground, streams or railway embankments constitute natural obstacles to tanks.

Mine-fields will naturally only be employed on sections of the front favourable to tanks; and any defile confining the possible tank routes will be a particularly good site to mine.

On these sections some portions of the ground will probably favour concealment of the mine-fields more than others, and this will be a factor in the selection of sites.

There may be covered approaches constituting dead ground which it will be difficult for anti-tank artillery to cover. This may justify the laying of a mine-field which is not covered by the fire of the defence, as an enemy tank disabled in such a site could not use its weapons effectively.

The Responsibility for Siting Mines-Field.—The factors affecting the location of mine-fields and the arms affected are so various that it is important that the responsibility for determining their siting should be definite. The final responsibility should rest with the C.C. Infantry Brigade holding any sector; and a sound procedure would be for an R.E. officer to be detailed to carry out reconnaissance on each Brigade front. The Brigadier would lay down the general policy of anti-tank defence at his conference preliminary to the reconnaissance of the position. The R.E. officer would accompany the anti-tank artillery commander on a detailed reconnaissance of the whole Brigade front, on completion of which he would be able to submit a complete plan of proposed mine-fields for the confirmation of the Colonel-Commandant.

It is important that records of mine-fields laid should be kept systematically. The danger of our own tanks suffering from our own mines has already been referred to.

Use of Mines in Rear of the Main Infantry Zone.—The foregoing notes have been confined to a consideration of the employment of mines as part of the defences of the main zone held by the infantry, because it seems probable that it is there that their use is likely first to become general. As the powers and range of movement of tanks increase, the problem of providing anti-tank protection for Brigade, Divisional and Corps Headquarters, and important administrative centres in rear of the main zone will become increasingly important.

Anti-tank mines will play their part in these defences no less than in the forward defences.

Training and Organization.—The example of the German attempt to improvise anti-tank measures in haste during the last months of the war, should be sufficient to emphasize the importance of organizing any form of such defence during peace, and ensuring that the officers and men concerned are given such training as may be necessary.

The technical training of the R.E. personnel in laying the mines requires very little time; and, once the mines or dummies are available, could be carried out in a few hours.

The training of officers is more important. Officers should know what constitutes a natural tank obstacle, and what does not, as this knowledge must form the basis of any anti-tank defence. They should be able to judge whether a railway embankment or cutting is sufficiently steep to prevent the passage of tanks; whether the tree-stumps in an area cleared of wood are high enough to stop tanks; and whether the banks and bottom of a stream permit tanks to ford it.

Sapper officers should know the powers and limitations of the Pack Artillery Howitzer, and Pack Artillery officers should have similar knowledge with regard to mines.

All senior officers and staff officers should have the knowledge required to enable them to co-ordinate the scheme of anti-tank defence on a Brigade front. The transport problems that will crop up as soon as mines are demanded must be realized and considered beforehand if they are to be dealt with effectively in war.

None of this training is difficult. It is only necessary to give these questions consideration whenever troops are being exercised, or schemes and staff rides are being carried out, under conditions which lend themselves to the problem.

STEREOSCOPIC PLOTTING MACHINES FOR USE IN PHOTOGRAPHIC SURVEYING.

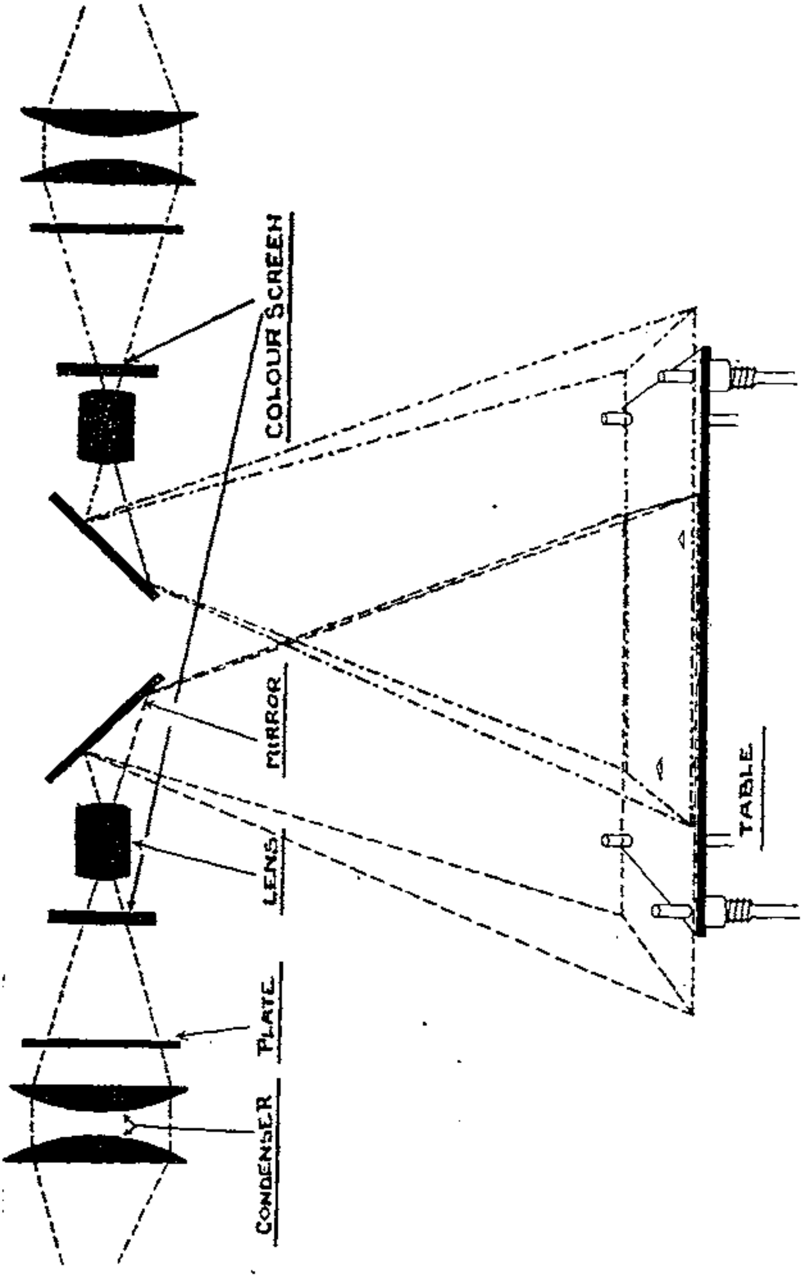
By COLONEL H. ST. J. L. WINTERBOTHAM, C.M.G., D.S.O.

FOR the preparation, in war time, of maps of areas into which our surveyors cannot penetrate we must rely upon surveying from air photographs, and it is obvious that there will be no time to waste. We cannot afford to rely, wholly, upon those graphic, optical, and photographic methods which, theoretically sound enough, entail in practice laborious and lengthy personal work. If only the problem is solvable by some swift and reliable automatic machine, not only will the difficulties of war-time mapping be lightened, but surveying from air photographs may force its way to a position of economic equality with the ordinary ground methods.

An individual photograph is a two-dimensional view of a three-dimensional landscape. Whatever we do, therefore, we cannot survey completely anything but a flat plain from it. We must have two views of the same area from different view-points if we want both to map and to contour. If we take each view individually, and separately, we can extract from it nothing but bearings, but if two views of the same area can be examined simultaneously in a stereoscope we secure a three-dimensional image. To make it possible to secure this image, however, we have to place the two views in the same relative position to each other as they actually assumed in the air. This done, we can move them so that the stereoscopic fusion of the twin images of a definite spot occurs at a distance and bearing corresponding to the distance and bearing in nature from the air base. The problem is then to use the movements of the views (negatives, diapositives or prints) relatively to each other and to the observer in such manner as to plot, automatically, the position, and to record the height, of the point we examine in the stereoscope.

It is quite commonly held that stereoscopic fusion is attainable only with acute intersection. The limit, on the analogy of our own ordinary powers, is supposed to be of the order of 16°. Indeed, it is not always easy to persuade experts that fusion can be secured, under normal circumstances, and for small areas, at angles which approach even to the right angle. Such is, however, the case. Being in no sense of the word an expert on these matters, I cannot

Plate I.



PRINCIPLE OF THE CAMERA-PLASTICA.

explain it, but I think there may be something favourable in an air photograph which is the more marked as the angle of exposure approaches the vertical. Here one deals with a surface whose variations in height are small in proportion to the height of the aeroplane, and objects stand up from it so comparatively little as to limit the depth (and hence alteration in scale) of the image. Whatever the reason may be, the fact remains, and we need apprehend no lack of accuracy due to a small parallactic angle.

We have had our national pioneers in the construction of stereoscopic plotting machines. Lieut. F. V. Thompson, of the Corps, was, I think, the first to evolve a semi-automatic plotter, and Capt. Deville, Surveyor-General of Dominion Lands of Canada, invented an interesting reflector type of stereoscopic plotter. But the subject has not offered much prospect to English surveyors in the past, because we have been faced either with the large-scale survey at home of a relatively flat country, unsuitable to photography from ground stations, or, abroad, with the small-scale mapping for which photography, in general, is unsuited. With the advent of photography from the air we can secure photographs at any angle, and can therefore suit our procedure to the landscape.

There are no British models of stereoscopic plotters on the market, but there are three such which are of great interest, one of which is Italian, and two of which are German.

The Italian model, the " Nistri photo-cartograph," is known to us only by advertisement. It rests upon the old "*camera plastica*" principle, due to Scheimpflug, of a simultaneous projection on to a flat surface from two diapositives which reproduce the relative camera positions in the field. The German models, the Autocartograph and the Stereoplanigraph, are partly optical, partly mechanical. These latter instruments I was able to see, thanks to the kindness of Gustav Heyde & Co., of Dresden, who make the Autocartograph, and of Zeiss & Co., of Jena, who make the Stereoplanigraph.

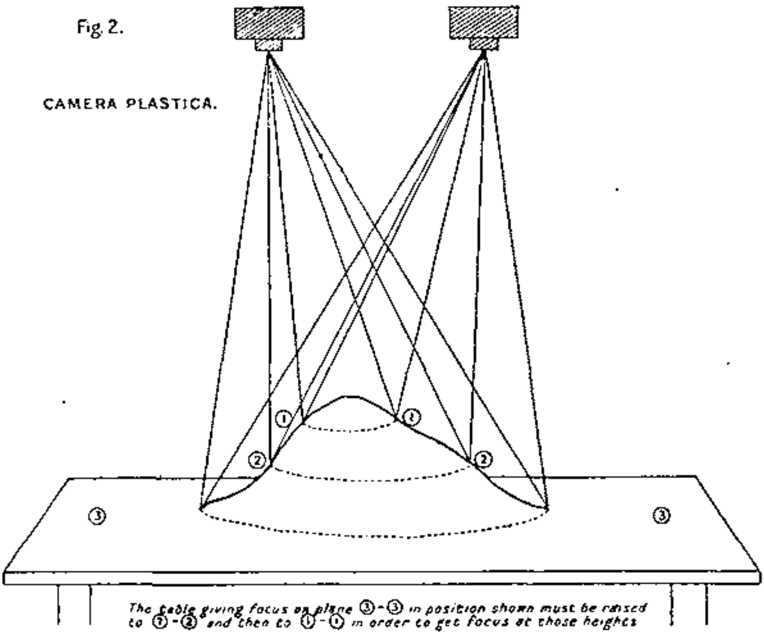
The Camera Plastica.

The expression " camera plastica " is the most suitable which the Air Survey Committee can think of. If anyone can suggest a shorter and more applicable alternative it will be received with gratitude. The underlying idea is to place the two views (in the form of diapositives) in carriers, in the positions in which they were taken relatively to each other, and to project the images upon a surface which can be moved nearer to or further from them (see *Plate* I). Each view is, in practice, focussed separately upon images of control points plotted on a white surface, and when the views are combined sharp focus is secured only for such points as lie at a height corresponding to the distance between views and plotting surface.

(See *Fig.* 2.) To this simple form all sorts of modifications may be added. In one form, which was seen by members of the Air Survey Committee last summer in Germany, two complementary colours were used. When focus was sharp the image was white, when not in focus a mottled smudge of green and red. In front of the sources of light a revolving wheel cuts off each light in turn at such a speed as to leave the two images simultaneously on the retina. The image rocks backwards and forwards, except where it is in focus, and leaves one with a distinctly after-dinner feeling.

Fig. 2.

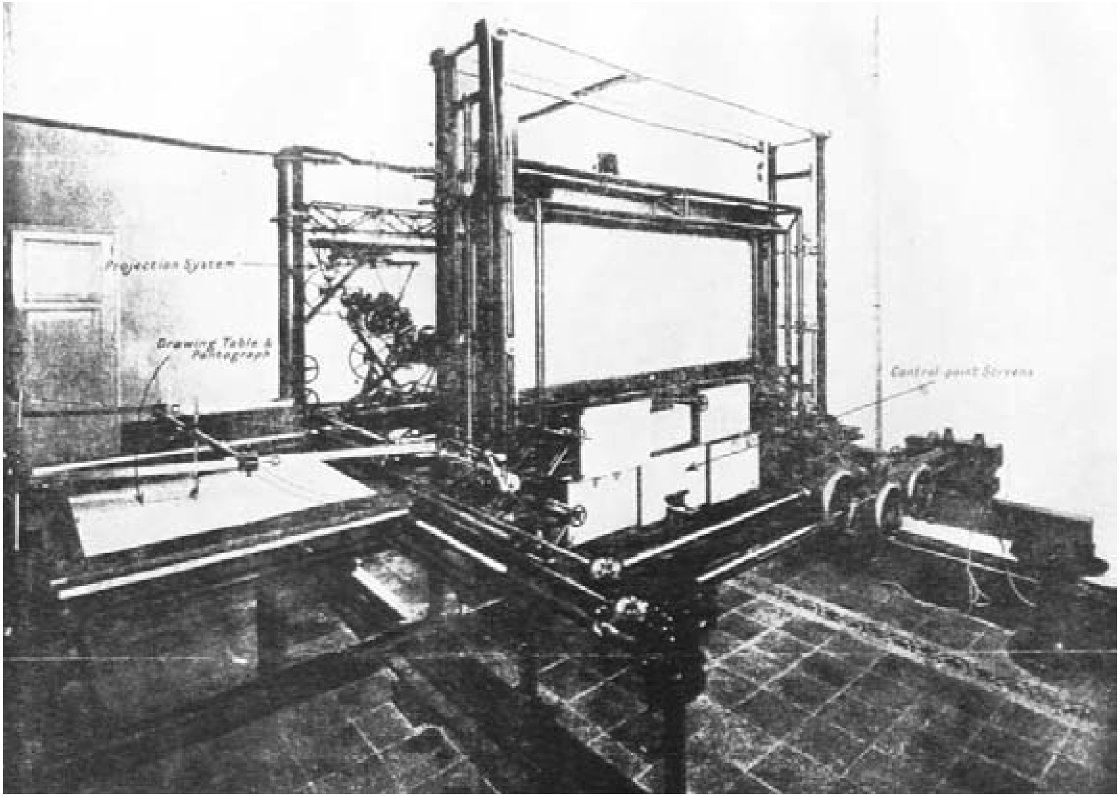
CAMERA PLASTICA.



This type of stereoscopic machine is being made under several different names. The name "Inagverfahren" (the "Inag" being simply the initials of a firm) is perhaps most commonly associated with it.

Obviously it is not a difficult matter to convert the movements of the plotting surface in altitude into a fairly good measure of height, by one of two alternatives, namely, (*a*) the combination of complementary colours, and (*b*) the selection of stationary (or focussed) from moving (or unfocussed). Some pantograph arrangement can then be made to copy, at the required scale, the contours so defined; but there are serious difficulties in the way of attaining precision in either contouring or tracing the outline.

In the first instance, it seems probable that it will be difficult to survey ground on which little detail appears. This difficulty is



THE NISTRI PHOTOGRAPH

PLATE III.

NISTRI PHOTOCARTOGRAPH.

Fig. 3.

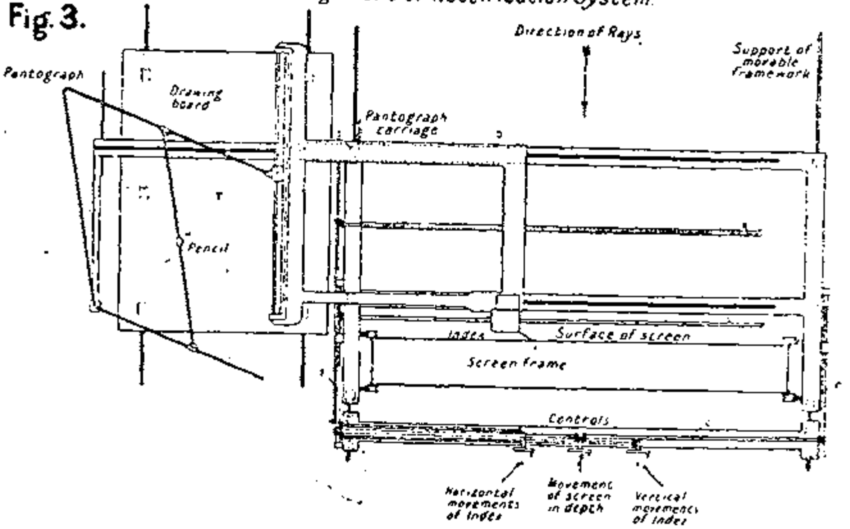
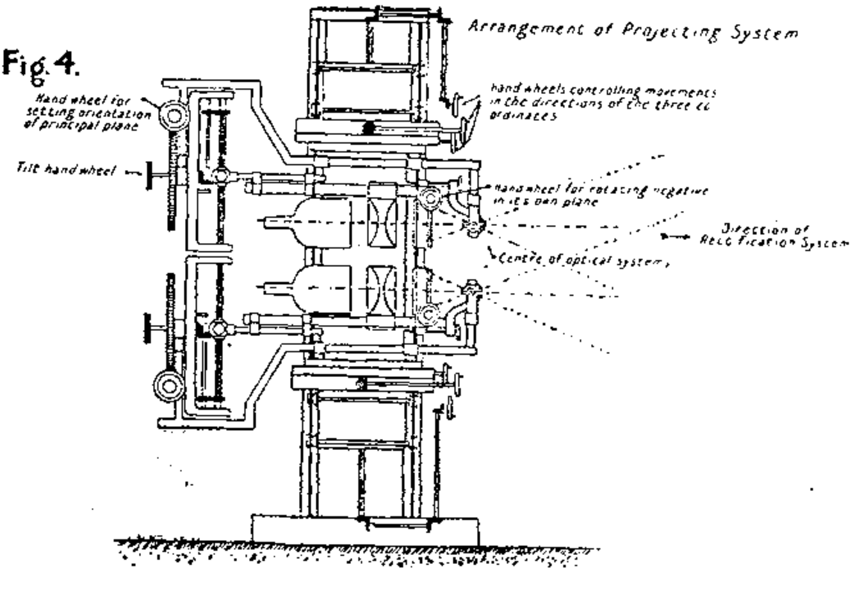


Fig. 4.



avoided in the autocartograph and stereoplanigraph by a suitable survey mark.* To examine focus without its aid on bare ground will be difficult. Secondly, it would appear to call for peculiar precision in the relative heights of projectors and plotting surface; and thirdly, there are optical troubles in securing focus at the different heights, without a change in the position of lens and diapositive. Moreover, the scale of the projection will be difficult to reduce to practical limits. It is for the medium scales (1/40000 to 1/5000) that the chief value of photography offers. It is doubtful whether one can secure a projection on these scales. Naturally the results obtained at, say, 1/1000, can be reduced, but the additional time taken in working at a large scale and reducing are drawbacks. There is, however, the other side to the picture. The apparatus is very easy to construct and the results obtained, if possibly, though not necessarily, not of a very high order, will be comparable generally to most topographic contouring.

The Nistri Photocartograph.

Plate II and *Plate* III (*Figs.* 3 and 4) show the general appearance, and some details of the construction of the "Nistri" photocartograph, which, according to a recently-received publication, is now on the market. It embodies the *camera plastica* principle. Judging from the photographs, this machine must stand from 7 to 10 feet high, and occupies perhaps 80 sq. ft. of floor space. The positions and design of the projectors are immaterial for an understanding of the broad lines of the machine. It is sufficient to note that they are movable and that the images are thrown upon a series of screens which are at different distances from the projectors.

It seems likely that the control points (say, 4) are plotted each on the screen corresponding to its altitude. Each projection is, then, fitted to this control by moving the corresponding projector until the images of the control points lie properly and in sharp focus on their correctly-plotted positions. An opaque drawing-board is now substituted for the individual screens, and the contours are traced (and copied by pantograph on the fair drawing) by following the lines of correct focus. It is noteworthy that contours so drawn are correct in the scale of your chosen plane of reference The outline must be plotted in the same way—that is, only such portions can be traced on the board, at one time, as lie at the corresponding altitude. The Nistri people claim that their "photocartograph" is a general-utility instrument; that is, that it may be used for photographs taken with the optical axis at any angle to the ground. This statement should be accepted with some reserve. As a system it lends

* It seems possible that in some manner or other the survey mark is introduced in the Nistri pattern discussed later.

itself most readily to photographs taken with a vertical axis, because in this case the movements from the plane of reference are a minimum. It would be a matter of obvious difficulty to arrange for screens at distances ranging from the immediate foreground to the far distance.

There is no particular danger of not being able to contour well from vertical-axis photographs. The ratio of horizontal to vertical scale can be varied at will by altering the length of air base (or overlap of the photograph). Little can be said of this model at the present moment, however, because little is known.

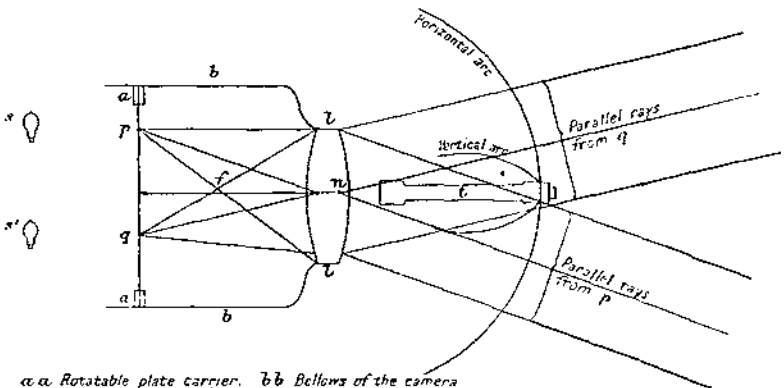
THE GERMAN MODELS.

It has been possible to study the German machines in more detail. The autocartograph and the stereoplanigraph are essentially different in principle. The former is an intersection method and does not reproduce, directly, the conditions in the field. The latter is an interpolation method and does, much more nearly, reproduce field conditions, but both differ from the projector type in this, that attention is focussed upon the cutting-point of two rays and does not treat the area as a whole. There are one or two matters which are common to both models and may be dealt with separately.

The Photogoniometer.—The first models of stereo-comparators-plotters or -autographs, designed to deal with stereoscopic pairs taken in the vertical plane, and either parallel, or nearly so, effected the convergence of rays, proper to the stereoscopic fusion of corresponding images, by shifting one plate with reference to, but still in the same plane as, the other. Where the planes of the plates may assume almost any angular relationship to each other this principle no longer serves. The photogoniometer (see *Fig.* 5),

Fig. 5

THE PHOTOGONIOMETER



a a Rotatable plate carrier. b b Bellows of the camera
f Principal distance. l l Lens. n Front nodal point
t Theodolite. s s' Moveable source of light
p q Images on diapositive.

which solves the problem in a convenient way, was first designed by Porro, of Milan, and was improved upon by Koppe. The general idea is to place a diapositive in the plate-carrier of a camera at the principal distance characteristic of the camera used in the air for the original exposure. Through the camera lens the diapositive is examined with a theodolite. The camera portion is pivoted round the front nodal point and the vertical and horizontal axes of the theodolite generally pass through that point, too. That, however, is not a vital matter, as the rays from images emerge parallel. The important feature of the instrument is that the lens employed should be as nearly as possible an exact copy of that employed for exposure in the field, and the principal distance must also be exactly the same. The plates employed for photographic surveying show fiducial marks, one on each side, so that lines may be drawn joining opposite marks to intersect in the principal point. They also show corner marks so that the angular distance from centre to corner, on each side, may be tested by measurement on the horizontal and vertical axes of the theodolite.

Supposing that for some cause, even so apparently negligible as particles of dust, the plate is not correctly set with relation to the lens, appreciable errors may be introduced. In the autocartograph (to be described later) a three-point adjustment is used to bring the plate to its true position.

If the exposure in space was tilted, then either the camera, or the theodolite (arcs and all), is tilted accordingly, and, as field conditions can, by this means, be absolutely reproduced, horizontal and vertical angles can be read off directly upon the theodolite arcs.

Even in this simple form the photogoniometer promises to be a most useful instrument. Providing a good reliable method is found of measuring the tilt, either in the air, or afterwards, in a special instrument such as the tilt finder, the photogoniometer promises a speedier and more satisfactory approach to precise survey of detail and to contouring than do methods of rectification. But beyond this direct form of utility, it opens the way to examining stereoscopic pairs of plates in automatic plotters, and is used, although in different forms, in practically all models and designs.

In the autocartograph vertical angles are read on the plate by swinging the objectives of a binocular telescope (which replaces the goniometer theodolite), round a horizontal axis, whilst horizontal angles are measured by swinging the camera (set to the angle of tilt) round a vertical axis. In the stereoplanigraph the telescope is replaced by an auxiliary lens combination, which is pivoted for movement in all directions, whilst the camera is given movements to correct tilt and swing.

The Survey Marks.—In looking through the telescope of a theodolite the collimation axis is defined by a graticule of cross hairs. One wants some similar "foresight" to direct each eye along this axis when working stereoscopically, and, to serve this purpose, a "mark," a "floating mark" or a "survey mark" (for all three expressions are used) is put in each eye-piece so that it appears, individually, at infinity, or in stereoscopic fusion at that position whose xy and z co-ordinates are recorded by the instrument. The usual mark (as used by Lieut. F. V. Thompson, for example) was a ball surmounting a pointer. It did not appear (to me, at any rate) to have substance, when "fused"—although the images came together. An excellent type of mark is shown in *Plate* IV, *Fig.* 6, which, when examined in a stereoscope, will be found to take the form of a hollow cone. This type of mark was used with the stereoplanigraph.

The usual type of survey mark.

THE AUTOCARTOGRAPH.

The general appearance of this instrument is shown in *Plate* V, and the working of it in *Plate* VI. In this latter Plate (which refers to an earlier model than *Plate* V) the photogoniometer is shown under its German name of "Bildmess theodolite."

Geometry.—The two azimuthal arms are the projections, on the horizontal plane, of the rays from the two ends of the air base to the object. It would be difficult to design the machine in practice so as to include an actual point of intersection of these arms, and this difficulty is overcome by the use of similar triangles.

The left-hand arm is that which defines the bearing or azimuth; for it is moved to right or left, sliding, in its sleeve, along the distance piece. This movement brings the survey mark in the left eye-piece on to the object. The distance piece is now moved to, or from, the line of clamps (but remaining parallel to it), sliding up or down the left-hand arm and rotating, as it does so, the right-hand arm until the survey mark in the right-hand eye-piece falls also upon the object. *Fig.* 10 shows clearly the triangle which is actually formed, with its base on the distance piece and, as its sides, the right-hand arm, and a line parallel to the left-hand arm. Now these arm movements have to be given by the observer who is looking through the binocular telescope at the plates in the plate-holders of the goniometers. In *Fig.* 8, *Plate* VI, it will be seen that these goniometers rotate around a vertical axis. They are first of all "set" on control points, separately, in their correct positions relatively to each other, as will be described later. Subsequently, by moving them round their vertical axes, the same effect is obtained as by rotating the telescope of the goniometer (described above) round its vertical axis. The extent of rotation, governed by a system of gear wheels, moves the arms relatively to each other. Heights are obtained by reading the position of two further arms or levers, which are moved by elevating

FIG. 6.—A good type of Survey Mark. Similar to that used in the stereoplanigraph. Examine through a stereoscope.

FIG. 7.—A stereogram such as is produced (as an accessory to the map) on the autocartograph. Examine through a stereoscope.

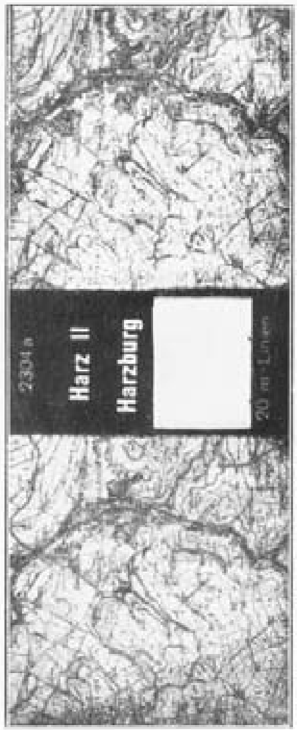


FIG 6 & 7

PLATE VII.

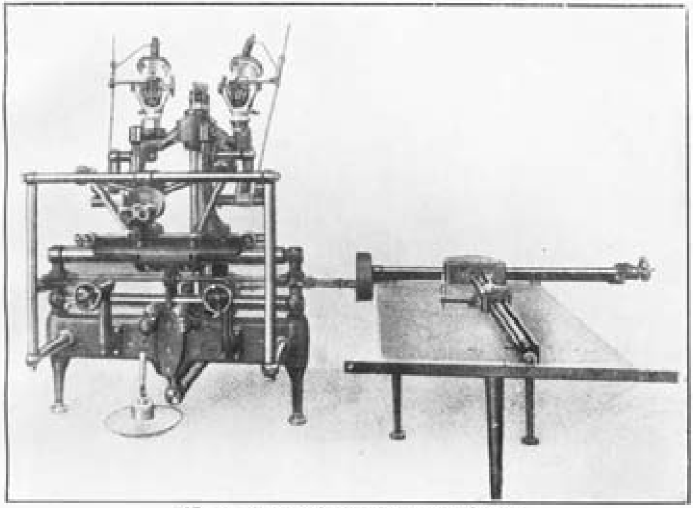


FIG. 11. – Stereoplanigraph (Front View).

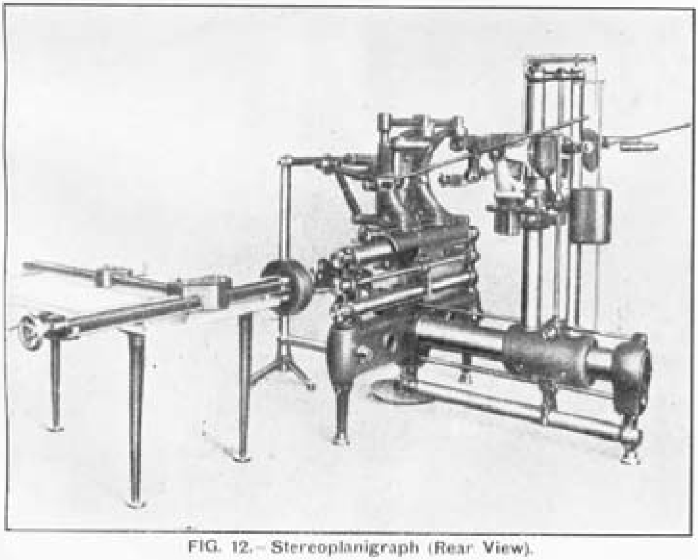


FIG. 12. – Stereoplanigraph (Rear View).

PHOTOGRAPH 2

PLATE VI.

SIMPLIFIED DIAGRAM OF THE AUTOCARTOGRAPH.

Fig.8.

Plan

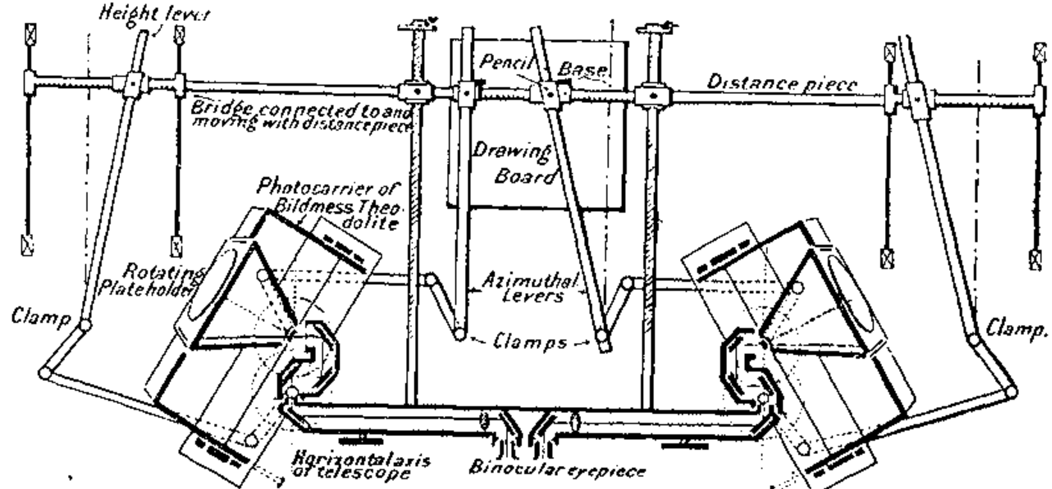
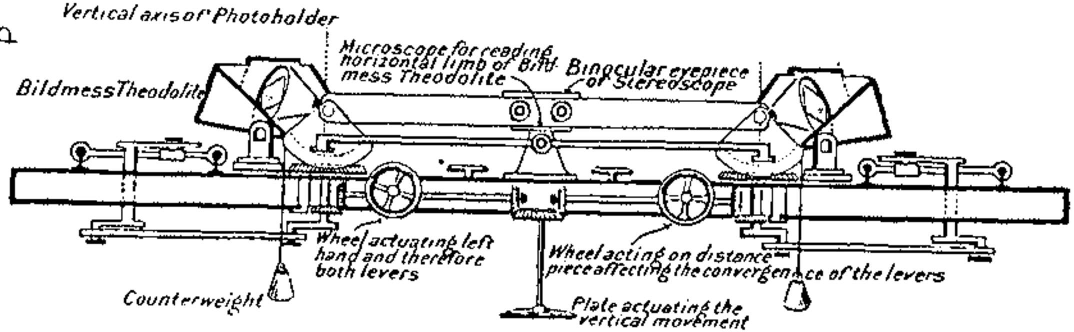


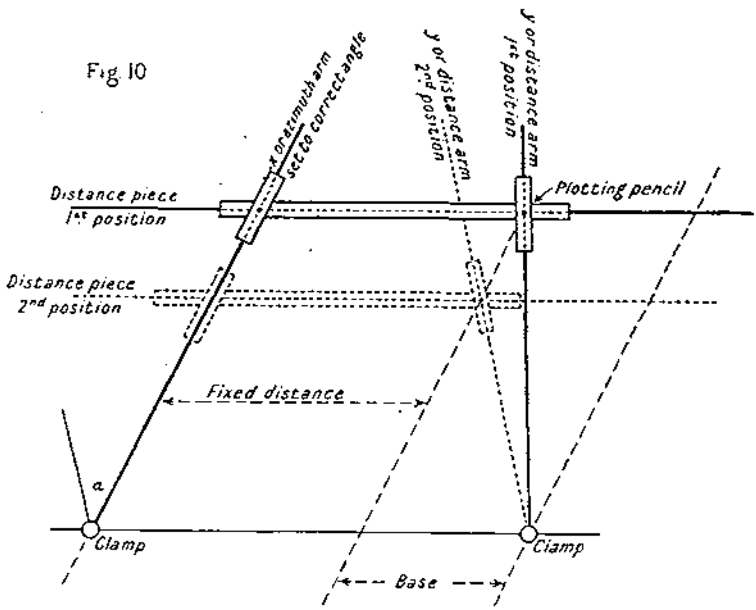
Fig.9.

Elevation



or depressing the objectives of the telescope round horizontal axes, which are shown in *Fig.* 9, *Plate* VI. The heights themselves are defined by the usual equation $h = d \tan \theta$ (where d is the horizontal distance and θ the angle of elevation or depression). It will be noticed that horizontal and vertical angles would, in the goniometer described above, be read on the horizontal and vertical arcs of the telescope, and that the autocartograph adaptation is to give the horizontal movement of the telescope to the plate-holder whilst keeping the telescope itself on a fixed azimuth, and to rotate the telescope vertically whilst holding the plate-holder at a constant angle to the vertical. The pivotal lines of plateholder and telescope intersect in the lens of the goniometer. The survey marks are in the eye-pieces of the binocular telescope.

Fig. 10



Plotting.—The position of the drawing-board is shown in *Fig.* 8, *Plate* VI. On this board are plotted the control points, X co-ordinates being measured parallel to the distance-piece and corresponding, therefore, to the movements of the left-hand arm and of the left-hand driving-wheel. Y co-ordinates, perpendicular to the base, are governed by the right-hand wheel and by the movements, to and from the machine, of the distance-piece. Heights (or Z co-ordinates) are perpendicular to the plane of the board, and correspond to the rotation of the telescope objectives, and to the drive from a potter's wheel (worked by the foot) called " Plate actuating the vertical movement " in *Fig.* 9, *Plate* VI. The pencil is held in the sleeve which keeps the right-hand arm to its position on the distance-piece. It can be dropped on to the paper by an electric switch in front of the observer. The pencil can be left in contact with the paper to draw automatically (in cases where plotting affects only X and Y movements on a horizontal plane, *e.g.*, tracing a contour with the height lever clamped) or can be used for point-by-point plotting, where the movements include Z or height measurement and are too complicated for following automatically. As explained above, the survey marks define the two optical axes, and position is not correctly determined until the mark is in actual stereoscopic fusion with the point of detail in question.

Setting the Instrument.—The preliminary adjustments to the diapositives in the plate-holders of the photogoniometer have been dealt with before. When they have been concluded, the plates (or diapositives) are adjusted in turn upon the control points. Normally, exposure is made, in the aeroplane, either with a vertical axis or at some pre-arranged angle of tilt. (The autocartograph is primarily designed for tilts of about 60 degrees.) Whatever the actual angle of tilt may have been, an estimated value is taken and the plate-carrier is tilted to correspond. The following routine is then completed :—

(*a*) The horizontal angles between the images of three or more control points are measured by rotating the photogoniometer and reading the included angles, as observed through one arm of the binocular telescope.

(*b*) Using these angles, a graphic resection is made from the plotted control points and gives preliminary and approximate (say, within 100 metres) figures for the X and Y co-ordinates of the position of exposure.

(*c*) Vertical angles are then read on the diapositive by rotating the objectives of the telescope and, using the approximate horizontal distances obtained from (*b*), the approximate height of the point of exposure is calculated ($h=d \tan \theta$).

(*d*) Using the approximate data so obtained for each exposure, and so for the air base, the plates (in combination) are fitted, by trial and error, on the plotted trigonometrical control.

The programme outlined above may take from two to four hours to complete. A fairly good position (say, to within 6 to 10 minutes of the true tilt) is easily procurable. The final adjustment is an affair of practice, and of honest and careful manipulation. Obviously, if Major MacLeod's tilt finder answers to expectations it will save considerable time at this stage. It is to be noted that the mathematical solution of the position in space, thought indispensable in earlier models, has been entirely given up. Indeed, it meant days, rather than hours, of work, and was an insuperable bar to the economic use of the instrument.

Extra Fittings.—

(*a*) A motor drive can be used to work the arms, and to combine motions of the X and Y co-ordinates. This device may be useful in tracing contours, for such combined movement is easily controllable by a wheel, which resembles a motor-car driving-wheel, and can be regulated to any desired speed. It is, however, of little value if the potter's wheel is to be used at the same time. It was certainly beyond me to follow the changing height with the potter's wheel, while moving the azimuthal arms, fast, with the motor. I doubt the real usefulness of this modification.

(*b*) *The Front Drum.*—The plotter works away in front of a maze of wheels and movements, and could not readily see what he had done, when working with the first models. A drum has, therefore, been added where the plotter can see it, and on this drum is drawn a replica, at any required enlargement or reduction, of the plan on the drawing-board. The drum revolves and, in doing so, naturally suffers an alteration in diameter (and hence in scale), for the roll of paper on it must start somewhere. The effect of this uneven diameter is probably not entirely negligible, but the fitting is a good one if only on the score of the convenience of the plotter.

(*c*) *Profiles and Stereograms.*—Profiles can be drawn by a device fitted in front, and also small but interesting stereograms. A sample of these stereograms is given in *Fig.* 7 of *Plate* IV. It should be viewed through any convenient stereoscope.

(*d*) *Co-ordinate Indicators.*—These indicators show the actual values of the X, Y and Z co-ordinates at any moment corresponding to the movements which have been given to the machine. It is undoubtedly a convenience to have this possibility.

Cost, Space, Weight, Time and Staff.—The autocartograph costs something about £4,500. It is not possible to be more precise, because this class of instrument seems to fluctuate a good deal in price. It stands about 5–6 ft. high and covers about 100 sq. ft. of floor space.

Its weight I should put at about 2–3 tons. The staff normally employed is 1 part- and 2 whole-time mechanics and draughtsmen. The adjustment of a pair of plates takes, say, 3 hours, on the average, and the plotting of a pair of plates about another 6–8 hours. These figures are but approximate, since the type of country and the class of photograph introduce variable factors.

Test Survey.—About a year ago Professor Hugershoff, the designer of the autocartograph, offered to send over his own cameras at the firm's expense, and to produce a map from the exposures made in the air with these cameras. The offer was accepted, and the photographs were taken. Before the map could be made it was necessary to send data concerning control points (*i.e.*, their co-ordinates and heights). It is not easy to procure such data in England without original survey on the ground, because the trigonometrical stations of the Ordnance Survey are generally buried (and cannot, therefore, be identified on a photograph), whilst the spirit-levelling does not, generally, extend to them. Positions were therefore measured from the 1/2500 plans, and heights were obtained by interpolation between contours. The map produced by Professor Hugershoff answered very well to the data he was given. In one or two instances the contouring left the surface of the ground where woods and copses hid the view. The autocartograph, in fact, came well out of the test, but the cameras supplied did not. The focal length was insufficient to cover the plate, and definition in the background was very poor. The map could be extended over the foreground only. But it is the plotting machine, and not the camera, which is under discussion, and there seems no doubt that it is capable of fast and good automatic plotting.

The Stereoplanigraph.

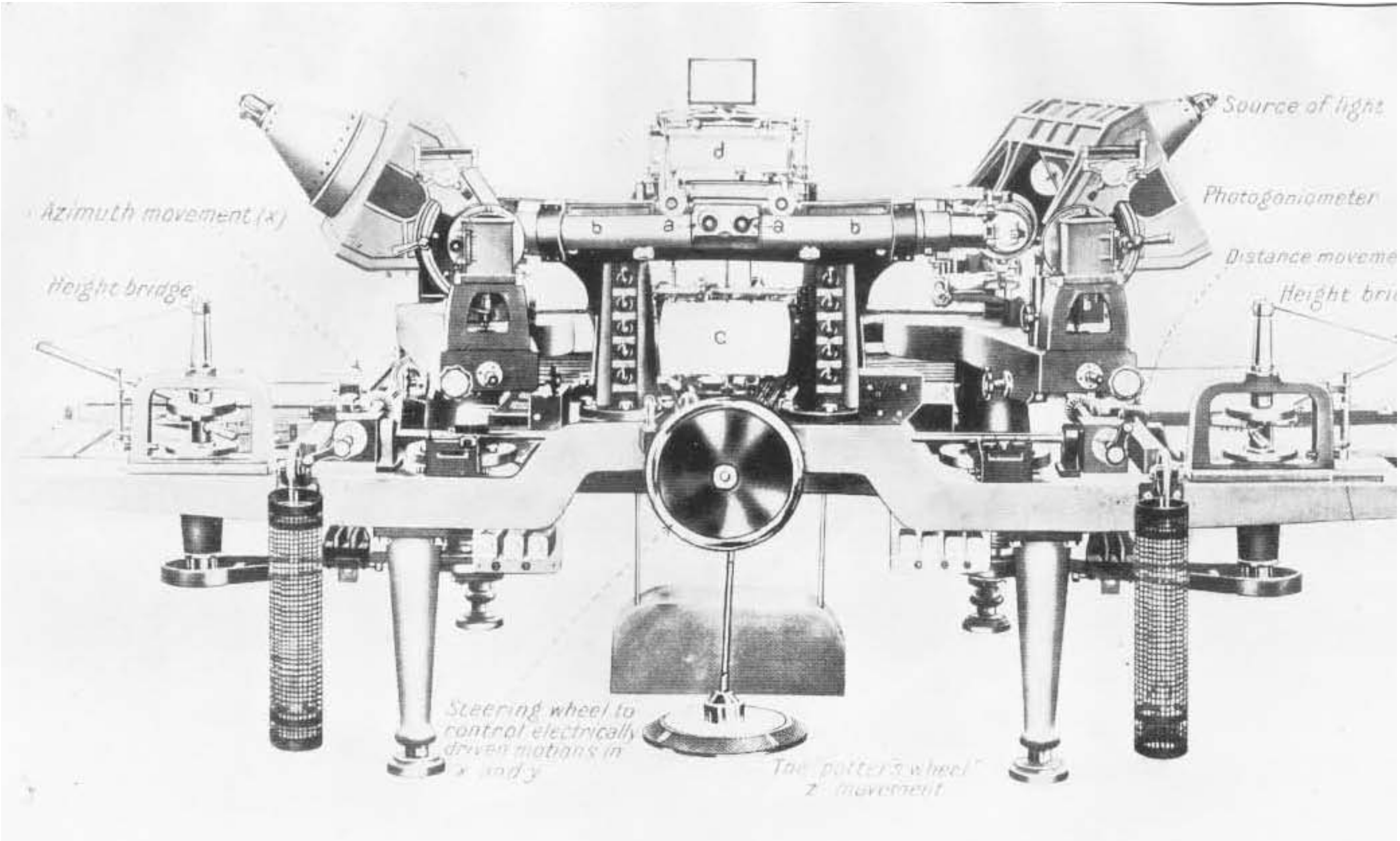
The stereoplanigraph is a more difficult instrument to grasp than the autocartograph. This is partly due to the employment in its construction of a number of daring optical expedients, or combinations, and partly, in my opinion, to a real lack of that simplicity which is so desirable.

The essential difference between this resection type and the autocartograph is that the positions of exposure in space change places with the position of intersection. The plotter, or observer, is "at the point." The photogoniometers are the positions in space and they are movable, therefore, away from, and in relative height to, the observer.

Plate VII, *Figs.* 11 and 12, give general views. Several features in them are easily identifiable. The plotting table, on the right in *Fig.* 11 and on the left in *Fig.* 12, is clear, and so also are the two photogoniometers which appear on the top rear of *Fig.* 11 and on the right of *Fig.* 12.

The driving-wheels for X and Y motions are seen on the left and right of the front of the instrument, in *Fig.* 11, and the "potter's wheel" (Z co-ordinate) appears below the observer's position. The eye-pieces of the binocular telescope are identifiable, on *Fig.* 11, vertically above the potter's wheel.

Before going further, it will be as well to show generally the



THE AUTOCARTOGRAPH

mechanical movements which measure the X, Y and Z co-ordinates. Looking at *Figs.* 12 and 14, it will be seen that the photogoniometers are mounted upon a carrier which slides up or down between two steel guides. This up-and-down movement is the Z or height movement (effected by the potter's wheel). The carrier and its vertical guides stand upon a metal drum which slides backwards and forwards along a stout steel cylinder, and brings the photogoniometers nearer to, or further from, the observer. This is the Y movement (effected by right-hand drive). The X movement is a simultaneous motion of the two survey marks. Now, these marks are in

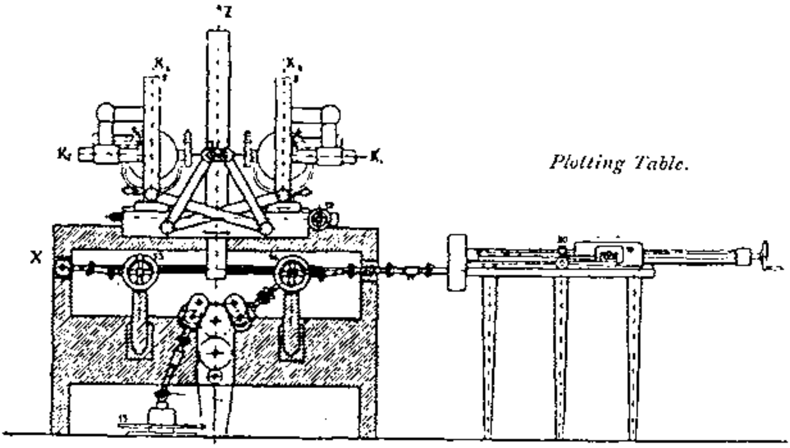


FIG. 13.

Key to Fig. 13. *Front view.*

K_1 K_2 Carden Axes.
2. Survey Mark Carrier.
6. Adjustment of Dove prisms.
12. Adjustment of shifting PP_1.
13. X-drive.
14. Y-drive.
15. Potter's wheel (Z-drive).
19. Sliding arm.
20. Drawing pencil.

objectives, which are on the rear face of the main instrument, and can be seen at the instrument end of the two guides (whose object will be explained later) which lead from the photogoniometers (see *Fig.* 12 and *Fig.* 14). The distance between the two objectives (with their survey marks) should—if we were going to construct the actual triangle—be zero. As that is not, instrumentally, possible, the distance between them is made equivalent to that length on the autocartograph distance-piece, which is kept constant, between the right- and left-hand arms (see *Fig.* 10).

Fig. 14 gives a bird's-eye view of the instrument. It will be seen from this figure that there is no direct connection between the survey marks (P and Q of *Fig.* 14) and the photogoniometers, to connect the apparent movements of the survey mark with the corresponding Y and Z movements.

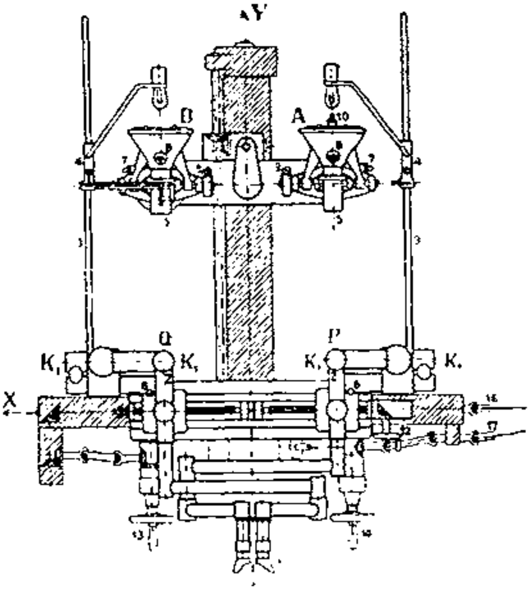


FIG. 14.

Key to Fig. 14.

A and B. Plate holders.
P and Q. Survey marks.
K_1 K_2 Carden axes.
1. Eye-pieces.
2. Survey mark carrier.
3. Auxiliary combination guide and cam.
4. Guide-block of combination guide.
5. Auxiliary combination.
6. Adjustment of Dove prism.
7. Adjustment of parallax.
8. Adjustment of swing.
9. Adjustment of tilt.
12. Adjustment of distance between survey marks.
13. X-drive.
14. Y-drive.
16. Transmission of X.
17. Transmission of Y.

Consider P and Q as one point R (see *Fig* 15).

When the machine is set at R, correct for the stereoscopic fusion of images a' and a'', the parallactic angle at R is along a definite bearing measure of the distance of that point from the air base. Suppose we now look at images b' and b'', we have then to move the goniometer-carrier further away (although, for simplicity, in *Fig.* 15 we have moved R by a corresponding distance back to R'), and what enables us to see b' b'' (instead of a' a'') are auxiliary lens combinations which hinge at points h' and h''. One can imagine the optical axes or lines of collimation between R and h' h'' (R′ and h' h'') as being elastic yet taut strings. The auxiliary combination is composed of a bi-convex and a bi-concave part. It hinges in front of the goniometer lens, at the rear focus of the combination, and brings the rays to a point again on the survey mark. But as the photogoniometer moves

Fig. 15

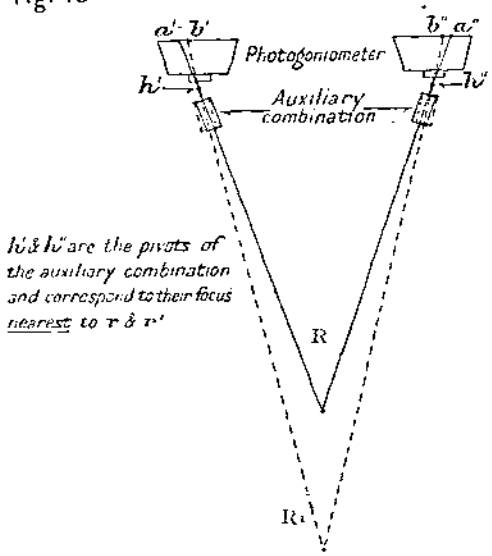
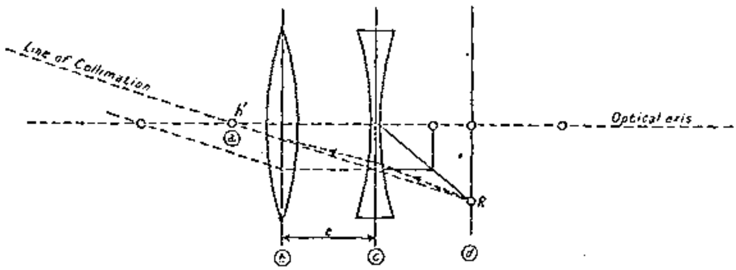


Fig. 16. AUXILIARY LENS COMBINATION.



As y co-ordinate increases ⓐ (the pivot) moves to left with the Photogoniometer, ⓑ moves by the same amount, ⓒ not so much and by separating from ⓐ increases distance ⓒ ⓓ — maintaining focus on R (the survey mark) which remains fixed

backwards and forwards (see *Fig.* 16) the image must be brought to a point at varying distances from h', and this is effected by a movement of the bi-concave lens relative to the bi-convex.

The movement of the lenses in the combination is regulated by a cam on a guide shown in *Fig.* 14.

One advantage secured by this arrangement is that the magnification of the image at R′ is greater than it is at R, and by an amount equivalent to the greater distance of the point from the air base. Now this is a real advantage over the autocartograph. Accuracy of plotting depends primarily on the size of the parallactic angle, but it is also influenced by the size and clearness of the image. In the autocartograph the background diminishes in scale. In the stereoplanigraph the same scale obtains throughout.

Before leaving the auxiliary system it will be well to add that it moves, or pivots, on h' and h'', vertically as well as horizontally, and so completes the optical connection in both Y and Z. It is unnecessary, probably, to add that the auxiliary attachment and the carden-links carrying the survey marks correspond to the telescope of the theodolite portion of the goniometer previously explained.

Now to hark back to the survey marks, we come to an amazing optical system. Four serious troubles arise in the design of the binocular telescopic system :—

(*a*) The inclination of the line of collimation, from goniometer to survey mark, varies with the position of the goniometer. The lines of collimation (h' R, h'' R, etc.) are thus not normal to the plates unless an equivalent rotation is given to the objectives which carry the marks.

(*b*) If such a rotation is given, it will also rotate the landscape, viewed in each eye-piece, round the optical axis—and in order to maintain a proper stereoscopic fusion some counteracting optical measure is necessary.

(*c*) The observer must, for convenience, remain sitting in the same position, but the X movement would carry eye-pieces with it, were connection between survey marks and eye-pieces rigid.

(*d*) The images have to be reversed in order to allow them to be seen in their proper relative positions.

The first point is met by the insertion of optical carden-links and by the rotation of the objectives carrying the survey marks.

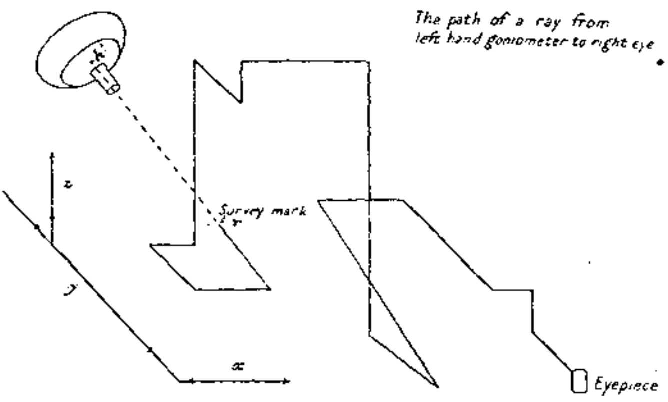
These carden-links have the additional effect of rotating the landscape round the particular image which is being plotted. The effect of this rotation (the second of the difficulties alluded to) is to introduce a loss of parallelism between the eye base and the air base. But, to obtain a satisfactory stereoscopic fusion, the proper relationship must be maintained, and, in order to counteract the rotation, Dove prisms are introduced in the paths of each ray.

Difficulty (*c*) might have been solved by carrying observer, chair and all, on the X movement. Admittedly this would be drastic and, consequently, to meet both *c* and *d*, no less than 16 optical (and mostly working) joints are interposed between each eye and its survey mark, in order to procure the necessary elasticity and inversion.

The dotted line (h' R of *Fig.* 17) is, however, kept in its correct position by the guide which directs the auxiliary combination upon the survey mark (and turns the latter to face the required direction), and it would seem that, if this optical line is kept to its proper azimuth, *i.e.*, if the image of the point in question is brought to a focus on the survey mark, any subsequent irregularities between the survey mark and the eye are relatively immaterial. Loss of light can, however, hardly be avoided.

The preliminary adjustments are such as to reconstruct the exact relative positions of the cameras in the air. There are, therefore, adjustments for tilt, swing and direction of optical axis on each goniometer.

Fig. 17



The geometry of the solution of the position in space is simple enough, and needs no detailed explanation, but it implies that each goniometer is relatively at its correct height. On one, therefore (left-hand, looking from the observer's seat), there is an adjustment for height relatively to the goniometer carrier (in the Z co-ordinate). It is also necessary to allow of a small adjustment in Y (or range) to compensate for the projection of the ray into the required plane, and on the right-hand goniometer a slide is provided by which this adjustment is made.

The survey marks are movable relatively to each other on the X (or azimuth) movement in order to set to, and clamp at, the distance proper to the occasion. Once clamped, the survey marks move together, and no longer relatively to each other.

The plotting-board pencil moves over the surface of the board according to the movements of the X, Y and Z drives. It is connected to them by worm gearing with jointed shafts and bevel gears. The scale of the instrument itself, *i.e.*, of the landscape as one measures it, is limited by the length of base available (38 cms.), but any scale can be used for plotting which lies between $\frac{1}{25}$ and $\frac{25}{1}$ of the instrument scale. A gear-box connecting the drives to the first (and, perhaps, only) table allows of a range from $\frac{1}{5}$ to $\frac{5}{1}$, but a similar and second table drawing a second map adds the additional factor. It is noteworthy that Y and Z drives can be altered in purpose, in order to allow of plotting over the whole range of possible tilts. The arrangements so far discussed are suitable for plotting between tilts of 40° and 90° (from the vertical). The Y and Z movements can be exchanged for tilts from 0° to 50°.

The preliminary arrangements for adjusting particular views to the control points follow pretty well the same order as those described for the autocartograph. I think, perhaps, they are inclined to be a little more tedious, because of the care required in effecting the adjustments. The instrument is not of so robust a type as the autocartograph, or so it seemed at the time of our visit. The time taken to adjust the two views separately and then to combine them is about four hours, normally, but may be cut down with vertical axis and horizontal axis pairs to about two hours. Plotting is, I think, easier on the stereoplanigraph than on the autocartograph. With the latter we made errors of 6–10 metres in plotting pretty consistently for an hour or two. With the former the average was considerably less.

The size and weight of the stereoplanigraph are very similar to those of the autocartograph. No details are available as to price, but it is certainly of the same order as, and will probably be found identical to, that of the autocartograph.

The same number of staff, two permanent and one half-timer, are required for working.

The stereoplanigraph is a fascinating instrument and Doctor von Grüber, who explained it to us with great patience, is as great an expert as he is courteous as a guide.

SUMMARY.

There are at least three models of these machines on the market. Of these the Nistri pattern is known to us only from advertisement, in which few details are given. It is not possible to pass judgment upon it.

The autocartograph designed by Professor Hugershoff and manufactured by Gustav Heyde is a large and costly instrument, but does actually perform the task it attempts. The stereoplanigraph manufactured by Zeiss and Co. of Jena is also a practical and efficient instrument. Both models are of general application; that is, they will plot from a stereoscopic pair at whatever angle exposure may be made in space. They are, in this respect, a considerable advance upon the stereo-autograph.

The photogoniometer, which enters into their design, is a valuable instrument in itself. The plotting machines are too heavy to accompany any but large formations to the field, but a photogoniometer might prove invaluable with lower formations, and particularly so if a good measure of the tilt of exposure can be made.

For any large operation a stereoscopic plotting machine of the autocartograph, or stereoplanigraph, type would be of the greatest value.

Their purchase price will be against their introduction into peace-time surveys, and the more so as they are fitted neither for cadastral nor for small-scale mapping. Nevertheless, the call for good topographical maps of areas which are difficult of access, or which offer only a short field season, is not an uncommon one. If photographic surveying is chosen as the suitable method, then it would seem that the last two instruments I have described would be well worth a trial, for, if the price be forbidding, the subsequent labour in the office is more than correspondingly lightened. In my opinion the greater initial cost would soon be wiped off in competition with any photographic method based on the rectification of individual exposures. This is, of course, only an expression of personal conviction, but it is borne out by history. Photographic surveying (or rather, topography) from ground stations has gone through the same graphic stages as we have recently passed through in mapping from air photographs, and has developed into the stereoscopic stage represented by the stereo-autograph.

It is probable that the precision obtainable from air photographs will never be of the same order as that from more stable, and easily fixed, ground stations, but the autocartograph and stereoplanigraph can plot from such photographs as well as from those taken in the air.

Perhaps, after all, the most serious impediment to the more general use of these German instruments is the limitation to their employment imposed by the makers.

Thus up till recently governments were graciously allowed to purchase so long as no private work was done, and private purchasers had to form national companies which then acquired, on agreement to pay royalties, the sole national rights. Such restrictions are obviously well-nigh intolerable, but will have the welcome effect of setting us all to work to design something for ourselves.

AUTHORITIES.

The *Stereo-autograph* of Von Orel, to which the autograph owes its general design, is described in *Maps and Survey*, 2nd Edition, Cambridge Press, by A. R. Hinks, and in the *Geographical Journal* for April, 1922, by the same author.

The *Autocartograph* (a previous model) was described by Major M. N. MacLeod in the *Geographical Journal* of April, 1922.

The *Autocartograph* and *Stereoplanigraph* are described in the Report of the Air Survey Committee, No. 1, 1923. H.M.S.O. (*Plate* VI, *Figs.* 8 and 9 are borrowed from this Report.)

German literature is voluminous on this question. The following are quoted as bearing particularly on the design of the machines described above.

"*Leitideen bei Konstruktion der für Raumbildmessung dienenden Auswerte-Instrumente.*" Dr. Otto V. Grüber, Jena. (An extract from an article in *Mitteilungen aus dem Markscheidewesen*, 1922.)

"*Der Stereoplanigraph der Firma Carl Zeiss, Jena,*" von Dr. Otto V. Grüber. An extract from *Zeitschrift für Instrumentenkunde.* (*Figs.* 13, 14 and 16 are borrowed from this atricle.)

"*Grundlagen der Photogrammetrie aus Luft Fahrzeugen,*" Hugershoff and Cranz, Stuttgart, Witwer, 1919.

"*Die Phototopographie und ihre Andwendung auf Flugzeugaufnahmen,*" von Dr. Ing. R. Hugershoff. (An extract from the *Geographische Anzeiger*).

A very useful bibliography is given in Appendix VI of the Report of the Air Survey Committee for 1923.

THE TRAINING OF TERRITORIAL R.E. UNITS.

By MAJOR H. G. EADY, M.C. and CAPTAIN G. E. GRIMSDALE, R.E.

THERE appeared, in the September number of the R.E. JOURNAL, an article on the training of a Territorial Army Field Company, in which a very comprehensive, though perhaps rather Utopian, scheme of instruction and organization was outlined. The article did not, however, more than touch upon the most important period of training—the annual camp; and it is the purpose of the present writers merely to try to add a few notes on this period, to show the main difficulties which arise, and to suggest means by which assistance could be given to the T.A. units by regular units of the Corps.

So far as the training previous to camp is concerned, one feels that the difficulties were, if anything, underestimated in the September article, at any rate for units in the London or industrial areas. One is up against "*unavoidable* cases of absence," which cannot be altered by the "nature of the instruction given, the recreational facilities provided, or the state of the organization of the unit." These absences, causing the continual change in personnel present on consecutive nights of instruction, make progressive training of any kind extremely difficult, with the very limited number of instructors at the disposal of the unit. Everyone will agree with Major Palmer's statement that "the foundation on which the efficiency of the unit can alone be built is an organization in which each of its members carries out personally the duties which belong to the post which he holds"; and one of these duties is the instruction of men by the unit officers and N.C.O.'s. Herein lies the main difficulty, a difficulty which is greatly emphasized at camp, as the facilities for educating these officers up to the standard of instructors are small. Every officer, during the first four years of his commissioned service, has to complete a six-weeks' course at the S.M.E., a course which may be carried out in instalments at considerable intervals of time. This is the only obligatory training at a school of instruction which he has to undergo, and during this period he is supposed to get the grounding of all the technical work of a field company. Can this be in any way adequate to train him to train others? He is the first to acknowledge that it is extremely inadequate. The only further training that he obtains, except in the camp period, is in the evenings in the drill hall, where the sole instructors are the permanent staff, who have all other ranks to cater for; in the days spent on musketry; and in the occasional week-end staff rides. The scheme of correspondence courses, suggested in the previous article, is an admirable one for increasing the theoretical knowledge of the officer personnel, but it cannot really deal with the difficulties of teaching the practical instruction of others.

The beginning and end, then, of the difficulty in the pre-camp period, really seems to be—lack of instructional staff.

Before discussing actual camp organization, one must again emphasize the great difficulty with which the P.S. has to contend—that practically no two individuals in the unit have reached the same standard of training. Many sappers have possibly never seen a pontoon, except in a store, and have never handled an explosive; drivers have never driven horses, except from a cart; and horses are provided which have never been in service harness. Alongside these are N.C.O.'s with possibly considerable war experience, but whose knowledge of training is small, and rusty. In addition, one often gets officers who have only been commissioned just previous to camp, and who are completely untrained, not only in the technical branches, but also in the elementary drills, etc. To compete with all this, there is still only the same permanent staff. Now, if any real value is to be obtained from such a short period of training, the first essential is a thoroughly organized scheme, which can only be based on an adequate provision of officers, etc., qualified to instruct. It is again this fundamental basis which is lacking in the most important early days of camp. Most T.A. officers of any service, and many N.C.O.'s, are fit to carry out the instruction of their unit after a sharp "brush up," but, as has already been pointed out, they have neither the time nor the facilities for really keeping up-to-date in their practical training. What, then, seems essential during the first days of camp, is an intensive course for officers and N.C.O.'s, so as to fit them to undertake the instruction of their subordinates, while the other ranks can be kept in the all-important hands of the P.S. drill instructor. It is exactly at this period that the Adjutant and his staff are most heavily employed on other duties. Camp details, pay troubles, sanitation, orders, rations, horse-lines, etc., in units which have, to all intents and purposes, just been mobilized, will occupy almost the whole time of the P.S. The Adjutant has to be the father and the mother of the unit to ensure smooth working. It is physically impossible for him to do this and to supervise adequately the training of officers and N.C.O.'s. Lectures, demonstrations, etc., take many hours' careful preparation, especially when so much has to be crowded into so short a period, and when it is so essential to capture and hold the interest of the audience. The administrative work and this instruction cannot be done by one man: the adjutant must obtain assistance, as his P.S., however excellent it may be, is scarcely likely to be capable of instructing officers and N.C.O.'s in all branches of the technical training required.

To overcome this difficulty, it is suggested that regular officers should be attached for the period of camp. There are many who could be made available for this purpose, and not many would be required. There are only fourteen divisions to be catered for, and one officer per division is really all that is essential. This officer would be under the orders of the C.R.E. and Adjutant, and would assist them generally in organizing and carrying out the training programme. He would be informed some weeks or months before camp as to which division he is to be attached to, and he could then get into close touch with the C.R.E. and P.S., and could probably get to know the unit officers as well. It is suggested that these officers could easily be supplied from Chatham, the R.M.A., and especially from the ranks of those whose time is spent in theoretical instruction or administrative services, who would probably benefit considerably themselves by a short period in direct contact with troops. The scheme is really as much for the benefit of the regular side of the Corps as for the T.A. Few regular officers understand very much about the T.A. units, the difficulties under which they labour, and the sacrifices of time and leisure they make in efforts to obtain adequate training with inadequate material, unfit and untrained horses, few facilities for practical experience, and lack of instructional staff. There can be no proper *liaison* until this lack of understanding is eradicated. The writers last year completed a camp in the positions of adjutant and attached officer, and can vouch for the keenness with which this scheme was accepted. The units concerned received with enthusiasm the suggestion that a regular officer should be attached to them to help, did everything in their power to further the success of the scheme, and certainly provided the attached officer with an extremely interesting and pleasant fortnight.

It is tentatively suggested that the scheme should go further, and that throughout the rest of the year a considerable amount of assistance could be given by officers and N.C.O.'s of regular units to the T.A. units in the same areas and commands. This is, however, beyond the scope of this short article.

Finally, the writers would like to call attention to the courses for T.A. officers at the S.M.E., though fully realizing that they are stepping in where the proverbial angels fear to tread. The S.M.E. messes generally are large, with an ever-changing population. This all naturally tends to the formation of interests, which are either rather self-centred, or which centre round the "batch"; but at the same time, it is essential to realize that the T.A. officer very largely depends on his course at Chatham for his outlook on the regular side of the Corps. This outlook is very much coloured by the way he is treated in the various messes, and if there were only a closer personal *liaison* between regular officers, especially those most junior, and the T.A. officers, with a fuller realization of the latters' point of view, there would be a greater mutual regard, and a deeper conviction that all ranks, whether regular or territorial, belong to the same Corps.

THE NEXT GREAT WAR.

By Capt. B. H. Liddell-Hart.

I. Science and Military Strategy.

In seeking to estimate the nature of the next great war, the course of our thought must inevitably reflect the progress of scientific invention. This development, whether for good or ill, is the supreme factor in modern civilization and is affecting the organization and mentality of national communities in such measure that it is only reasonable to suppose that the methods of war will reflect the ever-changing face of civil life.

The field of survey is so great that some bounds must be set on our researches for the purpose of the present study. Otherwise the problem appears almost too wide to tackle by any other method than the unrestricted imagination of a Jules Verne or an H. G. Wells.

This is the realm of possible scientific *discovery*. The future may undoubtedly bring to fruition the dreams of the sensational novelist—discovery in bacteriological and electrical science may lead to the wars of the future being waged by means of the germs, or the green, purple and other rays, lurid in hue and effect, which form the properties of the prophet-novelist. But for a reasoned attempt to forecast the nature of the next war we cannot rely on suppositional discoveries of such a revolutionary character. Scientific *invention*, on the other hand, is concerned with the evolutionary development of the powers and properties which are already known to us.

The restriction of our survey within these limits appears justified historically by the precedents of past wars. History shows us that no entirely new weapon has radically affected the course of any war; that the decisive weapon in a war has always been known, if but in a crude and undeveloped form, in the previous war.

It is foolish, also, to leave out of account the natural conservatism and prudence of military hierarchies or the parsimony of governments in regard to expenditure on military experiment in peace-time.

Let us, therefore, meditate on the probable lines of development of existing means of war instead of launching out into fantastic speculations which may prove but chimeras in the desert of future war—futile of advantage for practical military needs. Such a study divides itself into two natural realms—those of strategy, which is pre-eminently the science of communications, and tactics, which is the domain of weapons.

To put it more simply, strategy is concerned with the primary element, movement, and tactics with that of destruction—whether it be of the enemy's flesh or his will-power, the bodies of his troops or the nerves of his commanders and government.

A Means of Test for Military Truth.

Having considered our potential opponents, we come to the kernel of our subject—the effect of scientific invention on our next major war, in regard both to strategy and tactics.

The common method in speculations on the future is to rely solely on imagination, swayed, possibly, by the personal prejudices and inherited ideas of the author. Such a method, though harmless in a Wellsian novel and all too common even in traditional military literature, is surely both vain and out of place in any study which aims at a serious military purpose and as a guide for rational thought.

We require some means by which we can test the various hypotheses and ideas which are advanced, so that we may co-ordinate them and classify them scientifically according to their several values.

In other words, the paramount need is for what may be termed a compass or test-tube for military thought. It would surely appear that such a scientific means of test may be found if we can establish the fundamental principles of war—those which history shows us have been proved true and immutable by the experience of all past wars.

Since the end of the last war there has been a general realization that the absence of such a synthesis of basic principles was the root cause of the failure, common to all the warring nations, to adapt without perilous delay the prevailing methods to the changes in the conditions and weapons. As a result numerous attempts have been made to formulate the essential principles. The present author has been guilty of one such attempt.

That at least an approximation to truth has been obtained is shown by the fact that in essentials nearly all these syntheses agree, the differences being mainly of terminology or degree of comparative value assigned to the respective parts of the table.

In order to avoid, or at least minimize, controversy, it is proposed, for the purpose of this study, to take as our means of test the table of principles set forth in the official *Field Service Regulations* of the British Army. Eight principles are listed: the principle of the Objective, for in every operation of war an objective must be determined and held in view throughout; the principle of the Offensive, which may be more simply termed "hitting"; the principle of Security, or guarding; the principle of Mobility, which is necessary both for successful hitting and guarding. The other four principles given are those of Surprise, Concentration, Economy of Force, and Co-operation.

Colonel Fuller has divided these principles into two groups, the first four being the "elemental" principles which are derived directly from the four main elements of war—mind, movement, weapons (*i.e.*, destruction), and protection (*i.e.*, maintenance against destruction). The other four he terms "accentuating" principles.

Elements :—				
	Mind	Movement	Weapons	Protection
Elementary Principles :—				
	Objective	Mobility	Hitting	Security
Accentuating Principles :—				
	Surprise	Co-operation	Concentration	Economy of Force

Having thus got a table of fundamental principles, we can proceed to test all new ideas on armament, movement, and organization by means of it, although with reference to the probable conditions under which the latter will have to function.

In order to keep our survey within limits, we shall deal only with the two concrete elements, movement (or communications) and weapons, which are the basic factors in strategy and tactics respectively, and in this article with the first only.

Communications.

As strategy precedes tactics in chronological order, let us first deal with the subject of communications and the effect on them of scientific inventions. Movement—a simpler word for communications—is of three categories—by land, sea, and air. These main categories may again be sub-divided—land-movement into track (road and rail), and trackless, sea-movement into surface and submarine, air-movement into heavier and lighter than air.

As they are to-day, what are the relative advantages of each? Let us examine these three physical elements and apply the test of our synthesis, for the sake of "economy of space" only mentioning those principles which are relative to the points under consideration. From the point of view of *mobility* air is easily first, land (rail) second, sea third, and land (road) fourth. For *surprise* movement, sea was first and land second, whether by rail or road—before the introduction of aerial observation. Now, so far, at any rate, as a European theatre of war is concerned, the surface of the sea has lost much of its advantage as a medium for surprise through secrecy. Moreover, it is the element which is least suitable for the attainment of secrecy through movement by night combined with concealment by day. Surprise by sea is, therefore, limited either to movement in submersible vessels, or on the surface at such a range that a complete " bound " can be made during the course of a single night. What regions are included in this definition? The coast of France, Belgium, and Holland alone. The Mediterranean also is ruled out by reason of the distance between our naval bases, should any Mediterranean power be included among our enemies. Nor even, were the Bosphorus held, could we reach any point on the Russian Black Sea *littoral*.

For *concentration*, and to a lesser degree for *economy of force* and *co-operation*, the sea remains supreme for long-range movement. So long as we do not lapse to a position of naval inferiority and so long also as we maintain the asset of our mercantile marine, we can best fulfil these principles strategically through the medium of amphibious operations. Sea transport still holds the palm for bulk capacity and simplicity of organization. *Security* is dependent on the command of the sea, and to a lesser degree, on command of the air.

Next, we come to the air. For *mobility*, this channel of movement is easily superior to any other, and its margin of superiority must inevitably increase rather than decrease, as it is immune from the effect of natural obstacles, while it enjoys a decrease of atmospheric pressure, which retards movement. In regard to *surprise*, at low altitudes air transport is the most difficult of any to conceal, but there is no reason why aircraft movement should not be carried out at levels which preclude observation from the ground under the normal climatic conditions which prevail in Europe. Further, the speed of aircraft is such that the need for secrecy in order to achieve *surprise* is considerably discounted. Being trackless, aircraft have a considerable advantage in regard to *security*.

Are we to assume that the air must necessarily become the sole medium for military movement? No, because there are certain inherent defects which threaten its otherwise preponderating advantages—viewed as a means of communication for the existing pattern of military forces. In the first place, aircraft have to descend at some time and their landing places are vulnerable, particularly if temporary sites in the zone of the armies. Secondly, the carrying capacity of the heavier-than-air type is still very limited, whilst the gas-filled airship, although at present rather better in this respect, presents too great a target surface. In other words, the essential requirement of *concentration* is wanting, which defect weighs down the scales against air transport.

Turning to the land, we realize that movement by rail is governed by the communications established in peace-time. These, among the Powers of Western Europe, are unlikely to undergo any extensive alteration for commercial purposes, whilst definitely strategic railways excite suspicion and thereby defeat their object so far as surprise is concerned.

Russia, the one country affording scope for a commercial extension of the railway, is the least likely of possible Allies, while its distance from this country makes our use of such communications improbable, and discounts any consideration as regards the organization of our forces.

The railway, moreover, is of all means of communication the most difficult for secrecy, and most open to the operations of all branches of enemy intelligence. *Surprise* in *direction* or *time* is a virtual impossibility, and even in *quantity*, or concentration, increasingly hard to obtain with the development of observation from the air. Nevertheless, the railway, by reason of its transport capacity, remains at present the best medium for the achievement of *concentration*. In *mobility*, even in countries where the road system is highly developed, the railway is also far superior not only in regard to speed but because of its carrying capacity in proportion to space occupied. For *security*, road communication is a degree superior to rail, offering a more-easily concealed and more widely spaced target, a larger choice of alternative routes, and being more quickly reparable after damage has been inflicted. But if one transcendent lesson is to be drawn from the experiences of the last war, it is the inadequacy of either road or rail communication to cope with the requirements of modern armies. From the first German onset of August, 1914, to the final Allied advance of 1918, this lesson stands out above all others. Yet in neither of the cases we have mentioned were the difficulties in any considerable degree the result of hostile interference from the air—the trouble was from within rather than from without.

It is surely undeniable, however, that aircraft means of action must increase in range and effect, rather than diminish, with the passing years.

If this progress be axiomatic, then the nation which continues to organize its military communications on the basis of roads and railways is running for a fall.

What is the alternative? The condition common to both these means of communication is that they move along fixed tracks, which cannot be varied save after a long period of labour and preparation. The opposite method to tracked movement is trackless. There is already in existence a means by which the fixed and prepared track is no longer a necessity—the chain-track machine, such as the Citroen tractors which have recently conquered the Sahara.

Let us study this form of movement over land.

Mobility, so far as speed is concerned, seems at first to be inevitably worse than by road transport—the slowest of all existing means of communication. On a level and prepared surface there can be no question that, where equal motive power is employed, the wheeled vehicle must be faster than the chain-track one. If the power is increased disproportionately in the case of the latter machine, then on economic grounds at least the change is for the worse.

But are the majority of roads level or of a good surface? Far from it! Moreover, this defect will be increased in most of the regions where our army is likely to operate, both by their existing shortage and by the heavy traffic caused by military movements. If we regard Russia as a probable enemy the weight of this consideration is multiplied. On roads that have been cut up or are little better than tracks, the caterpillar vehicle scores in speed every time over the wheeled vehicle. In the next place, the roads, of Europe particularly, are far from level, considered as a whole. On gradients, the caterpillar machine with the new sprung track is actually faster than the wheeled vehicle of equal horse-power; the feet of the track grip the surface better than the wheel, and have the further advantage that they damage the surface less—a factor of immense importance, not only for war but also for peace purposes.

Therefore, for the conveyance of loads the use of the caterpillar lorry is better *economy of force* than that of the wheeled lorry, for its margin of superiority on poor surfaces is immense, whilst on good surfaces, except in flat country, its lesser speed in proportion to power output on the level is balanced by its greater speed per horsepower in undulating country. The principle of *economy of force* tells us that a vehicle which has a definite commercial value has a decided advantage from a military standpoint, as its chances of mechanical development are greater and its expansion in emergency assured.

For *surprise*, the fact that the caterpillar vehicle can move off the roads defeats the enemy's *information* and establishes its superiority over the wheeled vehicle, which is of necessity tied to the arteries of traffic—these are shown on the map and can be kept under observation from the air.

In *concentration*, the caterpillar machine solves the problem of congestion, which has always been the brake on concentration of force at the decisive point.

It is not suggested that roads will be abandoned—so long as good roads exist it is more advantageous to use a smooth surface than a broken one. But the chain-track does enable the concentration of traffic on any particular line of movement to be multiplied, not merely double or quadruple, but tenfold, twenty-fold, or even more. Moreover, even on the road the volume can be increased. The weight which can be carried in wheeled transport is regulated by the pressure per square foot which the road surface can support without damage. A three-ton lorry is the largest which normal roads can carry, and even then the injury is soon manifest. Thus on 100 yds. of road space only some 24 tons can be borne by wheeled lorries, whereas by using 24-ton caterpillar lorries approximately 170 tons could be carried with an actual reduction of pressure per square foot on the surface. This reduction of road space required not only multiplies concentration, but necessarily increases the *mobility* of a force.

Security is made possible of achievement in the case of chain-tracked transport, for on the approach of danger from the air it can move off the road and seek shelter or decrease the target by dis-dispersion—possibilities which are denied to the present lorry, with its one-dimensional power of movement. The former machine could, moreover, afford to sacrifice a fraction of its weight-carrying capacity in order to protect directly, by armour plating, the vital parts against any injury except that inflicted by a direct hit.

Future Development.

In what respect is progress likely in these various means of movement as the result of scientific invention? If our speculations are to have any practical value, it is useless to indulge in flights of the imagination which take no account of the many problems of science still to be solved. We should confine ourselves to improvements of detail in means already existing, keeping our feet on the solid rock of truth as it is known to-day, rather than assuming, as certain, changes which involve a revolution in principle.

On the sea the large capacity submersible is a proved possibility. It does not, however, seem likely to supersede the surface ship as a general means of transport, as the cost and space wasted in making a ship submersible is not economic, and holds out no compensating advantages for mercantile purposes. As such vessels will necessarily be restricted to use in war, the number of them will, owing to financial causes, be small. They will, therefore, be available only for the conveyance of small striking forces against special objectives.

On land, neither railway nor road transport offers a prospect of radical development from a military point of view.

The cross-country machine capable of moving on and quitting the roads at will is an established fact and only requires improvements of detail. One line of development is a machine which will combine wheels with a caterpillar track for alternative use. More probable is a further improvement in springing, which will render feasible the use of an ordinary motor-lorry engine and at the same time enable the machine to move on roads at a speed equal to that of the present wheeled lorry and without appreciable increase of wear on the road surface.

In the air the airship, with its huge volume of gas-filled envelope in proportion to its small lifting power, is uneconomic.

In *mobility*, the aeroplane will still make progress. In *surprise* also, both by reason of its speed, and by the use of protective colouring and engine silencers. Its *security*, however, is hampered by the laws of gravity. Armoured protection can only be gained at the expense of carrying capacity, *i.e.*, *concentration*, and even then is only possible within narrow limits. Practical experiments on present lines do not augur well for the production of the giant air liners beloved of the imaginative novelist.

Our conclusions, then, in regard to the strategic communications of the Imperial Military Forces, can be briefly summarized.

As an island state the first stage of our communications will still be by sea, in surface-travelling ships. Submersible transport can however, be used to launch by surprise small and specially-composed striking forces at suitable objectives.

The second stage of our communications, on land continents, should no longer be based primarily on the railway, but on caterpillar transport. *Mobility* indicates that the latter should move on the roads, provided that sufficient are available. *Surprise* indicates that movement should, so far as possible, be by night "bounds." *Security* tells us that caterpillar transport will quit the roads and move across country on the approach of enemy aircraft and on reaching the zone where contact with the enemy land forces may be anticipated.

Aircraft transport may become a useful auxiliary, like the submersible ship, but no more, so long, at least, as ground troops remain a staple part of the national forces.

2. Science and Tactics.

It is proposed in this second part of the article to discuss the element of weapons, which is the main constituent of tactics, and to discover, as far as may be, the probable development of weapons and their respective values, as affected by the progress of scientific invention.

The Scientific Development of Weapons in Relation to the Existing Arms of the Service.

1. Infantry.

At present the infantry unit resembles the stage brigand—with weapons of different kinds and patterns sticking out of every portion of his anatomy.

To its staple weapon, the rifle and bayonet, have been added the light automatic, the machine-gun, the grenade—hand and rifle, explosive and smoke, the light mortar, and in some armies the accompanying gun, which is also advocated for our army in the form of pack artillery.

Is it advisable to utilize so varied an assortment of weapons?

The keynote of the value of infantry is *mobility*, or rather, locomobility—its still unique power to move in, over, and through every yard of any given locality. All these new weapons certainly add to the hitting power of infantry; but do they detract unduly from its mobility?—that is the test question. If they reduce that essential mobility to an appreciable degree, they discount the value of the increase in fire power. Could fire-power alone win victory there would be no place for infantry even in the armies of to-day; the auxiliary arms can supply a far more potent fire. But infantry can carry its fire to close quarters and supply that tangible human threat which makes the enemy run.

Important as is fire in paving the way for the advance, it is in forward movement that the decision rests. The legs of the infantry are as essential on the battlefield as their "arms."

Therefore we surely ought not to allot to infantry weapons which may induce it to rest content with firing on the enemy from more or less stationary positions.

If we apply our test of *mobility*, the machine-gun, the light mortar, and the accompanying gun are surely condemned at once as infantry offensive weapons. Either they fall ever further to the rear during the infantry advance or the pace of the real infantryman has to be checked constantly in order not to outstrip them. In the former case they are valueless assets to the infantry; in the latter case they render the infantryman bankrupt of his mobility.

The tests of *surprise* and *security* confirm this conclusion. These new weapons attract far greater attention and present a far larger target than the "pure" infantry.

Depending for movement on limbers, pack mules, and—in the final stage—man-handling, they cannot afford the direct protection of armour, while at the same time they cannot avail themselves of the indirect protection of ground cover to the same degree as the infantry.

The principle of *economy of force* tells us that our organization should be as flexible and interchangeable as possible for tactical efficiency. Weapons which lead to dispersion of effort and wide variations of mobility are condemned by this test.

Internal *co-operation, i.e.*, within the battalion, always one of the chief problems of battle, becomes far more difficult when the fractions which have to co-operate vary in armament and mobility.

The light automatic and the grenade suffer from the same disabilities but to a lesser extent. The danger in the case of the grenade can be avoided if the quantity issued to infantry is reduced to very small proportions. To do this in the case of the explosive grenade is to make it a negative asset, and therefore it should be reserved solely for the clearing of fortified defences. The effect of the smoke grenade is, however, of such value in proportion to its bulk, that it is economically sound to carry a few for action even in open warfare.

Owing to the usure of ammunition by a light automatic, the fact that it requires a minimum of three to four men for its service, and the appreciable loss of mobility entailed by it, it is open to question whether it is superior to a section of well-trained riflemen. A reduction in weight that would make it more handy is a likely step in development, but this improvement would not justify its issue as an individual weapon owing to the rapid expenditure of ammunition.

2. Cavalry.

The arguments for and against the retention of cavalry have been discussed at such length since the war that to recapitulate them would only be wearisome.

Apply the test of *protection* (*i.e.*, *security* to themselves), and the answer is so transparently clear that for a civilized war it is decisive. Cavalry in bulk are so vulnerable a target that they cannot exist on a modern battlefield. On the one hand, they cannot avail themselves of the direct protection of armour, nor, like the infantryman, can they make use of the indirect protection of ground. The cavalry charge, therefore, is dead—at least against efficient troops.

Further, as the use of any instrument in war depends on the existence in peace of its means for production, the horse must eventually become extinct in course of time, as it is being rapidly ousted for all commercial purposes. The horse cannot be bred rapidly in large quantities in emergency as can be manufactured mechanical weapons and means of transport.

Although, however, the supply is decreasing and will necessarily continue to decrease with the years, the progressive release of horses from the artillery and transportation services will ensure sufficient for the possible needs of cavalry for some period yet.

As cavalry are clearly obsolete for *hitting*, is there sufficient reason to justify their retention for the *security* of the army?

For long-distance and large-scale reconnaissance aircraft have displaced the cavalry body. But for close and wooded country the cavalry trooper moving on the ground can obtain detailed information denied to the observer above.

The obvious solution to the problem we have propounded is that a certain proportion of cavalry should be retained for this purpose until such time as the locomobility of the caterpillar-tracked machine is fully equal to that of the horse in every respect.

But the obvious solution is not necessarily correct. The man on foot is necessarily more loco-mobile than the man on horseback. The latter's superiority rests only in his *speed*, which is but a part of *mobility*.

A small and light chain-tracked machine could be produced even now which would move over any kind of ground traversable by cavalry, except dense woods and hill tracks. If the general mobility of such a machine is greater than that of the cavalryman and the loco-mobility of the man on foot is similarly greater than that of the cavalryman, the deduction is surely that the sum of the two is greater. Any reconnaissance, therefore, could surely be carried out far quicker, and with at least equal results, by a chain-tracked machine, whose crew could leave their machine when necessary and carry out the detailed exploration on foot, than by the cavalryman. Moreover, the need of the latter for a horse-holder when he dismounts for reconnaissance over very broken ground infringes the principle of *economy of force*.

3. ARTILLERY.

What are the probable developments of the artillery in *mobility*, *hitting* and *security*? Let us consider this arm in two categories —field artillery, including both light and medium guns; and heavy artillery.

(*a*) *Field Artillery.*

These can only improve in mobility by being motorized, which implies that they are to be hauled by a caterpillar tractor, mounted on or carried in a caterpillar transporter, or fitted in a tank.

An increase in mobility will automatically increase the power of *concentration*.

Neither of the first two methods will affect indirect *security* by secrecy, but the third will diminish the possibilities of concealment by ground.

Direct *security* by protection while in movement, is only possible, by fitting the gun in a tank. The latter method loses the protection given by an emplacement, but compensates for this loss by the double security given by armour and by the fact that it is a moving target.

Finally, this method enables the gun to dispense with the necessity for being guarded, or secured, by another arm. The abolition of the need for an infantry escort or screen in front of the gun simplifies the problem of *co-operation*, the most difficult of all principles to fulfil in war.

Security against the enemy's information is likewise far easier to achieve if the gun is constantly changing its position, as it will if fitted in the tank, or to a lesser degree if mounted on a transporter.

(*b*) *Heavy Artillery.*

As this form of artillery is already moved mechanically, an appreciable improvement in *mobility* cannot be anticipated. *Hitting* power is the only factor susceptible of material progress.

The question is rather as to the value of heavy artillery. First, let us consider *hitting*. The aeroplane can hit with equal effect, but not so rapidly or frequently. It can also hit a moving target with greater acuracy. If the armies of the future are to be composed of mechanically-moved units, the heavy gun loses its target. In that case the heavy gun will be relegated to the bombardment of fixed fortified bases or towns, as it was in the past; it will lose its utility with field armies.

Secondly, *security*. The heavy gun cannot hit its aggressors, the aeroplane and, possibly, the tank, while they can hit it with impunity once they discover its location. By reason of its size, it is difficult to secure it against enemy information and blows.

4. Tanks.

Let us now test by our table the tank of the modern type, with its sprung track, maximum speed of 28-30 m.p.h., and an average speed across country of 15-20 m.p.h.

In *mobility*, the tank has a vast margin over all other arms except cavalry, which, however, is placed out of court by reason of the fact that it can never use its speed against modern fire-arms.

In *secrecy* (for *surprise* and *security*) the tank is inferior to the other arms. Its speed, combined with the power of discharging smoke-clouds, redresses this defect to a considerable degree, but does not entirely balance it.

Hitting power demands a more detailed examination and must be weighed with *concentration* and *economy of force*. The economic unit of infantry which corresponds approximately to the tank is the platoon, the replacement, repair, and petrol cost of the former being balanced by the fact that the pay, food, and maintenance of its crew is but a fraction of that of the platoon. The infantry platoon has an armament of two light automatics and 24 effective rifles, even including section commanders and the spare men of the light automatic sections. To this must be added a half-share in a machine-gun and an eighth share in a light mortar. Assessing the tank armament at the minimum of one 6-pounder gun and three light automatics, the fire-power of the tank is seen to be clearly superior, especially when it is remembered that the tank can fire during movement, whereas the platoon has its fire-power reduced by one-half, at least, owing to the need for covering fire.

Co-operation, again, is demonstrably simpler in the case of a self-contained tank than between four infantry sections.

Security likewise gives the tank a clear margin of superiority over all arms, for it alone can carry direct protection by armour. The field gun's armoured shield is not all-round protection, nor is it available during movement.

5 AIRCRAFT.

Although these are at present organized as a separate service, apart from the military forces of the nation, they must be included in any survey, as they act over land and, therefore, exert a profound influence on the action of the land forces.

Let us, therefore, consider aircraft strictly in regard to their operation against the land forces.

In *mobility* they have a tremendous superiority over all the other arms.

In *secrecy* (for *surprise* and *security*) they are at an equal inferiority tactically, for, save in exceptional conditions, early warning of their approach is obtainable. Against arms which have the power of quickly sheltering, like infantry, under cover of ground, or, like tanks, by rapidity of movement and the use of smoke-screens, this lack of secrecy of approach is a disadvantage.

In *concentration* of hitting power, aircraft are difficult to assess. Their development is, however, subject to restrictions, due to gravity, from which the ground-moving arms are free.

In *co-operation* they share in the advantage of the tank.

In *security* they are, at present, most vulnerable save for the indirect security afforded by their mobility. The armoured aeroplane is, however, already in course of development. But this protection, to whatever degree it is increased, will always be subject to the limitations of gravity. Here lies the joint in the aeroplane's harness.

6. THE GAS WEAPON.

No investigation of future war can overlook this weapon, which cannot be abolished by the decrees of Leagues and Conferences.

Economy of Force.—Its speed and economy of manufacture is superior to that of any other weapon, because it is the only one which is a commercial product, manufactured from chemicals which are an essential requirement of peace-time industry. In emergency, therefore, there is no need for the tardy establishment of special plant.

Mobility.—In speed of discharge it is necessarily supreme, because it is continuous, which not even the quicker-firing missile projector can be.

Surprise.—In secrecy of manufacture it is unequalled, because its constituent chemicals are commercial products, and can, therefore, defeat the enemy's *information.* All other weapons are, in part at least, destined for a definite military purpose, and so their production in quantity cannot be kept secret except at the expense of *concentration* of hitting effect.

In *secrecy* of discharge it is paramount, because it is noiseless, and, if used at night or combined with smoke, invisible.

In *hitting power* and *concentration* it is supreme, firstly, because its volume is infinitely greater than any projectile—the most rapid-firing missile projector, the machine-gun, can only fire 600 bullets in a minute, whereas the gas cylinder can discharge millions of invisible bullets or molecules in the same time; secondly, because, unlike any projectile, it leaves no voids unswept in its beaten zone; thirdly, because it requires no skill in aiming and is therefore unaffected by the emotions or physical deficiencies of the firer.

Security serves to emphasize the superiority of gas, for an antidote can only be produced by those who know its actual constituents. Therefore, the users of a new kind of gas possess an almost certain chance of effecting a surprise against a totally unprotected enemy, whilst they themselves have a complete immunity from danger from their own weapons. The indirect value of this immunity is even more far-reaching than the direct, for their progress is in no way hampered by the fear of masking fire or by the curtain of an artillery barrage. Thus the dreaded interval between the lifting of fire and the actual clash of the troops is abolished.

It may be argued that we cannot consider the employment of gas, because the moral sanction of the peoples is refused to it. But if it be demonstrated that gas is more humane than any missile weapons, because it can achieve its object—the capitulation of the enemy—equally well in a non-lethal form, this moral prohibition on its use will be removed.

The Elimination of Traditional Arms.

Having surveyed the probable developments in weapons and analysed the qualities of each, let us endeavour to draw conclusions from them. To do so, let us consider the various arms of the service and their weapons in relationship to each other. As gas is established in our mind as the weapon of the future, let us make it the starting-point of our comparison. How can the respective arms protect themselves against its effect? Aircraft, by rising above it; tanks, by being air-tight and producing their own oxygen inside whilst being impervious to the outer atmosphere; infantry, cavalry and field artillery by the use of some form of respirator. A respirator is only proof against known kinds of gas; it cannot be worn for long without incapacitating its wearer from active exertion; it cannot protect the whole body, unless it be transformed into a complete diver's suit, in which movement would be almost impossible. If a man cannot move freely, he cannot fight. If a horse cannot move, what use is his rider? If the artilleryman cannot serve the gun freely and the gun is immovable, field artillery is useless. Therefore, we are left with the aeroplane and the tank as the only effective arms, if gas becomes a standard weapon.

This conclusion is reinforced by the fact that, as gas requires a projector, the latter needs to be carried. To move it mechanically is obviously better in every respect than to move it by muscular power—for *mobility*, *surprise*, *concentration*, *security* and *economy of force*.

Given that the factor of bringing gas to its place of discharge is equal, cloud gas is infinitely superior in effect to shell gas. This consideration rules out the artillery as its means of projection.

But are even two separate arms necessary? Cannot the use of aircraft dispense with the need for tanks or the reverse?

No, because they act in different elements, possess different qualities and limitations, and neither is decisively superior to the other when they meet in direct opposition.

In offence the aeroplane is invulnerable, so long as it remains at a sufficient altitude. But from this height it can only hit the tank by a rain of gas. Against this weapon, infantry, cavalry, and artillery can only protect themselves fully at the price of their mobility and hitting power—in which case they have no value. The tank, however, can be made air-tight and defeat the purpose of the aeroplane. Therefore the aeroplane is forced to descend very low, if it is to have a chance of hitting by bomb or bullet so small and rapidly-moving a target as the tank. If it flies low, the tank can hit back effectively. The odds in such a contest would be on the side of the aeroplane because of its infinitely superior speed and its power of three-dimensional movement, but they would not be long odds, because the effect of gravity weights the scales against the aeroplane and in favour of the tank in the struggle to increase *concentration* of fire-power and *protection* by armour. In its turn the tank has a clear margin in counter-offence by attacking the landing and refilling grounds of the aeroplane. The latter is severely handicapped here, because it can only conduct its defence from the air.

These bases of the aeroplane can, however, be fortified against the tank's attack. Here we discover the only future use for infantry and artillery—as the stationary defenders of these fortified bases.

Therefore, when gas is installed as the primary weapon, our deduction is that the forces which act over the land will be composed principally of aircraft and tanks, with a certain proportion of heavy artillery as fortress destroyers, and of infantry, armed with super-heavy machine-guns firing armour-piercing bullets, and light artillery as fortified base-defenders.

Let us assume, however, that the warring powers will abide by the wishes of the League of Nations and Disarmament Conferences, and that they will not employ the gas weapon. To what extent will our deductions be affected? To solve this question let us propound, and try to answer, a series of questions.

1. What are the foes of infantry and how can it act against them? First, the *hostile infantry*—whose resistance is based mainly on machine-guns and light automatics. How does it counter these? Not by its own fire so much as by the aid of artillery and tanks. Infantry is only self-sufficient when it has passed through the organized screen of enemy fire and got to grips with the hostile infantry.

Co-operation between two different arms is so difficult in practice that a single arm is clearly preferable if it can act as effectively. The only part of the infantry attack which the tank cannot execute with infinitely greater efficiency and economy is the final phase of digging the enemy out from their earths—natural or artificial.

Second, the *enemy artillery*—whom it is usually powerless to reach and whom it can only counter by the aid of other arms; unnecessary problem of co-operation once again.

Third, the *enemy tank*. Infantry cannot act offensively against the tank, because the speed of the latter can always enable it to avoid conflict at will. Infantry's only direct means of defence against the tank are by anti-tank accompanying gun or machine-gun, or by the land mine.

If either of the former category of weapons is used, we are brought back to the old struggle of projectile *v.* armour, with the odds all in favour of the tank, because, being mechanically moved, it can increase its ratio of *protection*, whereas the infantry anti-tank weapon, being muscle-moved, cannot increase its ratio of penetrative power without becoming immobile. If it becomes immobile, it is useless to infantry in the field; if it adopts the other alternative and becomes mechanically moved, it is no longer an infantry weapon, but a tank.

As regards the land mine, the only form which can be portable and rapid in employment is one which is small and visible; even then it suffers from the grave defect that it negatives *offensive* action by infantry. Such a mine can be exploded harmlessly by some form of tender in front of the tank. If a large land-mine is used for buried systems, it is only available for restricted areas and in stationary defence, a confession that infantry are only fortress defenders.

Fourth, the *enemy aeroplane*. Infantry in the open have no effective means of hitting the aeroplane unless it comes low. The aeroplane, on the other hand, can remain at a moderate height and by bomb and bullet inflict serious injury on its helpless victims, who can only hope to lessen, not to escape, casualties by dispersion or by turning themselves into human moles.

Thus we are forced to the conclusion that, as infantry cannot effectively *hit* any of its opponents except by co-operation with other arms—a co-operation to which it contributes no assets—its value in war vanishes, except for two special functions. These are, first, as the defender of positions fortified by nature or art, and secondly, as the " ferret " to eject from these positions its opposite number.

It is needless to consider cavalry, for it suffers from all the disabilities of infantry, save only that by reason of its speed it has an increased chance of escaping from the tank, but less from the aeroplane because of the greater target which it offers.

2. What are the foes of field artillery and how can it act against them?

First, the opposing artillery—for which it needs the *co-operation* of aircraft for information. Aircraft can destroy artillery, which cannot—as does the tank—escape by speed, without the co-operation of any other arm.

Second, the infantry. While artillery suffers less risk from infantry, the last war proved that it is less effective than the tank in destroying infantry. If this was so in a war of positions, how much greater the disparity in a war of mobility, where the infantry can hope to escape artillery fire by movement, but never the tank.

Third, the tank. The field-gun was undoubtedly the most effective anti-tank weapon of the last war, but it is questionable whether, in the later stages, it destroyed more tanks than the latter destroyed guns. Such successes as it obtained were against tanks moving at not more than 3 m.p.h. What chance would it have against a tank zigzagging at a speed of over 20 m.p.h.? If it cannot hit, it will be hit. To have any chance the gun must have a fixed mounting with all-round traverse—in which case it is no longer a field weapon, unless it is fitted on a tank! The latter method is the obvious solution, for only a weapon of equal mobility can compel the tank to come to action.

Finally, we come to the aeroplane and the tank, which have already been considered in their relation to the other arms and to each other. How and with what weapons will aeroplane fight aeroplane and tank fight tank? Not with gas, because both the aeroplane and the tank can be made gas-proof. Rather, with armour-piercing projectiles. Both machines are independently moving and fighting self-contained units, fulfilling in the higher degree the principles of *hitting power*, direct *security* by armour, *economy of force*, facility for gaining the *objective*, *surprise*, *mobility*, and *co-operation* both between the parts and from above, which here signifies that the commander has the power of instantaneous control. What established type of fighting organism already possesses the combination of these qualities? The warship.

Thus the tactics of tank *versus* tank must, of necessity, conform in principle to those of naval war, while overhead Tennyson's " Airy navies grappling in the central blue" find literal and not only figurative fulfilment.

If, therefore, we have at our disposal for use on land a machine capable of fulfilling the complete rôle of a self-contained fighting organism, which can dispense with the need for external *co-operation*—that thorniest of problems—is it a rational policy to retain arms which are essentially incomplete?

To do so would be equivalent to the folly of sending a thousand swimmers armed with grenades and supported by floating batteries to attack a man-of-war. Everyone realizes the farcical nature of this suggestion. Is there not a want of common-sense in the common failure to grasp the superiority of the tank over an amalgam of infantry, cavalry, artillery, and infantry-bound tanks—the latter like mongrel curs snivelling at the heels of a stout and sluggish dowager instead of like hounds on the scent of their quarry.

Summary.

The sum of our deductions is clearly that military operations in the future, the exact date being still indefinite, will be carried out almost exclusively by fleets of tanks and aircraft which will be maintained by communications based on the caterpillar tractor, with the aeroplane transporter as an auxiliary or secondary line of supply. Under these conditions heavy artillery and infantry will alone survive of the other arms, the former functioning again in the original defensive rôle of garrison artillery, whilst infantry will become a species of "land-marines" for the defence of fortified bases and to be discharged as "landing" parties, from the bowels of a tank fleet, for "ferret work" against suitable objectives. But to suppose that this metamorphosis from traditional armies will be accomplished as by the wave of a wizard's wand betokens an ignorance of the slow fruition of all new changes throughout history, due to the natural conservatism of the military masses even more than that of the leaders. When, as at present, this conservatism is reinforced by the most severe financial stringency, we must realize that "axes" are more probable than "wands" and have a keener edge. The consummation of the common-sense pattern army which we have sketched is therefore likely to be a slow process, comprising a series of limited "bounds."

REINFORCED BRICKWORK.

By CAPT. T. W. D. MILLER, M.C., R.E.

Description.—These notes are collected from work done in the erection of an Officers' Hostel at Chaklala, near Rawalpindi. This building was originally designed for a single Allahabad tiled roof over a jack-arch ceiling, while the verandahs were to have reinforced concrete roofs. The A.C.R.E. considered that the appearance of the rooms would be much improved by the use of a flat ceiling; and that cost would be reduced by employing reinforced brickwork in the verandahs, not only in the flat roofs but in the bressumers.

The idea is the same as in reinforced concrete, the tension stresses being taken by steel bars in the joints, while the compression stresses are resisted by the brick in cement, which here takes the place of the mixture of broken stone, sand, and cement used in concrete. The system was used on a large scale in the erection of Government buildings at Patna by the P.W.D.

Excluding temporary roofs of mud on reeds and matting and semi-permanent roofs of mud on planks, there are four types of flat roof for permanent buildings in India.

1. Tiles 12 in. long by 2 in. thick, set in lime, covered with mud or lime concrete and carried on either wooden joists or steel beams.
2. Reinforced concrete.
3. Reinforced brickwork.
4. Cement concrete on jack-arches.

Considering the first alone, it makes a good roof for servants' quarters; it is cheap and cool; the mud, however, wants constant attention, and even the lime concrete is washed away at times; wood is always liable to attack by white ant or rot, and steel beams only 12 in. apart are expensive; both wood and steel require periodical oiling or painting.

The disadvantages of reinforced brickwork in comparison with reinforced concrete may be stated as:—

(*a*) Comparatively few variations, *e.g.*, a slab can only be 3-in. $4\frac{1}{2}$ in., 6 in., $7\frac{1}{2}$ in. or 9 in. thick.

(*b*) Lack of flexibility, *i.e.*, the bars must be $4\frac{1}{2}$ in. apart in a 3 in. slab, and 3 in. apart in a $4\frac{1}{2}$-in. slab. The size of the bars must be kept low or cement is wasted in the joints. Waste of iron is probable, for the spacing cannot be varied as in concrete, and English $\frac{7}{16}$-in. and $\frac{9}{16}$-in. bars are not always obtainable in India.

(*c*) Possibility of cheating on iron, as each bar is placed separately and hence the iron framework cannot be viewed and passed as a whole, before the laying of the bricks is started.

(*d*) Waste of cement by careless workers, who let the joints get too big.

The advantages appear to be :—

(*a*) Economy in cost.

(*b*) Centring may be made lighter, as there is no ramming ; the face need not be so highly finished, and the joints need not be so close.

(*c*) More fool-proof, especially as the masons are accustomed to lay brick floors ; and as there is less likelihood of the reinforcement being displaced during laying.

(*d*) For beams no side-centring is required.

There are, of course, local considerations. At Chaklala bricks are very cheap (Rs.14 8an. per thousand) while good stone has to be brought 20 miles by rail, and costs Rs.9 4an. per 100 cub. ft. delivered on siding in $1\frac{1}{2}$ in. cubes ; it has then to be broken to size for reinforced concrete. The method seems better suited to an Indian workman who likes to work squatting, and does not make a success of ramming.

Erection.—The ceilings were erected as continuous spans from wall to wall, supported at intermediate points by the trusses, which were at 10-ft. spacing; the slabs varied from two spans in the residentia quarters to five continuous spans in the dining-hall. The tie-beams of the trusses were formed of two channels (3 in. by $1\frac{1}{2}$ in. or 4 in. by 2 in.) back to back, above which the ceiling went. The tie-beam, which thus projected through the ceiling, was boxed in with planking for the sake of appearance. See *Photo* F.

The system of laying was as follows :—The rods were bent to shape on a template on the ground, and the ends bent over to form a hook. After the centring had been fixed, a steel bar was placed over the supports at each end of the slab and the rods were threaded on these. After a course of bricks had been laid, a rod was pushed against this, and fixed at its proper height by a couple of wooden wedges. A number of bricks were then laid, thus permanently fixing the reinforcement, after which the wedges were withdrawn and the course of bricks completed.

The lower side was usually coated with lime plaster for appearance, the upper side of the ceilings was left rough, but the upper side of the verandah was brought to a plane surface with a skin of cement : this formed a waterproof coating.

The centring was left in position for ten days at least, and thereafter no one was allowed on the completed work for another week.

All roofs exposed to the sun were made in sections of about 20 ft., separated by $\frac{1}{2}$ in. expansion joints. These spaces were covered by half-round Allahabad tiles.

Calculations.—The system adopted is the same as for reinforced concrete: the safe stress on brickwork in cement being taken as 600 lbs. per sq. in., while steel is only taken as at 14,000 lbs. per sq. in., as a precaution against the use of inferior steel.

As shown on page 16, *Reinforced Concrete*, Part II, when brick and steel are equally stressed:

$$n' = mr\left\{\sqrt{1+\frac{2}{mr}}-1\right\}.$$

See *Sketch* II.

It has been found advisable, at least for a slab with its small depth, to have not less than one per cent. of reinforcement. Hence

$$n' = \cdot 418 \text{ and } 1-\frac{n'}{3} = \cdot 861.$$

The moment of resistance of the steel is given by Equation 4, Appendix II, *Reinforced Concrete.*

$$T = tr\left(1-\frac{n'}{3}\right) bd^2,$$

which, where $r = \cdot 01$, $t = 14{,}000$ lbs. per sq. in., and $\left(1-\frac{n'}{3}\right) = \cdot 861$,

$$\text{gives } T = 120\cdot 5\, bd^2.$$

Similarly, the moment of resistance of the concrete is

$$c = \tfrac{1}{2}\, c\, n'\left(1-\frac{n'}{3}\right) bd^2 = 108\, bd^2.$$

The lower value (108) must be taken in calculations.

Similarly, the constant for ·8 per cent. steel is 98.

Consider the roof of a verandah, 10 ft. wide, say, 10·5 ft. for calculations. See *Sketch* I. Take a 14-in. strip, equal to 4 bricks and 4 joints. Assume $4\frac{1}{2}$-in. depth is required.

Load per sq. ft.

Brickwork in cement $\frac{3}{8}\times$ 120 lbs.	=	45 lbs.
Cement plaster ... ... say,	=	1 lb.
Occasional load	=	20 lbs.
		66
	say,	70 lbs.

Load on 14-in. strip.

$$=\tfrac{7}{6}\times 70\times 10\tfrac{1}{2} = 857 \text{ lbs.}$$

$$B=\frac{WL}{8}=\frac{857\times 10\cdot 5\times 12}{8}=13{,}500 \text{ in lbs.}$$

$$M_R=108\,bd^2 \text{ and } b=14$$

Hence

$$d^2=\frac{13500}{108\times 14}=8\cdot 9$$

$$d=2\cdot 98 \text{ in.}$$

Allowing $\frac{1}{2}$ in. for cover, we get $3\frac{1}{2}$ in., hence $4\frac{1}{2}$-in. thickness must be used.

Amount of steel at 1 per cent.

$$=14\times 3\times \tfrac{1}{100}=\cdot 42 \text{ sq. in.}$$

This is in four bars, each of which must be ·105 sq. in.: hence one $\frac{3}{8}$ in. bar at ·1104 sq. in. in each joint will do.

For the bressumer take a continuous beam over three spans, each of 10 ft., carrying verandah roof taken above. Assume a section of $7\frac{1}{2}$ in. by $10\frac{1}{2}$ in. Load, 66 lbs. per ft. sup. Take width of verandah 10·5 ft. to allow for projection. Allow ·8 per cent. of steel.

Then load due to roof

$$=\tfrac{1}{2}\times 10\times 10\cdot 5\times 66 \quad = 3465 \text{ lbs.}$$

Weight of bressumer—

$$=10\times\tfrac{5}{8}\times\tfrac{7}{8}\times 120 \quad = \underline{\ \ 660 \text{ lbs.}}$$

$$4125 \text{ lbs.}$$

The maximum bending moment in this beam is $-\frac{WL}{10}$ over central supports.

Hence

$$B=-\frac{4125\times 10\times 12}{10}$$

$$98\,bd^2=\frac{4125\times 10\times 12}{10}$$

$$d^2=\frac{4125\times 10\times 12}{98\times 10\times 10\cdot 5}=47\cdot 71$$

$$d=6\cdot 90 \text{ in.}$$

Hence $7\frac{1}{2}$ in. by $10\frac{1}{2}$ in. beam is suitable.

Area of steel $= 10.5\times 6{\cdot}9\times{\cdot}008 = {\cdot}58$ sq. in.

There are two joints, hence a $\frac{5}{8}$in. bar at ·3068 is suitable.

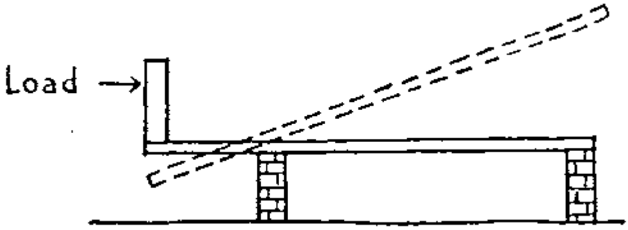
Similarly, in the end spans the maximum bending moment is $\frac{2}{25}$WL, and two $\frac{9}{16}$-in. rods will do; and in the centre span $B=\frac{WL}{40}$: two $\frac{7}{16}$-in. rods will do.

This bressumer is illustrated in *Sketches* IV and V.

Testing.—At present no accurate results for deflection under load are obtainable. At Patna the beams were tested to destruction and failed in the tension flange.

Some figures are given in the attached *Table* (p. 115). All the beams tested at Chaklala cracked along the longitudinal joints, apparently due to failure in tension or in adhesion. I was not very satisfied with the mortar, but at that time no testing machine was available.

An attempt was made to test a cantilever, with the idea of forming a sun-shade. There was some doubt if this would stand a load. The beam was of 10-ft. span with a cantilever of 3 ft. The free end of the cantilever was loaded with bricks as high as the staging would allow, but no sign of fracture was observed. The beam was then left for the night under load; something arose to upset the equilibrium, and the load on the free end lifted the inner end of the beam from its seating, the outer wall forming the fulcrum. Of course, as soon as this happened, the position of the points of contra-flexure shifted and the beam collapsed.



It would be very desirable if instruments could be obtained to take accurate measurements of the steel during test, as this would enable definite rules for the investigation of these beams to be deduced.

Cost.—Taken from bed-sitting room. Area of ceiling, 21 ft. 9 in. by 16 ft. 9 in. =364 sq. ft. Reinforcement parallel to long side of room, mortar 1 : 2.

I. *Materials.*

(*a*) Iron.

α. $\frac{3}{8}$-in. bars for reinforcement $2 \times 54 \times 12 \times \cdot 376$		487 lbs.
β. $\frac{1}{2}$-in. bars as anchorages $2 \times 17 \times \cdot 668$		23 lbs.
γ. Wastage		50 lbs.
		560 lbs. or 5 cwt.
(*b*) Binding wire, $\frac{1}{4}$ lb. per joint—		
$\frac{1}{4} \times 54$		$13\frac{1}{2}$ lbs.
(*c*) Cement		16 cwt.
(*d*) Sand α. In mortar	40	
β. Covering slabs	15	
γ. Waste	20	
	75 cub. ft.	
(*e*) Bricks at 500 per 100 F.S., including wastage $\frac{364 \times 500}{100}$		
		1820 No.

II. *Carriage.*

	Rs. a. p.
(*a*) Cement and iron, 2 carts at 10 annas	1 4 0
(*b*) Bricks, 1820 at Rs.3 2a. per thousand	5 11 0
	Rs.6 15 0

III. *Labour.*

(*a*) Fixing centring—	Rs. a. p.
5 Carpenters	12 0 0
8 Coolies	5 0 0
½ mate	0 12 0
	Rs.17 12 0

(*b*) Preparing iron, bending and wiring—	Rs. a. p.
3 Blacksmiths	4 12 0
4 Coolies	2 8 0
	Rs.7 4 0

(*c*) Soaking bricks in water, washing sand, laying bricks, covering with sand, watering, and finishing—

	Rs. a. p.
4 Masons	9 2 0
16 Coolies	9 12 0
3 Bhisties	2 7 0
½ Mate	0 12 0
	Rs.22 1 0

Note.—It is considered that 2½ masons should lay the brickwork in one day on straight work. The above includes raising all materials to the roof level.

(*d*) Striking centring—	Rs. a. p.
1 Carpenter	2 8 0
4 Coolies	2 8 0
	Rs.5 0 0

Resumé of cost, excluding cost of material for centring.

I. *Materials*—

	Rs. a. p.
(*a*) Iron, 5 cwt. at Rs.14 per cwt.	70 0 0
(*b*) Wire, 13½ lbs. at 4 ann. per lb.	3 5 0
(*c*) Cement, 16 cwt. at Rs.95 per ton	76 0 0
(*d*) Sand, 75 cub. ft. at Rs.7 per 100 cub. ft. ...	5 4 0
(*e*) Bricks, 1st class, 1820 at Rs.14 per 100 ...	25 8 0
	Rs.180 1 0

II. *Carriage* Rs.6 15 0

III. *Labour*—	Rs.	a.	p.
(*a*) Fixing centring	17	12	0
(*b*) Preparing rods	7	4	0
(*c*) Hanging roof	22	1	0
(*d*) Striking centring	5	0	0
	52	1	0

IV. *Centring, etc.*—	Rs.	a.	p.
(*a*) Share of carriage of materials for centring ...	2	8	0
(*b*) Share of cutting centring and making into panels	5	0	0
(*c*) Sundries, *viz.*, rope, nails, mortar pans	2	8	0
	Rs.10	0	0
Total ...	Rs.249	1	0

Rate per square foot $\frac{\text{Rs.249 1ann.}}{364}$ = 10ann. 11p.

Say, eleven annas.

The cost of the cementing to the top side of the exposed roof is Rs. 0 1a. 6p. per sq. ft. in addition.

For comparison, the agreement rate for reinforced concrete for this work is Rs.4 per ft. cube, which is a fair rate for lintels or posts, but would probably have raised a contractor's claim for extra on a panelled roof. The rate for jack-arch roofing (excluding cost of steel joists) is Rs.46 9a. per hundred ft. cube. Both above rates include allowance for centring.

PHOTOGRAPHS.

A. Shows reinforcement of verandah bressumer in position. The change at the point of contraflexure is clearly seen. The flat bars are not part of the reinforcement, but were ties to the tops of the verandah posts to resist the outward thrust of the sloping roof.

B and C. Show the laying of the verandah bressumer, for which calculations and drawings are given.

D. Shows rod in position wedged to right height.

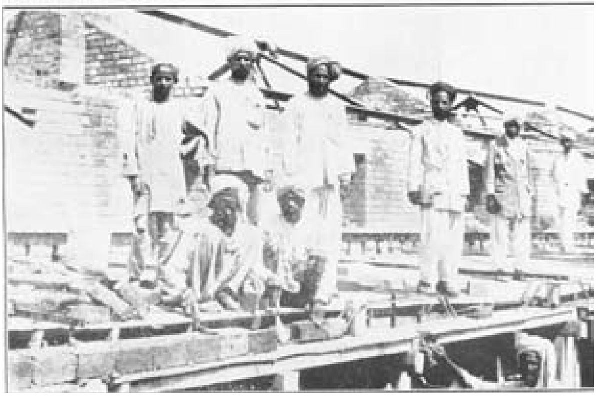
E. Shows laying in progress. The roof was cantilevered out to the left to form a sunshade over upper windows. Hence the rods are bent up to the top of the slab. On the right can be seen the anchorage bar, round which the ends of the rods are hooked.

F. Shows the centring of the dining-room being struck. The lower side of the ceiling can be seen in the top right-hand corner and the tie-beam of the truss that carries it.

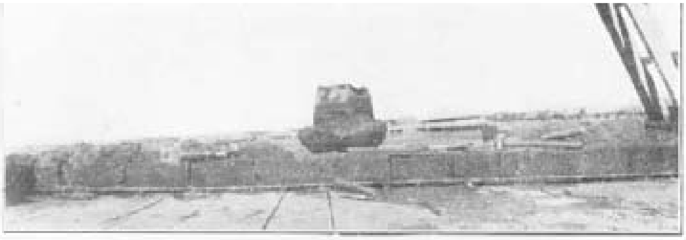
Conclusion.—The method of calculation and most of the hints on which the above paper is based were obtained from Capt. W. Hamilton, Garrison Engineer, M.W.S. Jhelum.

B.

C.



REINFORCED BRICKWORK



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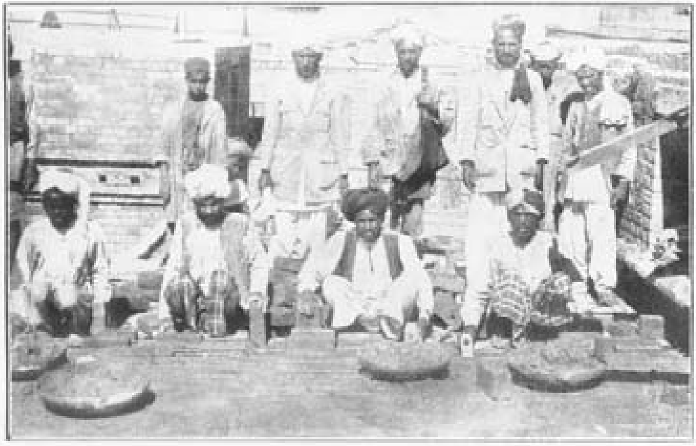
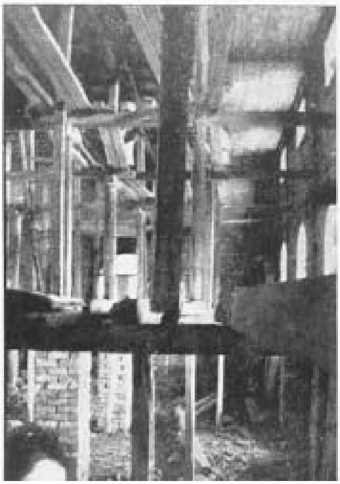


F.



PICTURES D, E, F

BEHAVIOUR OF REINFORCED BRICK BEAMS UNDER TEST.

Place.	Description.	Wt. of Beam. lbs.	Applied Load. lbs.	Total Dist. Load. lbs.	Deflection inches.	
Sialkot ...	Beam 12-ft. clear span, 14 in. wide, $4\frac{1}{2}$ in. deep, reinforced with five $\frac{3}{8}$in. bars. Tested 65 days after construction.	2775	756	3531	·05	Figures supplied by Capt. Wm. Hamilton, M.W.S.
			1512	4287	·12	
			2268	5043	·22	
			3024	5799	·33	
			3780	6555	·44	
			4536	7311	·61	
			5292	8067	·75	
			6048	8823	·89	
Chaklala ...	Beams 10-ft. span, 14 in. wide, $4\frac{1}{2}$ in. deep, reinforced with three $\frac{5}{8}$in. rods. Tested 14 days after erection.					ϕ Load was applied centrally, hence is multiplied by 2 to give figures in this column.
	(*a*) Cement 1 : 4	525	1170	1695	$1\frac{9}{16}$ in.*	
			1800	2325	$\frac{3}{4}$ in.	Beam failed.
	(*b*) Cement 1 : 3	525	462	987	$\frac{1}{8}$ in.	
			2100	2625	—	Beam failed.
	(*c*) Cement 1 : 1	525	510	1035	$\frac{1}{8}$ in.	
			3510	4035	$1\frac{1}{16}$ in.	
			3646	4171	$1\frac{3}{4}$ in.	
			3856	4381	—	Beam failed.

* Deflection reduced to $\frac{1}{4}$ in. when load was removed.

GERMAN RAILWAY WORKING, 1921–22.

By Bt. Major (temp. Lt. Col.) L. Manton, d.s.o., o.b.e., R.E.

"How is Germany to pay?" is a question which is exercising many minds in Europe to-day. There are many theories, but no solution has yet been made known. The French have, pending a solution, seized pledges which are to be productive, and among these pledges are the Railways of the Rhine and Ruhr. The British do not believe in the productive pledge policy: the German does not believe in the French pledge policy, but offers instead a far bigger pledge—to wit, the whole German railway system. The offer has not met with much enthusiasm, but certainly merits critical examination.

Such examination must be made with one object in view—the financial result of acceptance. And with the word "finance" one strikes at once the main stumbling-block, which stultifies any ordinary investigation from the business point of view. The only absolute standard of measurement, money, has disappeared from Germany. The *Mark* since 1919 has descended in value in a hyperbolic manner and, having now practically reached infinity, it makes it impossible to draw up a balance sheet for any business, let alone a railway. But even if one turns to pre-war figures and a stable currency, the accounts of the German Railways are not drawn up in a form which provides a definite basis for judging the undertaking as a business.

It was not treated as a business. The German Railways were not even a state railway: the undertaking was a federation of state railways, each state owning its permanent way, rolling stock, etc., each having different conditions of service for its personnel and each keeping separate accounts. Each state had a capital value debited against its railway property, but, being state property, this value was only to a certain extent represented by actual outlay or loans or private property of any sort. One might just as well talk of the capital value of the Navy or of the Post Office. The Railways were in the majority of cases built from state funds, in accordance with a "Budget," actual construction forming as a rule the subject of an "extraordinary" Budget. The ordinary "Budget" deals with normal current income and expenditure, including in the latter a proportion of the state debt service and the cost of construction of items costing less than *M.* 100,000—(£5,000); and it is this "Budget" which forms the main accounts of the German Railways and which shows the net surplus, commonly regarded as the "profit" on working the railways. That it is no "profit" in the true sense is evident from the fact that it does not emerge from a profit and loss appropriation account following on a capital account balance sheet, but merely from a statement giving the difference between income and expenditure.

As illustrating the difference between the ordinary Budget and the "extraordinary" Budget, it is interesting to quote the 1921 *Budget* figures (not actuals). An income of *M.* 37,504 millions was estimated, against an *ordinary* Budget expenditure of *M.* 48,339 millions, i.e. a deficit of *M.* 10,835 millions to be made up from public funds. In addition to this drain, State funds were called upon to provide for the "extraordinary" Budget, a further *M.* 24,796 millions, of which there was to be spent on

Rolling Stock building, and fitting with Kuntz Knorr brake *M.* 4,080 millions: and on

Construction generally, *M.* 2,114 million —

while the rest, *M.* 16,332 millions, was to pay an instalment to the individual states of the cost of acquisition by the German Empire of their railways.

These figures simply do not bear examination from a *business* point of view—they would be immoral. Whether they bear examination even from the point of view of State finance is doubtful, when one considers that the State in question is burdened with a Reparations debt. They are, however, sufficient to show that the accounts are not on a business footing, but, on the other hand, that the German Railway accounts differ in no important respect from the usual method of accounting for State funds.

On 1st April, 1920, the federation of State railways became *the* State Railway of Germany, and funds and accounts were centralized. Had conditions in Germany been "pre-war" in other respects, the accounts might have borne comparison with "pre-war" German accounts; but conditions are totally different.

How different must be briefly explained. In the first place, the railways were used as a reservoir to absorb demobilised soldiers, thus introducing (*a*) a surplus of personnel and (*b*) an unfair proportion of unskilled labour which hampered the efficiency of the skilled staff.

An actual comparison of numbers with pre-war is not possible from the figures available, but the German report gives the following figures as indicating relative efficiency. The German standard of "work done" is the wagon-axle-kilometre; and, while in 1913 a thousand wagon-axle-kilometres required 7·11 man-days, the same result was only attained in 1919 by 16·53, in 1920 by 14·46, and in 1921 by 12·78 man-days. Similarly, as an example of directly technical working, in 1914 the German locomotive consumed per mile 49·4 lbs.

of coal: in 1919, 75·9 lbs.: in 1920, 69·9 lbs.: and in 1921, 63·75 lbs. The corresponding figure for Great Britain is 54·8 in 1921 and 54·64 in 1922. The normal "peace-time" figure to which one used to work was 50 lbs.

Again, the rigid application of the eight-hour day forced a permanent increase of staff, i.e. the surplus of personnel became surplus to a lesser degree.

Thus, while the total employees of the State Railways numbered in 1921 in April 1,064,966 and in December 1,048,442, an order was issued in January 1922 to reduce staff, and by May a reduction had been effected of 43,124, bringing the total down to 1,021, 842. This was felt so severely that staff had to be re-engaged, and in the following four months 20,417 persons were enrolled. Allowing for a loss of 10,000 in Upper Silesia, the figure for the end of September 1922 is given as 1,032,243 heads. The variation is quite unimportant and shows that the eight-hour day effectually prevented economy in this direction.

In the next place, the whole flow of pre-war traffic was altered in direction and intensity by the loss of the Saar coalfields, the loss of the industries of the basin of the Moselle in Lorraine, the loss of the Upper Silesian coalfields, the loss of the agricultural produce of Poland and the deflections concurrent with the creation of the "Polish Corridor."

The year 1921 introduced particular difficulties on the German Railways owing to the introduction by the Allies of a Customs barrier on the east of the occupied territory, which caused very heavy delays to goods traffic. More important still was the drought which so hampered water traffic on the Rhine and the Elbe that the railways in the Cologne district and the Hamburg district suffered from very severe congestion. These transitory effects, however, are not as important as the permanent ones mentioned above. The loss of the Saar coalfields forces South Germany to turn for its coal to the Ruhr and Upper Silesia. Berlin, Hamburg and many cities of the coast area, which used before the war to depend on English coal, turned on account of the war and the subsequent devaluation of the *Mark* to the Ruhr and to Upper Silesia, only to find that, owing to Reparations deliveries, they were unable to get the quality of coal required and had again to turn to England; but in the meantime there was caused a tremendous expansion of the brown coal industry. Thus the wagons placed for brown coal loading in Central Germany rose from 1,961,820 in 1913 to 2,423,060 in 1921; in Saxony from 433,338 to 620,928 and on the left bank of the Rhine in the Cologne area from 628,859 to 892,708, and this expansion is continuing.

Again, all kinds of trade conditions have arisen which may or may not have a permanent character, depending on the way in which the future currency of Germany works out in relation between internal and external purchasing power. In 1921 the feverish prosperity consequent on inflation had begun to take full effect and resulted in an enormous increase of the manufacturing trade in Saxony and in the Ruhr. This had its effect on the ports of Bremen and Hamburg and caused railway congestion at these two places and in Dresden and Leipzig. It also affected agricultural trade such as, for instance, that of the potato markets. In peace time the west of Germany drew its requirements from Holland and Belgium. In the autumn of 1921, being unable to buy abroad, potatoes had to be imported from the Stettin district and from further east, which effect went so far as to create a record potato traffic through Stettin.

The last factor to which attention must be drawn is the irregularity of traffic caused by the Rates policy of the German Railways. Every time an increase of rates and fares was announced a rush of traffic followed to take advantage of those existing prior to the increase.

Even without the effect of the war weariness of the people, and even assuming the existence of a stable currency, such changes must render useless any comparison of post-war results with those of 1913. And the existing monetary conditions set the seal of impossibility on any examination of the working of the German State Railways by the ordinary monetary standard.

What standard is to be adopted? It is admitted on all sides that the railway is a public utility *business*; and the aim of that business is to sell "transportation," an intangible something which so far lacks definition and lacks it to an extent which is not usually realised. There is still much difference of opinion as to the method by which the output of a railway is to be measured and costed. This difference of opinion is clearly reflected in that the Ministry of Transport has introduced quite new statistics in England since the war. The English statistics differ from the German in very many respects and radically in that the basis to which the English work as a *standard of measurement* is the ton-mile of goods and the passenger, while the German uses the axle-kilometre, both for coaching and goods traffic, on which to base costs. Since costing is clearly impossible in the case of the German railways, one can only choose a few items of output for purposes of comparison with other railways whose costs *are* measurable.

The choice of items is a matter of considerable difficulty. It is necessary to explain briefly what ideas have governed the choice and to do this one must come down to bed-rock principles.

A railway exists by virtue of the fact that a locomotive running on a smooth track can haul a very large load at a very small cost. The essentials of a railway are then the locomotive and the smooth road or permanent way. Land for this is acquired and the permanent way and its ancillary buildings are constructed at a certain cost, which remains the same whether the permanent way is used or not used. The cost of the maintenance of the permanent way remains practically constant whether much or little use is made of it. This railway having been built for the purpose of making the permanent way and the locomotives earn money, it follows that the object for which the management must strive is to obtain the maximum possible use of these two primary articles. In other words, the management strive to create sufficient traffic to justify the passing over of the track by the maximum number of engines. The locomotive is, however, by itself a spending factor, not the earning factor; it is the load behind it which earns money for the management, and it is therefore the management's further object to obtain for each locomotive the maximum paying load which it can haul. Apart from all the complications which the management have to face, and which must be borne in mind when criticizing, it is not unfair to take as a measurement of output the amount of paying load which the management succeed in making their engines haul over the whole of their permanent way; and for the purposes of comparison, since the length of the railway systems differ, all such figures of output have been reduced to the unit "Per route mile," route miles being the length of the railway system quite apart from the number of tracks which may be laid over that length. In 1921, the British railways worked 20,281½ miles of route, on which 51,477½ miles of permanent way had been laid. The German railways in the same year worked 33,155 miles of route, on which 73,626 miles of track had been laid. The figures of *route* mileage (the lesser) are those which have been used in producing the calculated results which follow. The first comparison will be of the use made of these route miles by the engine.

An engine is doing what it was invented for when it is putting miles of route behind it. This leads to the "engine mile" as the unit by which the use of locomotives is measured and for statistical purposes engine miles are divided into four categories, viz. "Coaching train miles," when hauling passenger trains; "freight train miles" when hauling goods trains; "shunting miles" for work performed in a station or goods yard and "other miles" for other work, covering the time engines are in use for purposes not included under the first three heads. Of these heads the first two directly earn money: the other two do not, and they therefore represent a "complication," not an output. The comparable figures are:

	English	*German*
Coaching train miles per route mile	10,128	5,250
Freight train miles per route mile	5,410	4,260
Total	15,538	9,510

showing that the English railways attain a traffic nearly twice as *intense* as the German. But these train miles do not represent earnings.

"Earnings" bring in an entirely different factor, to wit, the success with which the management can persuade the public to make use of their output, or, to put it another way, good management strives not to produce more output than the public will use *fully*. The coaching train mile output is produced for the benefit of passengers and the number of passenger journeys made in 1921 was in Great Britain 1,786,671,112 and in Germany 2,318,499,589.

These figures do not go far enough as an indication of the potential earning capacity of the passenger traffic. To obtain this it is necessary to introduce the distance factor, since the further the average passenger goes, the more he pays. The average English passenger travelled 10·77 miles, while the average German passenger travelled 13·26 miles, and one is thus able to state that the relative potential earning capacity of the two systems was

	Number of passengers × average distance
Great Britain	1,786,671,112 × 10·77 = 19,242,447,876 passenger miles
Germany	2,318,499,589 × 13·26 = 30,743,304,550 passenger miles

or, when applied to the route miles standard,

Great Britain	948,792 passenger miles per route mile,
Germany	957,711 passenger miles per route mile,

showing that the British and German public travelled practically to the same extent: but the German public was carried at half the expenditure of output (coaching train miles per route mile) of the British. It is unfortunately not possible to say how far the British public made use of (or were forced to make use of) the available *seats* moved, since the British statistics give no indication of "seat miles" which would be the true measure of output. But the German statistics state that on the year's average 39·15% of the available seats were occupied in their passenger trains.

The passenger train is, however, not usually as great a source of revenue as the goods train, the engine of which earns money by hauling a load of wagons, which contain goods whose quantity is measured in tons. The same standard of judgment applies to goods traffic as to passenger traffic, i.e. the management strives to persuade the public to use 100 per cent of its output. The nearer the load carried in the wagon approaches to the limit of the wagon's carrying capacity and the nearer the load behind the engine approaches to its maximum hauling capacity, the better from the earning (and consequently from the management's) point of view. The comparative results (all based on 1921 figures) are as follows:

	Great Britain	*Germany*
Freight train miles per route mile	5410	4260

That part of the train load which *pays* is the goods in the wagon, and the use made of the system by tons of goods is shown by

Tons carried in 1921	*Great Britain*	230,785,884 tons,
	Germany	371,357,433 tons.

The German then carried more tons with fewer trains than the British companies. They managed to do this because the nature of the traffic they deal with admitted of an average train load (paying load) of 249·4 tons against an average English train load of 121·17 tons—i.e. a train load twice as great as the English. (In parenthesis, it may be stated that the *American* corresponding load was 647 tons in 1920.)

The amount of effort required to do this, i.e. the amount of wagon capacity used is shown by the average carrying capacity of the available wagons, which was

Great Britain	10·221 tons
Germany	15·37 ,,

and the average amount loaded into each wagon, which was

Great Britain	5·07 tons of paying load
Germany	11·2 ,, ,, ,, ,,

from which one deduces that the average German freight train carried paying freight up to 72 per cent of wagon capacity, while the English freight train only reached 49 per cent. The German percentage is extraordinarily high.

While tons carried indicate the amount of the load which pays, they do not indicate the amount of revenue coming in to the railway company until it is shown *how far* they have been carried. In general, the further goods travel the more revenue do they produce. Consequently one requires to multiply the amount carried by the distance it was carried before one arrives at a figure giving an indication of the potential revenue which can be extracted from Goods Traffic. The average distance traversed by the goods carried was in England 57·58 miles, and in Germany 95·05 miles. Multiplying "amount" by "distance" gives the *Ton Mile*—probably the most useful unit of goods traffic measurement yet devised: and the corresponding figures are for 1921

Great Britain	13,288,985,777 ton miles
Germany	34,827,735,401 ton miles
	($\frac{5}{8}$ of 55,724,376,642 ton-km.)

or per route mile

Great Britain	661,769 ton miles per route mile
Germany	1,052,162 ,, ,, ,,

showing a potential earning power in German goods traffic 60 per cent. higher than that of Great Britain. And it is with potential earning power that this paper set out to deal.

It has been sufficiently dealt with to enable certain conclusions to be drawn. But before even general conclusions are drawn a note of warning must be sounded on the subject of the statistics from which the figures have been compiled. They are the official statistics as published by the respective Ministries of Transport and must be taken as perfectly honest: but all statistics, and especially railway statistics, have to be regarded with understanding and sympathy. They are drawn up much more for the purpose of enabling an authority to compare results with previous periods than for actual purposes of measurement, so that an inaccurate basis will give relative results bearing a definite and useful relation to each other, period by period, while presenting a perfectly false picture to the uninitiated student of actual performance. It is only necessary to refer for an example to the method of obtaining freight ton miles. The British book states that the figure is obtained by multiplying the actual loaded wagon miles by the average load per wagon: and that the average load per wagon has been obtained by dividing the total tonnage handled by the total number of loaded wagons handled.

The German method is quite different and depends on the *revenue* obtained from each class of goods. It is very complicated and not worth explaining fully, and it very probably gives results nearly as accurate as the British: but the mere divergence of method is sufficient to show that any attempt to be dogmatic would be wrong.

Dogmatic statements would be wrong for another reason quite apart from statistics. Reference has already been made to the drought, to the currency question, and to the political events in Germany as effecting traffic in 1921, and it is only fair to draw attention to one outstanding event in Great Britain which also affected railway traffic, namely the coal-miners' strike in 1921. But even allowing for abnormal conditions on both sides, there seems to be a sufficiently wide difference between the potential earning capacity of the railway systems of the two countries to make it safe to say that the acceptance by the Allies of the German Railway System ought to be a handsomely paying proposition and that it would repay the labour involved to subject the German figures to criticism in order to ascertain, if possible, whether there is any very definite reason why the German Railways should have actually budgeted for a loss on working.

A criticism of German Railway Working based purely on statistics would be like dissecting Dead Sea fruit. It is essential, if any conclusions are to be drawn, to throw the light of observation and experience on to statistics and to judge them accordingly.

I have been fortunate enough to have had intimate dealings, from the administrative standpoint, with German Railways for some twenty-two months. During that time, I have been able to gather very definite impressions which the statistics do not in all cases bear out, but which, when applied to statistics, are a sufficient explanation of otherwise paradoxical results.

For the results shown are paradoxical. The German railways have carried more goods more miles in fewer trains and more passengers more miles in fewer trains than the English railways and yet the English railways incurred a gross loss of four per cent., while the German actually expected a loss of twenty-two per cent. on the ordinary Budget working. For the sake of clearness it must be repeated that the output or, in other words, the "transportation" which was offered for sale in 1924 amounted to

	British	*German*
Coaching train miles	205,415,970	173,983,803
Freight ,, ,,	109,708,783	141,142,872

This output, which the Germans call "Betrieb," represents the total *potential* earning power of the effort put forth by the Railway Administration. The output or "transportation" actually sold, which the Germans call "Verkehr," is shown by

	Great Britain	*Germany*
Passenger journey miles	19,242,447,876	30,743,304,550
Goods ton-miles	13,288,985,777	34,827,736,151

and it has been shown that the German sold 72 per cent of the goods train output, and 39 per cent of the passenger train output, while the British sold only 49 per cent of the goods output, that of the passenger train not being stated. In other words, the German management succeeded in keeping the amount of output down nearer to the "sales" level than the English and therefore, since they made a serious loss on working, their output must have been much too expensive, either absolutely or relative to income or both. The first thing to be examined then is the output.

"Output" is synonymous with visible expenditure. It was stated at the beginning of this paper that certain expenditure is incurred by a railway which has practically no relation to output—

e.g. maintenance, general management, guaranteed interest on certain capital, etc. Consequently it is the cost of output which directly affects the gross profit or loss on railway working, and of this cost the majority is caused by two great bills—Wages and Material, the latter including coal and oil. Wages must in this case be translated into terms of " heads employed " since the ordinary monetary standard is lacking—and in this case comparison of statistics gives the following results :—

	Great Britain	*Germany*
Total employees (1921)	735,870	1,064,966
Employees per route-mile	36·5	32·1

Bearing in mind the fact that the rate of wages in Germany in no case reached the level of the " cost of living " figure during 1922, (and probably did not during 1921), while salaries were little better, it is hardly conceivable that the figures can be telling the truth as a measure of relative expenditure, and they must be looked at in the light of experience to find some reasonable explanation.

It is obvious that the German passenger train carries more personnel than the British ; the German express, for instance, carries driver and fireman ; brakesman, luggage guard (Packmeister), often with an assistant; guard (Zugführer) ; conductor (Schaffner), one or more ; and often attendants in the carriages themselves, (Wartefrau, etc.). A goods train has never less than one brakesman in addition to driver, fireman and guard, and the number rises to eight and ten on the heavier trains or heavier sections of line where gradients necessitate more brake power. (It is to save these brakesmen that the Germans are fitting all their goods stock with the Kuntz Knorr brake, at which as a general administrative measure one can level a good deal of criticism.) The German station has more personnel than an English station. These things are there to be seen. A possible explanation of the coincidence which makes the British and German total figure of employees per route mile so alike is that Great Britain, more closely populated than Germany, has more stations per route mile, and that what is saved (relatively) on the smaller staff per station is made up by the greater number of stations per route mile. Unfortunately the British statistics are not so detailed as the German, so that one can only conclude that the British figures include items which do not appear in the German, or that the British do more work not *immediately* connected with operating. This conclusion is correct, for instance, in the case of locomotives. The Germans do not build new engines, but they buy them from private works; the British lines build their own locomotives to a large extent, and consequently employ more hands. Whatever the explanation, the fact remains that the paying British railways can employ more men per route mile at high wages than the losing German railway can employ at slave-driving rates. There are other comparative statistics which bear out the over-employment which one sees in Germany. The statistics of the Swiss *Federal* Railways are compiled on lines very closely copying the German model, and these give the following results :—

		German	*Swiss*
Administration	heads	42,804	865
	heads per route km.	*0·80*	*0·30*
Permanent way and Maintenance	heads	195,563	8,385
	heads p.r.k.	*3·66*	*2·91*
Traffic	heads	418,274	17,717
	heads p.r.k.	*8·40*	*6·15*
Loco. and workshop	heads	364,257	5,731
	heads p.r.k.	*6·82*	*1·99*
Auxiliary services	heads	—	5,673
	heads p.r.k.	—	*1·97*
Total	heads	1,050,898	38,371
	heads p.r.k.	*19·68*	*13·32*

These figures are striking—so striking, indeed, in the case of "Locomotive and Workshop personnel," that it must be mentioned that the Swiss do not do locomotive repairs in their own workshops, but let this work out to tender, while the Germans repair most of their own locomotives and thus employ more hands in the shops. The Swiss statistics do not specify clearly the particular "auxiliary services" which employ the hands given under that heading, but one can add them to the locomotive and workshop figure and the result is still very damaging to the German results. Again, whatever the explanation, these figures, added to what he who runs may read, justify the conclusion that the German railways were over-staffed in 1921, a conclusion which the German Government has now (November, 1923) recognised afresh by ordering a 25 per cent. reduction. It remains to be seen whether this order will be more successful than the order of January 1922 already referred to. But in addition to superabundant staff, is there no other way in which the German output suffers from non-productive operative costs?

Of all non-productive work on a railway probably that of the shunting engine is the greatest. It is unavoidable work, but it produces *no* ton-miles and *no* passenger miles, while it costs coal, oil and wages, and as a corollary it entails the cost of providing and maintaining shunting yards. The comparable figures are

	Great Britain	*Germany*
Shunting engine miles	102,739,026	204,055,631
Per cent of total engine miles	22%	35·7%
Tons of wagon capacity per shunting engine *hour**	24·1	15·8

* The Germans allow 10 km. and the British 5 miles per hour.

and show a very serious difference. Not only do the Germans spend proportionately much more time on shunting than the British, but they actually turn out less per shunting engine. The result would be even worse, were one to translate it into *wagons* per hour, since the average capacity of the German wagon is 15·37 against the British 10·221—in wagons the proportion is 2·3 to 1 in favour of the British. These shunting figures lead one to suppose that the corollary mentioned above should hold good—*i.e.* that the Germans require more room for shunting than the British, and the track mileage of the two systems confirms this expectation. The British "siding" miles amount to 28·6 per cent. of the total; the German "siding" miles to 35·25 per cent. of the total track mileage, and this in spite of the fact that the British have relatively more stations.

These figures again bear out one's personal impression that the German shunting yards are altogether too big and unwieldy. They appear to have been laid out for the purpose of handling the greatest traffic which intelligent anticipation could foresee. The result of this is that they are too big for the ordinary everyday traffic using the yards. They are almost universally provided with a hump for shunting purposes, very often with several humps. They are well signalled and well provided with engine run-rounds: (in one case, at Gremberg, near Cologne, a double engine line is provided and carried under the neck of the marshalling yard, providing a flying junction), and they show deliberate design in every way, unlike the British yards which in most cases show clearly that they have grown with the traffic.

These impressions of the German Goods Yards apply equally to their arrangements for passenger traffic, which are most elaborate, and, as a general summary of impressions, the deliberate statement can be made that the Germans appear unwilling to, or incapable of, working with any general lay-out which falls short of the theoretically perfect. This mental attitude was capable of some defence when the German railways were working to a profit, unburdened with any kind of debt, in no doubt as to the source or quantity of future capital requirements, and untroubled by any thought of interest on such capital. It so permeates public opinion as well as the Railway Administration that it constitutes in my opinion one of the greatest factors which prevent the business-like handling of the German railways.

The German railways are unquestionably a very fine machine. The perfection of the design of this machine, deteriorated as it may be by ten years' mishandling, is obvious to the eye, and is proved by the fact that the output is maintained with half the effort required from the English railways. The fact that the output costs the Germans too much is amply proved by the figures for personnel as compared with the Swiss, by their own statement that a unit of work now requires twice as many man-days as it did before the war, and by the fact that their shunting expenditure is too great and its output altogether too low. But none of these factors were in any way hidden. The Germans were as well aware of them as any one else. There is unfortunately no way of proving whether the shunting figures are worse now than before the war—though the probability is strong that they were just as bad—but even allowing for that, there is no justification in any of these working figures for the grave financial loss incurred by the German railways in 1921 and in 1922. There can only be one explanation, and it lies on that side of the accounts which shows the income paid by the " transportation sold." This was quite insufficient, and draws attention to the extraordinary rates policy of the German administration. German railway rates have deliberately been kept at an unremunerative figure.

But to discuss rates fully would require a volume to itself. It must suffice for the purpose of this paper to quote their own report, and from it to let the German policy be judged. After referring to the increase of working costs, the German report says :—" It was believed that National German Interior Economy could not bear a load of expenditure on the transport of passengers and goods such as would correspond to the universal increase in cost. The railway, as one of the most important factors of economic life, was to try and combat the continued diminution in the value of money by consciously holding back from any increase in its prices. This policy which was carried on to the end of the first half of the year under report (1921) had in general the support of the Government of the Reich and the law-giving bodies, and was, at least at that time, hardly disputed at all." The report then goes on to say that the continued depreciation of the *Mark* made it necessary to raise rates in a measure at least to cover what the Administration call " Self-costs." How these " Self-costs " are arrived at as a current measure is not very clear, since the unit is the cost per axle-kilometre—obtained apparently by dividing Traffic receipts by axle-kilometres; and in view of the way in which the German accounts are kept, they would not appear to be very reliable, but for the purposes of the German report they are very useful since they enable a graph to be drawn showing the income keeping pace with the " Self-costs." As a measure of financial stability these graphs would seem to be valuable to a less extent even than the accounts of the railways.

The German railways are supposed to be self-supporting, and, indeed, Article 92 of the German Constitution says they must be. They have failed completely to be self-supporting, and they put their failure down to the depreciation of the currency. Certainly, the depreciation of the currency in 1923 must necessarily completely swamp any loss which may have been incurred for any ordinary reason, but this excuse must not be allowed to hide the fact that the German railways, provided that they had a really business-like rates policy, ought to make a handsome profit. Their rates at present bear no relation whatever to the cost of living, and once more the Germans must be judged from their own publications.

In a pamphlet entitled "Tariff policy of the German State Railway," (a pamphlet defending the raising of the rates !), there are little diagrams showing that, whereas before the war the price of ten eggs would take a passenger 45 kms., on the 1st February, 1923, they would take him 337 km ; one pound of butter likewise would take him 62 kms. in 1913, and 600 kms. in 1923. Berlin to Frankfort-on-Main for the price of a pound of butter ! The index figure for the average wholesale prices in January, 1923, was 2,800, that of the average goods rate 1,650. One could go on repeating these figures almost indefinitely, but they do very little to assist one towards making an estimate of the probable profit or loss on working the German railways if the currency suddenly became stable, and rates reasonable. Sufficient has, however, been written to enable the nettle to be grasped and an estimate made.

Before actually estimating in figures, it is as well to draw up a summary of the conclusions come to. These can be put in the form of :—

Points favourable to the German Railways.	Points unfavourable to the German Railways.
1. Low train mileage.	1. Over staffing.
2. Good utilisation of trains.	2. Over shunting, with yards too big and output too small.
3. A very fine machine.	3. An unsound rates policy.

In my opinion the favourable points heavily outweigh the unfavourable, except in the case of the rates. The Germans have now applied a rates policy on a gold basis, and one may assume for the sake of argument that the policy is now reasonable. One may further assume that, had the currency question never arisen, the changes in traffic direction and the other war effects to which reference has been made would not have done much more to affect the finances of the German railways than the social post-war changes have affected the finances of other railways. It is instructive to compare in this respect the effects of the war on the British and Swiss railways.

The *Gross Expenditure* was :—

	Gr. Britain	*Proportion*	*Swiss Fed. Rys.*	*Proportion*
1913	£75,704,320	1	frs. 142,406,000	1
1920	£231,968,870	3·25	frs. 358,328,000	2·5
1921	£226,767,460	3·0	frs. 341,918,000	2·4
1922	£174,844,342	2·3	—	—

The *Gross Receipts* were :—

	Gt. Britain	*Proportion*	*Swiss Fed. Rys.*	*Proportion*
1913	£119,808,270	1	frs. 212,721,000	1
1920	£238,930,239	1·99	frs. 394,031,000	1·85
1921	£217,796,991	1·81	frs. 353,972,000	1·66
1922	£210,330,693	1·83	—	—

Considering how utterly the economic conditions in the two countries differ, it cannot be taken as a mere coincidence that the proportionate rise in expenses and the rise in revenue are so nearly alike in 1920 and 1921. The similarity in the case of traffic receipts and expenditure per route kilometre/mile respectively is even more striking.

Traffic Receipts per mile or km.

	Gt. Britain	*Proportion*	*Swiss Fed. Rys.*	*Proportion*
1913	£ 5,868	1	frs. 76,491	1
1920	£11,649	1·98	frs. 136,721	1·78
1921	£10,621	1·82	frs. 122,822	1·605
1922	£10,709	1·83	—	—

Traffic Expenditure per mile or km.

	Gt. Britain	*Proportion*	*Swiss Fed. Rys.*	*Proportion*
1913	£ 3,720*	1	frs. 51,207	1
1920	£11,430*	3·075	frs. 124,333	2·43
1921	£11,142	2·99	frs. 118,639	2·31
1922	£ 8,592	2·3	—	—

These figures are good evidence, even if they do not prove, that the rise in expenses, or, put the reverse way, the depreciation in the purchasing power of money is comparatively universal in Europe, and relatively uniform when measured in stable currency.

It is not unfair therefore to apply the proportion to Germany and to base on the result an estimate of the gold currency result of Railway operation in that country.

Unfortunately the only statistics immediately available to me for the *whole* of the old Germany are those of 1901, and it is necessary to relate these to the 1913 statistics of the Prussian-Hessian Railways in order to arrive at comparable figures. The receipts per kilometre in 1901 were :—

For all Germany *M.* 39,418.............................. 90·88%
For Prussia-Hessen *M.* 43,463.............................. 100%

In 1913 they were :—

For Prussia-Hessen *M.* 65,106 .... 100%

* Estimated on *Gross* Expenditure and consequently slightly high.

and consequently, taking the same proportion for 1913 as 1901, we may assume that they were :—

For all Germany *M*.59,168 .... 90·88%

Now, it will be observed that British receipts rose from 1 to 1·83 in 1922, and the Swiss from 1 to 1.605. It will be no injustice then to apply the lower multiplicator to the German figure thus :—

59,168 × 1·6 = *M*.94,669 per route kilometre.

In 1921 the route kilometrage was 53,357, which gives a gross receipt for Germany of :—

M.5,051,253,833

Turning to the expenditure side we find that the expenditure per kilometre in 1901 was :—

For all Germany *M*.25,913 .... 97·33%
For Prussia-Hessen *M*.26,622 .... 100%

in 1913 :—

For Prussia-Hessen *M*.45,058.......................... 100%

and consequently, taking the 1901 proportion for 1913, we may again assume that expenditure per kilometre was in 1913 :—

For all Germany *M*.43,855 .... 97·33%

In 1921 the Swiss expenditure was 2·31 times that of 1913 ; in 1922, the first uncontrolled year, and the first year which did not include some national calamity such as the coal strike, the British railways arrived at practically the same " multiplicator." Applying it, then, to the all-Germany expenditure figure, this gives :—

43,855 × 2·3 × 53,357 = a gross expenditure of

M.5,381,933,840

showing a loss of

M.330,680,007.

Applying the same multiplicators to Gross Receipts and Gross Revenue, adjusted to mileage differences between 1913 and 1923, this gives :—

Revenue	*M*.4,961,964,335
Expenditure	*M*.5,322,060,872
Loss	*M*.360,096,537

from which one arrives at the important deduction that if receipts increase by 1·6 times only, the greatest expenditure which the revenue will stand is attained with an increase over pre-war by 2·16 or 2·14 times; or, in other words, the German Railway Wages bill, Coal bill and all other bills for current expenditure when reduced to a mileage basis must not exceed the pre-war dollar value by more than 2·14 times, while the increase in income per kilometre at dollar values must average out at something over 160 per cent. of pre-war rates This conclusion, even if negative, is of some value and is justified in two ways. The multiplicators used are those of the Swiss Federal Railways in 1921, and it is firstly interesting to note that in that year the Swiss railways only just managed to make receipts exceed expenditure. In 1913 the difference between receipts and expenditure of the Swiss Federal Railways was frs. 70 million, in 1921 it was only frs. 12 million. The Swiss demonstrably do not suffer from the overstaffing disability, which alone is sufficient to turn a narrow "plus" on the Swiss Federal Railways into a "minus" on the German railways, and, as a second justification, it is sufficient comment on the German rates policy when it is stated that the *actual* income on a dollar basis from goods traffic shows a multiplicator ranging from ·907 in June, 1922, to ·2435 in November, 1922.

And with that plea of justification this paper must be brought to an end.

The writing of it has proved one thing to me—that dogmatism on any subject connected with railway working is quite impossible in the present state of our knowledge. Such conclusions as have been come to are put forward with all diffidence and considerable hesitancy, while the last conclusion, the estimate of the possible financial result of working the German railways with reasonable rates and an unastronomical currency, requests the charity of being called an intelligent guess.

The statistics used are summarised in the attached *Appendix*.

NOTE :—Since the above was written in November, 1923, conditions have changed in the following respects :—

1. The "Miracle of the Rentenmark" has restored a currency which is being held to a dollar value.

2. A real effort appears to be in hand to make the German State Railway independent of the Treasury and thus really self-supporting. The Treasury will of course take any profit made by the railway but will not grant credits.

3. Goods and Passenger rates are decidly on the high side, measured in Rentenmark.

4. Reduction of Staff, lengthening of the hours of work and reduction of pay are being carried out.

It is too early to judge of the permanency or of the effects of these changes.

10th February, 1924.

UNARMED DEFENCE.

By THE FIRST TWO SAPPER OFFICERS.

WE hoped that our first article would lead to a discussion, as we thought the subject an important one. We were pleased, then, to think, on opening the December *Journal*, that blood had been drawn. Alas—it was only a red herring!

The object of our first article, which our critic confesses to having missed, was to show that the policy of disarmament became more dangerous, the more generally it was adopted. This conclusion startled us (and shocked our critic), but as we could not find the flaw in our arguments, we published them, hoping that somebody would be good enough to find it for us. Instead of this, we have been met with a set of counter-arguments, leading to the opposite conclusion. We have failed, and our critic has not attempted to find any flaws in ours, but as it is obvious that both sets of arguments cannot be sound, it devolves upon us to demonstrate the unsoundness of his. We will do our best to demolish them, although it is difficult to test his thesis fairly, as so many of his pieces are missing.

He appears to have started by searching our article in vain for a reference to the League of Nations, and, finding none, to have written his own as a footnote to ours. We erred, he seems to think, in omitting all reference to the League. Our reply is that the omission was intentional. We left the League out of the discussion of the Ruhr question—but then, so did one of the two nations primarily concerned, while the other has, so far, been left out of the League. Furthermore, the League expressed no wish to be brought into the question, so who were we to presume to do so? Our critic has now dragged it in, much, we feel sure, against its better judgment. We apologize, but it is really not our fault.

Our critic's thesis may be broadly divided into five statements:—

Competition in armaments is the most fruitful cause of war.
War will inevitably lead to the destruction of civilization.
Armies must therefore be limited in size.
Loss of defensive power due to limitation must be compensated by mutual guarantees.
This policy can only be secured by the League of Nations, which will therefore stand or fall by its success or failure in this respect.

We differ from him on all these points, but we propose to touch but lightly on the first four, reserving our heavy artillery—or should we say our most learned counsel?—for the last, which we regard as the most pernicious fallacy of the five.

The idea that competitive armament causes war is one that, gaining popularity owing to its inversion of a classical tag, is being lifted from book to book by our younger writers and is gradually gaining, through mere repetition, the reputation of an axiom. Its truth has never been seriously examined. The late war, we gather, was caused by the efficiency of the Russian armies, or was due to the mobilization of the British fleet. Soldiers, we understand, like being killed and wounded, and the more of them there are in a state, the stronger will be the desire of that state for war. We live, it appears, in a world of comic song, where fire insurance increases the prevalence of fire.

We deny that wars are caused by armies. Armies are merely the instruments with which they are waged. The underlying cause of every war is the clash of the policies of the governments of the nations concerned. So long as individuals are civilized there will be states, and so long as there are states these must be governed. So long as there are governments these governments must have policies, and so long as there are policies these policies are bound to clash sooner or later. As soon as a state embarks on a policy, whether voluntarily or involuntarily, inimical to its neighbour, the seeds of war are sown. The sower is the statesman. The soldier is the reaper. Armaments are not the only tools in the hands of the statesman. He only uses them when all others have failed. He makes use of diplomacy, international finance, treaties, concessions, tariffs, and possibly arbitration, before he stakes his all on the hammer and chisel of war. The tool does the work, but it does not make it.

Our critic offers no proof of his contention that wars, if persisted in, will end in the destruction of civilization. He may be right, but his statement is open to question. History does nothing to support him, but rather shows that wars are merely milestones on the road along which the human race is travelling from barbarism towards the millennium; incidents in that eternal and inevitable conflict between men and nature which we call the progress of civilization. Sometimes wars have hindered progress, as in the case of the overthrow of Rome by the Goths. At other times they have undoubtedly helped it on, as in the case of the American War of Independence. Viewed as a whole, the balance appears to be rather in their favour, but we do not insist on this point. So much for past wars. But our critic, looking into the future, says: "It seems probable that a future war, with the increased powers of destruction which the rapid strides of scientific invention will afford, would destroy our Western civilization for good." Are we, then, to abandon our proved means of defence in view of this probability, a probability which is not only unproved but which has already been disputed? Colonel Fuller, for instance, would persuade us to the contrary in his book, "The Reformation of War." He contends that the weapons of the future will result in wars becoming more humane. On the other hand, Miss Cicily Hamilton, in her novel, *Theodore Savage*, using weapons and tactics very similar to those conjectured by the soldier, succeeds in reducing her civilized world to ruins in the short space of three weeks. We will not attempt to improve on the arguments contained in these two very excellent books, but even if the fiction, in this case, contains the truth, our critic's corollary, "Therefore we must reduce the size of armies" belongs, we think, to a different proposition. The danger lies in the size of the war rather than in the size of the armies employed and, whatever limits may be imposed in peace on the peace strengths or mobilizable strengths of the armies of rival states, no limits can be imposed on their powers of development during a campaign without drastic interference with the very progress of civilization which it is our intention to secure. We may hope that small armies will wage small wars, but the lessons of history do not encourage us in this assumption. Rather have wars tended to become shorter with the growth of armies. The mutual limitation of armaments will neither shorten wars nor lessen their economic significance.

Wars between civilized states are not the only factors which may endanger civilization as we know it. What of Bolshevism and the Yellow Peril, to name but two? If given a chance to spread, either of these two monsters would necessitate a war on a gigantic scale before it was crushed, and such a war would be worth waging. Limitation of armaments could do nothing to prevent such a war—rather would it precipitate it. Furthermore, the initial defencelessness of the civilized world would render the ultimate slaying of the dragon a slow and painful business for the slayer. It was war that set a limit to the incursion of the Turks into Europe in 1529. It was only by fighting that the Poles prevented their country from being finally and irrevocably overrun by Bolshevism in 1920.

Mutual guarantees can never be a satisfactory substitute for self-defence. Under the old despised system of "Balance of Power" a nation limited its commitments by treaties with other powers, with the result that it only had to defend itself against certain well-defined contingencies which could be accurately measured in terms of armaments. Under a system of mutual guarantees within the orbit of a League of Nations it must be prepared to defend itself against the whole civilized world in the event of the League deciding adversely on a question which it considers vital to its existence. To those who argue that the decision of the League is more likely to be right and just than that of one of its members, we would point out that the conflict of armies is only the result of the conflict of ideas or ideals. Ideals have small beginnings and are usually met at the outset by tradition, suspicion, and vested interests. They can only survive and grow after a prolonged struggle against a hostile world. Which side would the League have taken, had it existed in the time of the American War of Independence, the French Revolution, or the American Civil War? Would it have helped or hindered the abolition of slavery and the suppression of the slave trade? Which side would it take to-day in an international quarrel arising out of the prohibition question? Mutual guarantees serve but to increase the gamble inherent in a policy of disarmament.

And what of the League of Nations? Is it our only hope?

We have been at some pains to distil the true essence of the League from the mass of conflicting pamphlets that have been written and speeches that have been spoken on the subject, and it was largely to avoid adding to this welter of confused thinking that we omitted all reference to the League in our previous article. But our critic was restrained by no such scruples and we are forced to accept his challenge.

Our criticism has so far been mainly destructive, but we would point out that it has been levelled, not at the League, but at the policy of limitation of armaments. What is our alternative to this policy? Let our critic prepare for a surprise. It is a League of Nations!

But let us be quite clear at the outset. The League, as we see it bears little or no resemblance to the League as he sees it. It is the same League, but the spectacles through which he views it are rose-coloured and of great magnifying power. We are even inclined to suspect that they are bifocal. Ours are of plain glass. As a result, we see the League as a gathering of statesmen, prepared to discuss such questions as may come before them. He sees further. He sees the one and only question that they must discuss and the conclusion which they must reach or perish.

We emphatically deny his contention that the League will stand or fall on the results of its deliberations on the disarmament question, and we base our denial on no less an authority than Lord Robert Cecil himself. In a lecture which he delivered to the students at Camberley in 1919 he explained that the object of the League of Nations was to promote a habit of conference and an attitude of mutual understanding between all nations, so that, as time went on, the range of questions referred to arbitration would increase and the tendency of nations to resort to the arbitrement of force would diminish. As the League, organized on these lines, gradually became an universal reality, the tendency towards *competitive* armaments would automatically diminish, because the fear of aggression would fade into the background and mutual trust would take its place. An inevitable result would be that wars would occur more rarely, and then would be more easily localized. In short, the limitation of armaments may come, not immediately by the imposition of the will of the majority of the nations upon the rest, but gradually by mutual consent.

Our critic looks upon limitation of armaments as a patent medicine which will cure all the ills the world is heir to, and to the League of Nations as the only chemist who can make it up. We look upon the League as a worthy apothecary, skilled in the preparation of all sorts of homely and efficacious remedies for all manner of complaints, but who refuses to make up a bottle of " disarmament mixture " without a doctor's prescription, knowing, as he does, the danger of administering strong remedies to weak constitutions. The world is a very sick man at present. He is far too sick for such drastic treatment.

The League will provide a court where grievances can be aired, discussions raised, arguments met and differences settled ; the wits sharpened while weapons grow blunter. For here is one of the pieces missing from our critic's analogy. The reason why civilians can now go their ways unarmed, discarding the weapons of their forefathers, is not that the ruffians have become less numerous or the police more so. It is because the law behind the police is stronger and more respected. Even now a police force that is not supported by the law fails to keep the peace. Our individual immunity from molestation rests on a stable government, prepared to enforce its laws. The stability of the government rests on the will of the majority of the people. The laws are therefore made by the people's will and are founded on tradition and custom. The police exist merely to prevent crime, arrest criminals and regulate the traffic.

The League of Nations cannot be compared at present to a stable government. It has no international customs or traditions to fall back upon and no international police force to enforce its decisions. It has no international courts in which to try nations whose actions disturb the international peace. It has no international code of law to administer ; no recognized scale of punishment for international offences. These defects may, and we think will, be remedied in the course of time, but, meanwhile, nations should remain, like our ancestors, prepared to protect themselves. Habits die slowly and are hard to change, and a change that is forced is less stable than one which grows. Arbitration may eventually replace armament, but it is no more an alternative to it at the present time than divorce was to the duel in the days of George III. It took over a century to convince the individual that his honour could be vindicated as satisfactorily in a court of law as at the point of a rapier. It will take a long time to convince England that its honour will be safe when entrusted to an international tribunal.

The agreements regarding the limitation of armaments arrived at at the Washington Conference (the only effective agreements of this nature come to since the birth of the League of Nations) were concluded by America, Japan and ourselves solely because these countries, the three largest naval powers in the world, voluntarily and for their own individual and mutual advantage, decided that a certain degree of limitation was desirable and practicable without undue risk to any of them. The League of Nations had nothing whatever to do with it. If the League had interfered, no agreement would have been reached, for America deeply distrusts the League.

The League, sitting at Geneva, imperfect and incomplete as it is, has already discussed and settled many questions generally considered as being of minor importance, such as the white slave traffic and dangerous drugs—questions the triviality of which causes the cynics to sneer and the enthusiasts to despair—questions the like of which were found large enough in the past to be the causes of many bloody wars.

Surely, we may draw the conclusion that limitation of armaments is possible outside the League of Nations and, conversely, that the League of Nations can fulfil its destiny in the world without adopting limitation of armaments as its fundamental article of faith.

THE 21st COMPANY, R.E., IN THE INDIAN MUTINY.

The action for which the 21st Company Royal Engineers, under Lieut., afterwards Major-General, Sir Bevan Edwards, received their mention in Sir Hugh Rose's dispatch did not form part of the Battle of the Betwa, but occurred during the operations attending the capture of Calpee, from Tantia Topee, during the month of May, 1858. The action took place on the 22nd of the month and is called in some accounts the Battle of Golowlee. Sir Hugh Rose extended his force with his right resting on the Jumna and with several deep *nullahs* in front of his right flank. Soon after 10 a.m. his left and centre were heavily attacked, but he refused to reinforce those parts of his line by weakening his right, as he fully expected that these attacks were only feints and that the main attack would come from the *nullahs*. In this decision he was justified; his left and centre were hard-pressed, but the attack from the *nullahs* when it developed was successfully countered and its defeat decided the fate of the day. A feature of the operations was the appalling heat, which at times exceeded 130° in the shade. The 21st Company was in support of the right centre of the line, which was occupied by four companies of the 25th Bombay Light Infantry and half of No. 4 Light Field Battery.

The Dispatch was not written till the 22nd June; Sir Hugh Rose had had five attacks of sunstroke prior to the operations and, after Calpee, he was, according to his own words, " totally unable, although I attempted it, to compose dispatches which were to describe the remarkable operations before Calpee and do justice to the signal merits of the troops engaged." It was not published in London until February, 1859.

With reference to the reminiscence of Major-General Sir William Salmond, that the extract from the Dispatch was read out on parade at all stations where R.E. were quartered, a correspondent writes:—

The extract from Sir Hugh Rose's Dispatch, quoted in the memoir of Sir J. Bevan Edwards, and spoken of by Sir William Salmond in the December number of the R.E. Journal, was published by a circular dated 27th May, 1859, from the A.A.G., R.E., at Chatham (Lieut.-Colonel E. Stanton) to Officers commanding units of the Corps.

At that time, under Field-Marshal Sir John F. Burgoyne, Inspector-General of Fortifications at the Horse Guards, there was a " D.A.G.

for Engineers" (Colonel J. W. Gordon). Army Orders, Instructions, Circulars, etc., were minuted by him to the A.A.G. at Chatham, presumably on instructions from the I.G.F., "For circulation to companies" or "To circulate." In at least one case, a General Order on the good discipline of the troops on board a troopship destroyed by fire, the D.A.G. minuted "To be read on parade." The circular of 27th May, 1859, says that the extract "is promulgated for the information of the Corps," but the instructions from London directing the issue of the circular have not been preserved.

The Circular is given below with a copy of the Extract:—

A.A. GENERAL'S OFFICE,
ROYAL ENGINEERS,
CHATHAM.
27th May, 1859.

Circular.

The following extract, from a Dispatch from Major-General Sir Hugh Rose, G.C.B., Commanding Central India Field Force, to the Chief of the Staff of the Army in India, on the gallant conduct displayed by Lieut. Edwards, and the 21st Company, Royal Engineers, in the operations at Calpee, India, is promulgated for the information of the Corps.

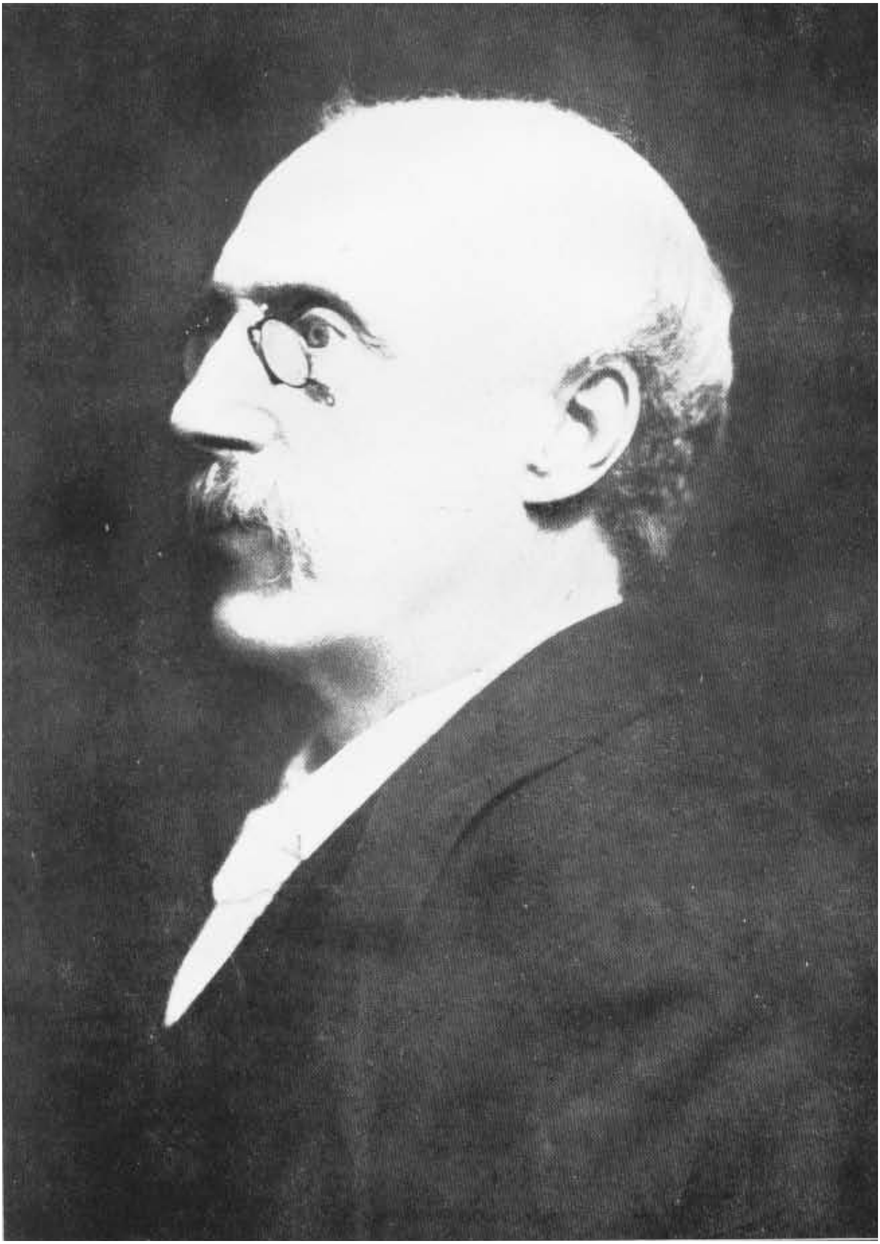
By Order,

EDWARD STANTON, *Lieut.-Colonel*,
A.A. General,
Officer Commanding Royal Engineers.

"GWALIOR,
"*22nd June*, 1858.

"The enemy, simultaneously with their attack on my right, had advanced with equal vigour against my right centre, guarded by part of the 25th Bombay Native Infantry, who, despite a most gallant resistance, were driven back by overpowering numbers, which afforded an opportunity to Lieut. Edwards, Commanding the 21st Company of Royal Engineers, which I had placed in support of the 25th, to charge with his Company, most successfully, the very superior force of the rebels, routing them with loss, and pursuing them till out of reach. I beg to mention, specially, Lieut. Edwards for his prompt resolution on this occasion; he is an enterprising and promising officer.

"The 21st Company fight as well in the field as they work in the trenches, and are worthy of their distinguished Corps."



Major General E L Bland RE

MEMOIRS.

MAJOR-GENERAL E. L. BLAND.

EDWARD LOFTUS BLAND, whose portrait appears in this number of the Corps Journal, was born in Belfast on the 10th December, 1829. He was the second son of the Rev. R. W. Bland, a member of the family of Blands of Blandsfort in the Queen's County, and Alicia Evans, of Gortmerron, Dungannon, Co. Tyrone, and a direct descendant of General Humphry Bland, who founded Blandsfort at the close of the seventeenth century. He died at White Abbey, near Belfast, on 26th February, last year, in his 94th year, the oldest of his generation of Sappers, all of whom he had survived. He retired from the Army in December, 1887, with the rank of Honorary Major-General, after service in the Corps that fell short of 40 years by 200 days only. Together with his period of retirement, 36 years, his connection with the Corps thus lasted for a period of 74 years.

He was commissioned from Woolwich in June, 1848, and served six years as a 2nd Lieut. His foreign service included periods at Nova Scotia (1851), Malta (1859), Corfu (1864), and Bermuda (1874). At Corfu his duty was to assist in the demolition of forts. At Portsmouth, soon after, he assisted in the building of a fort at Fareham, as one of the defences of the harbour. He served on the Survey of Malta, and afterwards as an Instructor of Fortification at Woolwich for six years.

His last appointment was that of C.R.E., Eastern District (1884–87). After retirement he lived first at Northam, near Bideford, and then (from 1894) at White Abbey, Co. Antrim, on the shore of Belfast Lough. For some years he did work for the Science and Art Dept. of South Kensington as an Inspector in West Cornwall and other districts.

Of a retiring disposition, he shunned publicity of any kind. His delight to the end of his life was in his garden and in the society of a small circle of friends. He had a strong artistic sense, which helped him as a photographer, a hobby in which he was an expert. A deeply religious man, he is very greatly missed in the small circle that knew and loved him. He married in 1859 a daughter of Robert Franks, of Dublin and Kilkenny, and grand-daughter of Charles Kendal Bushe, a Chief Justice of Ireland. He became a widower in 1894. He has left five sons and three daughters. He is buried in the Churchyard of Carnmoney, Co. Antrim.

R.N.B.

COLONEL J. L. B. TEMPLER.

ON Wednesday, January 2nd, passed away at Laughton Grange, Colonel James Lethbridge Brooke Templer, formerly of the K.R.R. (Militia), at the age of 78.

Col. Templer, though not in the Corps of Royal Engineers, was so closely associated with it, that he was well known to many of all ranks in the Corps.

He was the son of John Templer, a Master in the old Court of Exchequer, and was educated at Harrow and then at Trinity College, Cambridge.

I remember him, when as a boy I lived in Harrow, a tall powerful dark man whose aspect was rather stern and forbidding, but when I got to know him later in life I realized that in reality he was one of the kindest of men, who would sacrifice both time and money to help anyone in difficulties, and was most loyal to those who served with him.

He will be best known in the Corps for his services in connection with balloons, which he recognized early in life as being necessary for any modern army, and it was almost entirely due to his foresight, energy and determination that balloons were introduced into the army; he spent not only his time but considerable sums of money in order to prove their necessity.

He was not always popular with his official superiors, as his disregard of regulations and impatience with official delays and restrictions which stood in the way of progress frequently led to conflicts with them, but in the end he generally managed to get his way and convince them that he was right.

He did a good deal of free ballooning, in the course of which he ran many risks, and on one occasion when he and others with him were being swept out to sea and the only chance of escape was to bring the balloon down and all to jump out as it touched, one of the occupants (Mr. Walter Powell) failed to jump and was lost, and another broke his leg, whilst Templer himself escaped uninjured, except that the valve line to which he clung was dragged through his hands and seriously lacerated them.

Templer was much blamed for this accident, but I am convinced that, had it not been for his skill and courage, all three would have been lost; he did the only thing possible under the circumstances, which at least gave all a chance of life, and, injured though he was, he at once got off to a neighbouring seaport, hired a launch and did everything that could be done to follow the balloon to sea. It was, however, never found.

His first military work with the Corps was in the autumn of 1883, when he obtained sanction to construct a balloon and hydrogen plant at Chatham. He was given some rooms in St. Mary's Barracks and the help of a few Sappers, and I was detailed to assist him for a short time before going to India. There was constructed the first English Army Balloon, a silk one, coated with linseed oil, and christened "The Sapper," and a rough zinc and acid plant was also erected. From this small beginning ultimately emerged the Royal Air Force.

In 1885 small balloon sections were sent out to Bechuanaland and to Suakim, the latter of which Templer himself accompanied.

Later he discovered the method by which gold-beater's skin could be used for balloons and from this time on it was exclusively used, the first three dirigible army airships being also constructed of this material.

He was placed in charge of a small factory for the manufacture of balloons, the factory being later moved to Aldershot, first in the R.E. Lines, and afterwards to Cove Common, where it formed the nucleus of the present Air Craft Factory.

In the face of great obstacles, Templer made the envelope of the first English Airship, though it was finished too late for him to take part in its trials.

It was not only in Military Ballooning that Templer was the pioneer; he early recognized the importance of mechanical transport for the army, and it was owing to his energy and push that an outfit of traction engines was sent out to South Africa in 1900. The ship conveying the engines was unfortunately wrecked, but a few were later sent out and established their utility when worked under proper conditions.

Though it was not until the internal-combustion engine came into being that mechanical transport proved to be indispensable, there is no doubt but that Templer's work with the steam-tractors had awakened the authorities to the importance of its use with an army in the field.

We may look on him as the father of the mechanical transport of the present day.

Few who were at Aldershot from 1903 onwards will forget the teams of road engines and trucks that used to play in and out of the R.E. Lines, and were shown with pride to any officer who would come to look at them.

Templer remained in charge of the Balloon Factory until 1906, when he was retired on reaching the age of 60, though he was still as active and energetic as ever, and full of enthusiasm.

No sketch of his career would be complete without touching on one incident which, though most painful to him, was not in any way to his discredit. Whilst at Chatham, he was accused of selling Balloon secrets to a foreign government. Though everyone who knew him well must have realized that it was impossible for a man of his nature to even contemplate such an act, he had made enemies, who pushed the charges so far that he had to undergo trial by Court Martial. He was, of course, acquitted of a charge that should never have been brought, and was awarded by government a considerable sum to pay the expenses of his defence, but he felt the indignity of having to suffer in this way very acutely. His one consolation was that his trouble proved to him how many friends and sympathizers he possessed.

He married, in 1889, Florence Henrietta, third daughter of the late J. S. Gilliat, M.P., formerly governor of the Bank of England, and had one daughter.

His career was unique, and the Corps owes much to his association with it, an association which resulted in many of the officers who were brought in contact with him realizing the importance of the air and of mechanical traction for an Army.

His wonderful enthusiasm, his energy, his kindly temperament and dogged determination to push things through in the face of every obstacle, and his refusal to be downcast over any set-back, gave a great example to all who had the good fortune to be associated with him.

J. E. CAPPER,
Maj.-Gen.

BOOKS.

"A FIELD ARTILLERY GROUP IN BATTLE."

By Colonel W. H. F. WEBER, C.M.G., D.S.O., *p.s.c.* Published by R.A. Institution. Cloth binding, 10s. 6d. Paper binding, 7s. 6d.

UNDER the above title Col. Weber gives what he calls in his sub-title "A Tactical Study of the 2nd Brigade R.F.A., during the German Offensive, 1918, the 100-days' Battle, and the Battle of Cambrai, 1917." One might be excused for passing by such a volume as being a form of regimental history, interest in which would be chiefly confined to those personally concerned with the unit. This is far from being the case. The book not only gives a vivid account of the fighting in those memorable days, but the author has drawn from his experiences lessons which are rendered all the more forceful since they are not purely academic.

The book appeared originally in three articles, in a series of parts, in the R.A. Journal. The first article, which covers the period of the German offensive, 1918, is divided into three parts.

Part I. The experience of the Brigade, which throughout formed part of the 6th Division, in the retreat from in front of Pronville right back to Bucquoy and Hannescamps.

Part II. Deals with the difficult days in the Ypres Salient during the German attacks leading up to the capture of Wytschaete and Kemmel.

In *Part III* the author draws some general conclusions from the fighting during these two periods.

The second article deals with the general advance in September, October and November, 1918, from the neighbourhood of Bellenglise to Avesnes, where the 6th Division found itself when the Armistice was signed.

The third article tells in somewhat less detail the story of the Battle of Cambrai, in November, 1917, from the point of view of the group which the author commanded.

Throughout the Articles, interspersed with the hard, dry details of movements, orders, and defence schemes, one finds human touches which keep continually before one the feelings and thoughts of the men taking part in the events. Frequently the Author stresses the importance of the human element in war, and he certainly does not fall into the errors of those military writers to whom he refers as follows; "Military records and descriptions of war, unless intended for the front page of a popular journal, seldom bring to the reader's understanding such things as the conditions of life of the participants; even moral, though pronounced on all sides the most potent factor, generally receives only academic notice."

After the details of each day or phase in the operations follow comments which, while in most cases of special interest to the Gunner, are often of value to students of their profession in all arms.

The questions which receive most attention throughout the book are those of control and co-operation. The Author takes as his text in these matters a phrase from a Staff College lecture:—" Artillery must be controlled, but the principle of co-operation is superior to that of control." In this connection he, time and again, insists on the necessity of affiliated Artillery and Infantry Commanders having their headquarters close together, and suggests that, as the position of the Artillery Commander is largely dictated by communications, it will frequently be necessary for higher authority to order the movements of the headquarters of subordinate formations. His contentions are illustrated by many examples, lucidly demonstrated.

In connection with " control " Colonel Weber discusses the difficulties encountered by the Commander of a Group of several Brigades not provided with a special Staff or means of communications. He considers that up to three brigades may be grouped in this way under the Senior Brigade Commander in position warfare, but that in a war of movement any grouping is impossible without means being afforded to the Group Commander to control his subordinate brigades. The problem is one which is not peculiar to the Artillery.

The importance of a service of information, involving observation and *liaison*, receives interesting confirmation in the fact that Colonel Weber does not consider that he was overserved in this respect when he had twelve officers of his group engaged on this duty on one occasion.

The difficulty of an Army, trained and accustomed to static warfare, in adapting itself to the conditions of a war of movement is well illustrated. The pre-war trained personnel had largely disappeared and such terms as " outposts " meant little to the New Army, whose predecessors had a clear understanding of the functions of such detachments.

In *Part III* of the second Article, Colonel Weber gives his views on the " Transformations of War," to which further reference is made in his third article. Some of these conclusions may appear somewhat revolutionary, and certainly do not agree with those expressed by General Percin in " Le Massacre de notre Infanterie, 1914–18."

The writer points out that, on the Western Front, Field Artillery, both in attack and defence, was chiefly used for protection of Infantry. This task will in future be carried out largely by the tank with its own gun. He draws the inference that the importance of Field Artillery is waning, and that equally mobile weapons of heavier calibre and longer range, drawn by, or mounted on, cross-country tractors, will take over most of the duties not assumed by tanks. In his own words, " Heavy Artillery seems to be the weapon of the future, whereas Field Artillery may be one of the past; why else did the Peace Treaty abolish the German Heavy Artillery? "

Communications, ammunition supply, the technical training of artillery officers and N.C.O.'s, the importance of training in writing messages, are among the many points practically dealt with.

The articles are well illustrated by clear but simple sketch plans.

Altogether the book affords very interesting and valuable reading for officers of all arms, though primarily intended for the Royal Artillery. We would welcome other similar books by Commanders of all arms. But unless these books were founded upon personal notes made at the time, there would be a danger of their lacking that human touch which constitutes one of the great charms of the book under review.

R.P.P.-W.

REPORT ON TRANSPORT PROBLEMS IN JAMAICA.

By Lieut.-Colonel F. D. HAMMOND, C.B.E., D.S.O., R.E.

ATTENTION has already been drawn, in the technical press, to this interesting and able Report, which reviews, in a clear light, the peculiar conditions affecting transport in the island of Jamaica.

The Report first deals with the physical characteristics of the island, which possesses length without breadth, a remarkably rugged interior, and, consequently, a large number of ports, dotted along its coast line, from which produce—chiefly the homely banana—is shipped. It is difficult to conceive a more unhappy spot for the development of rail transport. Neglecting the question of gauge, any but purely local railway development is faced with a railway's worst enemies, viz:—Heavy grades, sharp curves, short haul of light perishable freight; and lastly, serious competition by road and sea.

It is indeed sad, as the Report indicates, that a railway of 4 feet 8½ ins. gauge should have been developed by the Government over a system totalling some 200 miles in length; for the project, from a commercial point of view, was foredoomed to failure.

The method suggested of fixing an arbitrary capital value to the railway, for the purpose of getting a basis of comparing yearly accounts, smacks rather of lending a pleasing verisimilitude to the bald and unpleasant fact, that under no ordinary circumstances will the railway system ever pay, and it might even be suggested that the most unprofitable portions of the system be closed down.

The remarks advocating the adoption of a proper renewals fund, are of interest, as without such a fund, based as suggested, no system of accounting can strictly be considered complete.

The Report next reviews the road situation, and establishes the fact that for distances up to 30 or 40 miles, motor vehicles compete successfully with railways and that, for distances up to ten miles, even the horse-drawn dray competes successfully with motor vehicles.

Attention is next drawn to the very low cost of transport by sea in coastal boats, and, consequently, the proposal to eliminate minor ports along the coast is not advocated, and the problem reduces itself as to how produce is to be transported from the Hinterland to each port serving as an outlet.

Railways are first dealt with, and the paragraphs on "popular misconceptions in respect of narrow-gauge railways, including in that term all with a gauge of 2 ft. 6 in., or less," are worthy of attention. It is demonstrated that such narrow-gauge railways are expensive to operate, the cost of haul, per ton mile, being higher than with a broad gauge.

It is next pointed out that, except under peculiar conditions, the cost of maintenance is high, and the fallacy of laying a light railway along a road, is also exploded. Finally, the idea that they are better suited to hilly country is dispelled.

The significance of these remarks may be appreciated as confirming the experience gained of narrow-gauge lines, laid and operated as railways during the Great War.

The Report next discusses a number of local projects for railway development, and it is clearly indicated that, except in isolated instances, where a limited Government guarantee is suggested, they are totally unsound.

The remarks on ropeways are hardly convincing, as no mention is made of the systems adopted or tried.

The pith of the Report lies in the recommendations for the development of roads, the proposals for which are worked out in considerable detail.

The method of raising funds for road improvement, by regulating the import duty on petrol, motor vehicles, and parts, appears to be quite sound.

A.B.

KENT'S MECHANICAL ENGINEER'S HAND-BOOK. 1923.

Edited by Robert T. Kent. (John Wiley and Sons). London, Chapman & Hall. Price $7.00.

THE first edition of this hand-book was published in 1895. It was the outcome of advice given to the original author as a young man, namely: "Every engineer should make his own pocket-book as he proceeds in study and practice, to suit his own particular business."

Had every Royal Engineer Officer kept such a note-book it is probable that before now a Royal Engineer Pocket-Book would have been published containing information on all the subjects Electrical, Mechanical, and Structural that the R.E. Officer may be called on to tackle in the course of his career. At present no such book exists, and therefore the R.E. Officer has to go elsewhere for his pocket-book of condensed information.

Many such books are published, but most of them specialize in electrical, mechanical, or other information. Kent's Hand-book is exceptional in that it covers a wider field than most of such publications, and, in consequence, is one of the best from an R.E. Officer's point of view.

The volume contains useful mathematical tables, notes on materials and their strength, including strengths, etc., of building materials, steel and wood columns, rolled-steel joists, etc., iron and steel, non-ferrous metals and alloys, applied mechanics, heat and fuel.

There is valuable information on building construction, including foundations, roofs, floors, partitions, and reinforced concrete, etc., together with notes on heating, ventilation, and illumination of dwelling houses, factories, etc. Useful notes on Electrical Engineering are included.

Chapter VII gives some valuable hints on office work, indexing and filing papers. As is very truly pointed out, the first essential in any system is the Methodical Mind. The chapters on Letter-writing and the Card Index are also well worth a study.

We are glad to observe that the writer insists that in all business affairs courtesy, and even friendliness, should distinguish everything we do.

In a book presumably intended for the general reader it is for consideration whether the occasional references to Theosophy are in place. With this trifling exception the book is to be commended very heartily, inasmuch as it supplies a long-felt want.

A.G.B.B.

OFFICIAL HISTORY OF AUSTRALIA IN THE WAR OF 1914–18.

VOLUME XII. PHOTOGRAPHIC RECORD OF THE WAR. (Angus and Robertson, Ltd., 89, Castlereagh Street, Sydney).

THIS book contains 753 illustrations, reproduced from photographs taken in almost every theatre of the war and depicting the activities of almost every arm of the three services. The reproductions are excellent and the photographs of the greatest interest. The book can be obtained in the central hall at Australia House, and a copy is being placed in the Corps Library at the Horse Guards.

RECHERCHE GÉHYPSOGRAPHIQUE DES LOIS FONDAMENTALES DE LA DÉFORMATION TERRESTRE (1889–1921). Colonel A. Romieux (Berger Levrault).—It is regretted that a review of this reprint of articles which appeared recently in the *Revue du Génie Militaire* has been delayed owing to the illness of a contributor.

MAGAZINES.

REVUE MILITAIRE GÉNÉRALE.

(*September*, 1923.)—*The Encounter Battle.* By Lieut.-Colonel Alléhaut.—Before the late war this was considered to be one of the most probable events of war. Long columns on parallel roads, covered by advanced guards with a small force of artillery, would meet, deploy, and fight a pitched battle with hardly any pause between the two operations. Now that it has been found impossible to engage with any chance of success without developing from the outset a preponderating mass of fire, this method must be modified. As the author views the course of events, the respective air forces will have approximately located the main bodies at some two days' march from each other. If both proceed, they will meet in 24 hours (case 1), or one may halt and entrench (case 2). Each then has 24 to 48 hours in which to prepare. In order to be ready, the attacker will deploy at once, first-line divisions extended with their guns ready to support them, and covered by advanced guards

Air-compressors and Fans, Water-power and Hydraulics, Pumps and Pumping engines, Steam-power, Gas-power, Power-transmission, Ice-making, Shop Practice, Machine Design, Friction and Lubrication are all clearly dealt with. There are also chapters on Marine Engineering, Transportation, Hoisting and Conveying.

The volume measures $4\frac{1}{2}$ in. × 7 in. × 3 in., and is too large to be carried in the pocket, but, considering the field covered, the book is extremely compact.

The figures are clear though small, as they are bound to be in a book of this sort. The right type of information is given, the indexing is good, and, generally, this hand-book can be recommended as one of the best published.

G.C.G.

MILITARY LAW MADE EASY.

By Lieut.-Colonel S. T. BANNING, C.B.E., *p.s.c.*, LL.B. (London), B.A., LL.D. 13th Edition. Gale and Polden, Ltd. Price 8s. 6d.

A new edition of Col. Banning's excellent book has just been published. It includes the amendments made in the various Regulations in the last three years, since the last edition was published, and the references have also been amended to agree with the new editions of King's Regulations, 1923, and the Royal Warrant for Pay and Promotion, 1922.

The book is therefore once more in a form which will render it invaluable to all students of Military Law, both those requiring knowledge for the administration of their units and those working for examinations, whether for promotion, or for Staff College Entrance. The author has taken opportunity to include considerable fresh matter, making room for this by omitting the Questions and Answers taken from past examination papers. These are now fully dealt with in the Reports on the Examinations published by the War Office.

Though the Table of Contents is very complete, it always seems a pity when a book of reference does not include an Index. This may have been omitted in an effort to keep down the already rather high price of the book. The references are, as in previous editions, exceptionally full and clear.

R.P.P.-W.

THE RITUAL OF BUSINESS.

By Major A. E. POWELL, late R.E. (Theosophical Order of Service). Price 2s. 6d.

IT may be taken as axiomatic nowadays that anyone who wishes to live an efficient, well-ordered life, and to achieve even moderate success in a career must have some grasp of business principles. This little book is therefore welcome, as it is written principally for amateurs, who have not the time or inclination to make a deep study of the subject, but who are unwilling to persevere in ignorance.

Major Powell writes in a very readable style, and gives a considerable quantity of useful information in a small compass.

with a fair proportion of guns. Infantry and guns will advance by alternate bodies, one half ready to fire and cover the advance of the other half, and followed by the remainder of the main body as reserve. The advanced guards will proceed until checked by a solid wall of fire, when they will entrench, either to defend themselves against a superior force and give the main body time to make their dispositions, or to organize a line from which the attack will depart. The organization suggested is adapted to both the cases mentioned, the main point being the power to develop the most intense fire from the outset. It may be argued that this implies delay, but it is better to endure delay than defeat, while, if the enemy has halted to organize a defensive position, it will be possible to attack it with a minimum of further delay before his works have been completely consolidated, and he will already have had up to 48 hours in which to work.

The Attack by the 27th Division, 25th September, 1915. By Commandant Janet, compiled from documents of the historical service and information supplied by participants in the battle.—A clear and concise narrative is illustrated by four good maps. The attack took place between Tahure and the Buttes de Souain, and was at first successful in the centre. Owing to delays on the wings a favourable opportunity was lost of breaching the German position, and, although the action was continued for three more days, little further progress was made. The article is worthy of perusal.

A Manœuvre of Kuroki. By Reginald Kann.—The writer contrasts Kuroki's action at the battle of Liao Yang with that of von Kluck on the Marne. Each, when pursuing a frontal attack, disengaged a large proportion of his troops to hurl them on the flank of his enemy. But whereas Kuroki, by so doing, also aimed a severe threat on the Russian communications with Mukden, so that Kuropatkin, instead of exploiting the gap left in his opponent's line, timorously withdrew his army whilst there was time, von Kluck was dealing with a more enterprising antagonist, and even if he had been successful could only have thrown the French 6th Army back on Paris with very little effect on the communications of the Allies. He followed a German theory of war, without calculating the effects which its application to the particular case would have on the general course of the battle.

Bibliography.—Among the books reviewed the following are favourably mentioned :—

Les grandes étapes de la Victoire, by Lieut.-Colonel de Wett-Guizot (Berger-Levrault).—Written by a master of his subject and a born author, this book shows at a glance the sequence of events in the late war, its remoter and immediate motives, the reasons for them, and their consequences.

Angora, Constantinople, Londres, by Berthe Georges-Gaulis (Armand Colin).—A book of travels, full of interesting episodes written by an acute observer. One is struck by the spirit of design and unflinching perseverance with which England has striven to make of the Ottoman Empire a British colony, to the detriment of French interests in the country. The arguments of Turkish nationalism are precisely analysed, and an unusual portrait of Mustapha Kemal is given.

Souvenirs de la campagne de la Marne en 1914. By Col.-General Baron von Hausen. (Payot).—The last of four books written by the four commanders on the right of the German line in 1914. The general does not spare criticism of the action of his own units; possibly the want of success of the 3rd Army was due as much to the health of its commander as to his Saxon nationality, which led to his early removal.

He corroborates the underlying idea of von Bülow's book, that it was the yielding of the right of the 2nd Army which caused the retirement of the whole German line. It affords an interesting insight into the weakness of the German High Command in 1914, and into faulty co-operation in the movements of the armies.

Mémoires du Grand-Amiral Tirpitz. (Payot.)—In spite of its undisguised effort at German propaganda this is a work of the greatest value for illuminating the history of contemporary Germany.

(October, 1923.)—*Ludendorff's Strategy on the Eastern Front.* By General Gamon.—A short abridgment of the course of the Eastern campaign. After briefly describing the plans elaborated by von Schlieffen and von Moltke for the opening days of the war, the serious miscalculation made by the Germans in regard to the time it would take to mobilize the Russian armies is commented upon. After the Austro-Hungarians had been thrown back on Lemberg, and the check to the German 8th Army at Gumbinnen, on 24th August, 1914, Hindenburg was sent to take command of the army, with Ludendorff as Chief of his Staff. Then follow the events leading up to, and the consequences of, their victory over Samsonov at Tannenberg, the defeat of the Austrians at Lemberg, Rennenkampf's defeat on the Masurian Lakes, the formation of the German 9th Army and the counter-offensive planned against the Russians at Przemysl. Shortly after this a copy of the orders of the Grand Duke Nicholas for the Russian offensive fell into German hands, and later on a message sent by wireless was intercepted. Hindenburg was now made C.-in-C. of the 8th and 9th Armies, commanded by Generals François and Mackensen respectively.—*(To be continued.)*

Wakeful Nights. By Jean Fleurier.—A collection of aphorisms and reflections on military matters, which, if somewhat pessimistic in tone, would be of interest to those studying contemporary French military ideas.

The Attack of the 27th Division, 25th September, 1915. The conclusion of the article by Commandant Janet.—The French advance was so far successful that it caused the Germans very grave anxiety, and a retirement was at first considered advisable, but was deferred. The reasons given for the failure to break through the German position are:—1st, the failure of the French artillery to cut the wire of the second position; 2nd, owing to bad weather interfering with aerial observation many German guns and machine-guns remained undamaged; 3rd, the disorder in the units of the division after its four-kilometre advance; and 4th, the checks occasioned to the infantry by delays in lifting the artillery barrages, due to a breakdown in the signalling arrangements. It is possible, however, that, if reinforcements had been opportunely available, further success might have been won. All these points are carefully examined, and the articles conclude by stating the lessons derived from the battle, which were applied later at the battle of the Somme.

The Campaign in Transylvania. By Capt. Salmon.—A brief account of the campaign from the invasion by the Rumanians to their expulsion by Falkenhayn a fortnight later. The general course of events and their mutual reactions are clearly brought out. At Hermannstadt Falkenhayn applied the ideas of his master, von Schlieffen, with the same boldness as Ludendorff in East Prussia and at Lodz. The strategy was rash, involving the engagement of all troops available on the spot, with few or no reserves, but met with success against Russian inertia and Rumanian inexperience.

Bibliography.—The following books are reviewed:—

L'héritage napoléonien. By Colonel Becker (Berger-Levrault).—An essay on the Napoleonic code, tracing its origin, and its effect on the development of French civilization. It is then shown that modern evolution continually demands the substitution of decentralized administration in political and social affairs for a centralized and individualist system. A few pages are devoted to internationalism, and, after expressing suspicion of the League of Nations, the colonel concludes, with Napoleon, that it is wrong to sacrifice country to idealism.

La troisième armée dans la bataille. By General Tarrant.—The diary of a staff officer, who, if he was an assistant and often a valuable counsellor to the generals who had the good fortune to find him under their orders, does not draw too flattering a portrait of the majority of them. Describing from intimate knowledge the life of a staff officer on field service, he leaves the impression that, at the outset of the war, the Army, Corps and Division staffs had much to learn, and, wanting method, failed to keep in touch with the actual incidents of the battle.

(*November,* 1923.)—*The German Infantry.*—In view of the possibility of another war with Germany, the writer, Commandant Pujo, deems the infantry tactics of that country worthy of study. Germany pins her faith on infantry as " the queen of battles." The article, which is well worth perusal, begins with a statement of the composition and strength of the German regiment, battalion, company and division, proceeds to consideration of the duties demanded of infantry, and then to a description of its action when on the defensive. Commencing with general principles, object of defensive action, means by which it is maintained, organization of the position, its occupation, use of features of the ground, camouflage and surprise, the disposition of the troops on the ground is explained and illustrated by diagrams of advanced posts, main defensive position, supporting points, and a sketch of an actual sector of ground occupied on these principles, reasons being given for the dispositions adopted. The general principles and conduct of the defensive action are then described.—(*To be continued.*)

The Reverse of the Medal.—This article, by Capt. de Gaulle, describes the want of co-ordination throughout the greater part of the war between Germany and Austria-Hungary. It might have been expected that on engaging in joint operations a German general would have been placed in supreme command, but the Emperor Francis Joseph, humiliated by

Germany in 1866, was no admirer of William II. nor of German methods, nor had he enough influence over his army to have induced it to take a subordinate position. Than Conrad von Hotzendorf, Chief of the Austrian G.S., no one could have been more acceptable to the Germans, but he was disgusted with the autocratic behaviour of their General Staff, nor was he inclined to place implicit faith on their High Command. Before the war no plans for joint operations had been drawn up, nor did either country know the concentration or operation plans of the other. The results were somewhat disastrous and rivalry between Hindenburg and Conrad made matters worse until common disaster compelled them to compose their differences. The question of command might now have been settled, but Falkenhayn's jealousy of Hindenburg's growing reputation led to difficulties. For a time the tact of Mackensen in command of an Austro-German Army brought success, and co-ordination of effort might have brought about unity of command, when again the personality of Falkenhayn raised further obstacles.—(*To be continued.*)

Ludendorff's Strategy on the Russian Front.—The article by General Camon is continued, and deals with the battle of Lodz, 11th to 20th November, 1914. At the end of October the Austro-Hungarian and German 9th Armies were in a critical position, inferior in numbers to, and thrown back by, four Russian Armies which were then on the general line Kolo (on the bend of the Warthe)–Kielce. To await attack, or to make a frontal attack would mean disaster; the only chance was to make use of the strategic railways bordering the Polish salient, and deliver an attack on the Russian lines of communication by rail with Warsaw. How this manœuvre was carried out is described in this number, and illustrated by two maps. The issue was not at once so decisive as was hoped, owing partly to faulty leadership, and partly to paucity of troops, but on 6th December the Grand Duke Nicholas had to abandon the important industrial centre of Lodz, with its capacity for the manufacture of much-needed munitions, and also his contemplated operations against Silesia.

Books.—*La guerre sur le front occidental.* Vol. IX. *Les offensives de* 1915. By General Palet. (Berger-Levrault).—This new volume is said to be superior to the earlier volumes, due to numerous documents which have come to light, and of which the author has made full use.

Le Domaine colonial de la France. By Armand Megglé (Alcon).—This book owes its great interest to the fact that it has been written in collaboration with the agencies established in France to act as links between the mother country and her dependencies. The maps and information have been supplied by the Army Geographical Service, the Commercial office at Beyrout, and the Colonial Institute at Marseilles. Each domain is separately dealt with, and the scientific and practical utility of the work cannot be too strongly commended.

Mémoires du baron de Schoen. (Plon.)—The memoirs of the diplomatist on whom, as ambassador to Paris, devolved the duty of presenting the German declaration of war. At the present time, when German propaganda is displaying all its duplicity to persuade the world that responsibility for the war was not German, M. Poincaré can have no better advocate. Through the tangled mass of explanations certain facts stand out with startling clearness: (1) That Germany, from the dawn of the century, intended to impose her hegemony on the world, and, as regards France, to reduce her to a condition in which resistance to Germany would have become impossible. (2) The responsibility of Austria is evident. (3) Germany upheld the Austrian pretensions on the plea of her duty as an ally. (4) Germany declared war on Russia after having made insulting proposals to France in regard to her neutrality. (5) Germany declared war on France on the basis of lying allegations communicated to the French government in a partly indecipherable telegram. The ambassador looks upon his part in the transactions as the most painful memory of his career.

(*December*, 1923.)—*Historical Sketch of the French Infantry.* By Commandant Padovani.—The first two chapters of this article are merely historical, the third chapter, dealing with the infantry of to-day, is of more general interest, and gives the composition of all units from the combat group up to the brigade in a few easily assimilated paragraphs.

Ludendorff's Strategy on the Russian Front.—The article by General Camon is continued.—After Lodz, Ludendorff was always contemplating a Napoleonic stroke from East Prussia on the four railways leading to Warsaw and Ivangorod from north-east and east, which supplied the Russian armies. Of three rail-fed routes open to him, Mlava–Pultusk, Lyck–Bialystok, Insterburg–Kovno–Vilna, he, for various reasons, favoured the last, but Falkenhayn, preoccupied with the necessity for supporting the Austro-Hungarians in the Carpathians, would not supply the additional troops required for the wider operation, and gave orders to attack the 10th Russian Army facing East Prussia. This manœuvre culminated in the battle of Augustowo, 7th to 21st February, 1915, in which the Russian 10th Army was practically annihilated, but exploitation of the victory was not possible, as sufficient troops were not available.

The next operation prepared by Falkenhayn took place under Mackensen's command, and resulted in the capture of the bridge at Jaroslav over the San, the fall of Przemysl, and later of Lemberg, but did not achieve the decisive results hoped for. Still, Austria-Hungary was able to dispatch sufficient troops to stay the Italian front. In July Falkenhayn again wished to flatten out the Russian salient in Poland; Ludendorff objected and again proposed the attack on Kovno, but was again overruled.—(*To be continued.*)

The German Infantry.—The article by Commandant Pujo is continued, and this month deals with the German idea of the offensive, which, in view of the inferiority of their artillery, must be carried through by dint of superior training and courage, skill and intelligence. The conditions necessary for success are discussed at some length; plans for attack must be based on three fundamental ideas: (1) to break into the enemy's position at different places, so that the cohesion of the defence may be destroyed; (2) to ensure that the shock troops receive constant support from the heavier arms; (3) to aim at envelopment even in the smallest local attacks. The dispositions to be adopted with these ends in view are then explained, and illustrated by a diagram of a battalion attacking.

Three phases are recognized in the attack; the advance from 4 kilometres to 400 metres, the attack and assault from 400 metres to the enemy's front line, then the fight within the position itself. The first phase only is studied this month.—(*To be continued.*)

The Reverse of the Medal.—The conclusion of the article by Capt. de Gaulle, tracing events on the Eastern and Italian fronts from April, 1915, to the end of 1916. Through the whole of this period Falkenhayn was intriguing to keep Hindenburg in the background, and displaying the utmost duplicity in his dealings with Conrad. The consequence was general lack of co-ordination; such disconnected operations as were undertaken failed of success owing to lack of reserves to exploit them. Thus Mackensen's success at Lemberg was not followed up; when Italy declared war Austria wished to concentrate on crushing her, but received no assistance; when Hindenburg was at length able to advance and take Vilna he was unable to prevent the Russian retreat. When Bulgaria entered the war a large portion of the Serbian Army made good its escape through Albania, and no advance on Salonica was possible, as Falkenhayn sent secret orders to Mackensen, who had been placed in command of the Balkan front, to leave the Bulgarians to act alone. It was not until February, 1916, that Conrad received any information of the projected German attack on Verdun, and, meanwhile, he had been preparing in the Tyrol an invasion of Italy, While the Austrians gained some success at Asiago, two of their armies were being cut to pieces by the Russians under Brussilov near Brody, and Falkenhayn was at length compelled to send reinforcements from the Western front, and acknowledge failure at Verdun. He and Conrad were now quite discredited, but even then the civil and military advisers of Germany hesitated to appoint Hindenburg to the supreme command. The intervention of Roumania, and the strong pressure thereupon brought to bear on the Central Powers by Turks and Bulgarians, brought matters to a head, and unity of command was at last achieved by the appointment of Hindenburg, with Ludendorff as his Chief of Staff. But in September Francis Joseph died, the young Emperor Charles quickly threw off German military tutelage, and the military convention which had been signed became a dead letter.

Books Reviewed.—Hindenburg et Ludendorff Stratèges. By General Buat. (Berger-Levrault).—An exceedingly interesting publication, written by one who has made a special study of the great military leaders of Germany, and based on their *Memories* and on those of Falkenhayn and Tirpitz. For two years whilst Falkenhayn was Chief of the General Staff, they were not masters of their actions, but after they had replaced Falkenhayn they themselves failed in presence of the vastly more intricate problems then given them to solve. In 1917 it was they who modified their methods. Their strategic conceptions did not expand with the needs of the situation, and effort was expended in the wrong direction. If, instead of pressing on towards Amiens in March, 1918, they had acquired comparable gains in the direction of Calais, they would have driven English and Belgians into the sea. Their ideas were too "colossal," and, when their effectives were failing, pride prevented retirement on to a less-extended front.

Liçocs da granda guerra. Tip. da Emprêsa Diario de Noticias. Lisbon. By General Adriano Beça.—Written by a soldier who has already established a reputation as a technical author, this book presents in a simple and interesting form a complete compendium of the lessons of the war. The work, informed by deep experience and supported by documentary evidence, is of considerable value.

La Marche sur Paris. By General von Kluck. (Payot).—To von Kluck's pre-eminent reputation in the German Army was due his selection to carry out von Schlieffen's master-stroke of outflanking the French left. On 28th August, 1914, the War Lord himself congratulated his general, but on that very day came a change. The enemy retreated south-east. Thereupon to von Kluck was entrusted the two-fold mission of protecting the German right and enveloping the French left, a mission lacking preciseness which orders from the High Command that the 1st Army was to march north of the Oise did nothing to clarify. He was ambitious, hoped to secure a victory over the French, but neglected his rôle of flank guard. An order of 2nd September that he was to place himself in echelon behind the 2nd Army found him a day's march in front advancing by forced marches, and destiny, in the shape of the Army of Paris, punished his disobedience. General Debeney, who has written an able preface to the book, brings out clearly the Kaiser's responsibility in this matter. That the High Command failed in co-ordinating the efforts of the various armies is probably correct, but that does not exonerate von Kluck for failing to find out for himself the presence of Maunoury's army on the flank he was directed to guard.

A. R. REYNOLDS.

REVUE DU GENIE MILITAIRE.

(January, 1923).—Railway Engines. The author discusses the merits of compound and simple expansion engines, the effect of super-heating, the size of wheels, number of axles, weight—describes the latest type of engine constructed for the French State Railways.

He comes to the conclusion that simplified single-expansion engines, using super-heated steam, having 4 axles with coupled wheels, give the best results from a military point of view.

Field Telephone Circuits using bare wire. The following points are discussed :—

1. Contact between wires due to wind or change in temperature.
2. Electrical disturbances between circuits or from extraneous causes.
3. Rapid and simple construction.
4. Ease and simplicity of repair.
5. Good results.

Reviews.

1. *Chemical Warfare from "The Military Engineer," July,* 1922.

2. *German Pioneers and the crossing of the Marne in July,* 1918.—No transport could approach the river without disclosing the projected attack. The plan of attack was (1) to carry boats to the vicinity of the river; (2) cross small parties of men in boats and simultaneously to commence the construction of rafts and of two boat bridges per division;

(3) to replace the boat bridges by one heavy bridge per division. A map and a brief history of the crossing is given.

3. *The organization of positions and mining in mountain warfare,* by the Austrian Major General of Engineers Moritz Brunner.

The reviews occupy some 25 pages and are very interesting reading. For mountain warfare in high altitudes the author comes to the conclusion that only specially selected and trained troops are of the slightest use.

(*February,* 1923).—*An Essay on the problem of Communications in War in the light of the experience of* 1914–18.

The Author states that most, if not all, of the offensives in the war were brought to an end owing to the failure of communications to keep pace with the advance. He points out that the equipment, as far as tools are concerned, of divisional engineers has changed little from Roman times. He analyses the respective functions of Pioneers, Divisional, Corps and Army Engineers; points out that the first must make possible the advance of fighting, personnel, machine-guns, 37mm. guns and eventually some 75 mm. guns.

The Divisional Engineers must do as much for the Division and must make roads capable of taking loads up to ten tons for a short period of time with sufficiently good foundations to carry heavy traffic for a very considerable period. These roads would be tactical and not over well suited for subsequent collection and distribution of supplies and materials. To be of any use these roads must be able to keep up with the advance of the Division. Lateral communications, traffic circuits, etc., would be outside their scope.

Corps engineers would (1) improve the surface of divisional roads to stand very heavy continuous traffic and (2) add transverse roads and crossing places, widen roads for double traffic, make traffic circuits, etc.

Army engineers must maintain the work done by the previous formations and gradually replace them by permanent roads and bridges, which, in the latter case at all events, will probably be on different sites.

The author discusses the establishments, training and equipment required: for divisional engineers, he suggests that young men from 25 to 30 years of age are required and that they should all be trained to be skilled carpenters, this being more important than that they should be good shots. As regards equipment, he considers essential that each company should have (*a*) one or two wagons capable of being used as cantilevers over gaps, and each fitted with a pivoting crane; (*b*) carry two sets of fittings for a modified Andersen pile driver so that whilst one pile is being driven the next can be prepared; (*c*) carry a small electric winch on the platform of the crane and worked from the shore by a small electric dynamo. He emphasizes throughout the necessity for speed, also that Divisional Engineers must make one main forward road with a fair surface out of materials to be obtained locally. This road must keep up with the advance of the Division, must be capable of standing a small amount of heavy traffic up to ten tons whilst the area is occupied by the Division, and must have a good enough foundation for the Corps engineers to be able to improve the surface and so make a semi-permanent road.

The Ornac Bridge over the Jaur, built by the 2nd Regiment of Engineers. This bridge was built as a peace exercise, consists of pile trestles, with the exception of three, which consist of double piers built on to concrete blocks. All expenses other than pay and rations of the working party were paid by the local authorities, as the bridge meets a longstanding need. Drawings, etc., are given.

A Study of Mine Chambers—Calculations are made and the shape and size of different chambers discussed. The question of detonating a charge to form a chamber is also fully considered. The *Study* is continued in the March number.

(*March*, 1923.) *Austrian Military Railway Bridges* (*Roth-Wagner Type*). These bridges are built up of standard sections and can be used for spans up to 107 metres. Joints are made by the use of bolts through cover plates or through the overlap of two adjacent members.

Only 50 different parts go to the making of the bridges and these same parts can be used to construct piers. The weights of the components vary up to 627 kilogrammes. 8 only are over 400 kg. The girder can be made of single or double unit depth, *i.e.*, 4 metres or 8 metres, and the bridge can be of either deck or through type. The author points out as a fact, and not as a criticism, that theory has been made to give way to practical results in some cases, with the result that certain components are needlessly heavy and that, in others, subsidiary stresses of indeterminable value are set up. In conclusion, he strongly recommends further study of the bridge and the obtaining of a bridge for experimental purposes. He considers that the bridge has very many excellent points, particularly in its adaptability and in the small number of different component parts. The article goes into very considerable detail and is well provided with drawings and photographs.

(*April*, 1923.) *M.D.* Battalions*, by General Protard. The author in his introduction points out that at the beginning of the war the engineers formed $\frac{1}{46}$ of the effective strength of the army and at the end $\frac{1}{27}$. The Engineer effort does not seem to be fully appreciated, and his object is to put on record the work done by the M.D. Battalions in the construction of deep dug-outs.

He describes, in the course of his article, two conveyers, one for removing spoil when working on or near the surface, and the other for use in deep dug-outs. These are extremely simple, easily portable, and require only a 3 H.P. motor. The latter can work at an angle of 66° with the horizontal. He gives details of many deep dug-outs, cut and cover dug-outs, cover necessary, speed of execution, etc. This article is concluded in the May number.

Review. The Re-establishment of Railway Communication with the Dobroudja after 1918.—This is a review of an article published in May, 1921, in "*Le Bulletin de la Société Polytechnique Roumaine.*" The review is in considerable detail and describes (1) the construction of a ferry-boat to take 22 locomotives and railway wagons, the ferry-boat itself being constructed out of three barges, (2) the construction of a barge bridge.

* So named after MM. Mascart and Dessoliers, Engineers, who were responsible for the special equipment of these Battalions.

The method of loading and unloading the ferry is worthy of notice, as the river has a considerable rise and fall of tide.

(May, 1923.)—*Reflections of a Heretic on the Defence of Fortresses*, by Brevet Lieut.-Col. A. Clément Grandcourt. This is a paper written by an Infantry Soldier in June, 1914. It is concluded in the June number.

The author lays stress on the fact that he is neither an engineer nor an artilleryman, so that he discusses the question from an infantry point of view. He discusses the French forts in the light of past history, criticizes and suggests alterations. That he is ahead of the times is proved by the fact that he foresees the use of heavy siege-howitzers, gas, aerial bombing, etc. Many of his ideas were carried out in the war, and the only point on which he seems to have gone seriously astray is in the amount of protection required against modern artillery. The gist of the article, which occupies some 60 pages, is perhaps best given by translating the preface written by General La Croix and afterwards enumerating the points on which he lays special stress.

General La Croix says:—" . . . A wide-spread pre-war paradox denied any value to fortresses and more particularly to barrier forts. Our adversaries, by means of immediate and clever propaganda, took advantage of the costly results they achieved at Liége to confirm this paradox and so to bring about premature surrenders or regrettable evacuations. Certain people, short-sightedly coming to hasty conclusions, and without due thought, have considered in consequence that the late war has brought about the condemnation of all forts and fortresses—a serious error which might have a deplorable influence on the conservation of repair of our defences, more useful than ever against a revengeful Germany. If, as ever, offensive action eventually brought victory, the defensive, *i.e.*, the delayed offensive, showed its utility and its strength. Where would the German invasion have been checked, if Lille and Maubeuge had been organized and could have been defended as was Verdun.

It is not only the vain satisfaction of having uttered true prophecies in 1914 that has led the author to exhume this article. It is the conviction that the reader will find in it several statements which the war has proved to be well-founded and some details which the national defence might well follow. The methods proposed in this article are generally capable of rapid execution and which could have been carried out in the first half of 1914, when the electrical atmosphere made observant patriots foresee the coming storm.

The author was not correct in all his statements. Whilst foreseeing the heavy German artillery, whose destructive effect was not suspected by so many officers, he did not realize the damage they could cause. Protection is, above all, resistance to shattering by heavy howitzers rather than to penetration by direct fire. Protection against shrapnel has become of secondary importance.

Lastly, the necessity of deep continuous trenches, even for the exterior line of defence, and the uselessness and even the danger of light overhead cover soon became evident.

These errors give a date to the work, which, let it be said again, is due to an infantry man. But it seems to me that the author must be given great credit for having foreseen among others: The importance of a very distant line of defence, executed or rather organized in peace time (Maubeuge); the precautions to be taken against raids by armoured cars (Liége); the organization of concrete block houses (German pill boxes); batteries in casemates and camouflaged from the air; the use of rapid-fire guns of small calibre and of incendiary shell; the fight against *Minenwerfer* and against gas; the defence against aircraft and the necessity of giving fortresses anti-aircraft protection; the organization of the close defence and of keeps; finally the capital rôle of personnel, staffs and troops, played in the defence.

Owing to its date the article is not a criticism of the late war; if it is, it is that the war has proved its soundness. In it are found the proofs that the German methods did not come as a surprise to those who were able to look ahead and who had taken the trouble to study. It is not, therefore, in spite of its date, but because of its date, that I recommend the following pages to the military reader."

In his summary the author states that he has tried to draw attention to the following points:—

1. The immense importance of the outer defence organized in depth;
2. Necessity for the complete protection of the fixed artillery and the development of the mobile artillery;
3. Permanent works to be a protection and not tombs; construction of keeps;
4. The use of woods in defence by means of " Pirate Forts ";
5. The rapid supply of heavy long-ranging guns, if necessary by borrowing from the navy;
6. The increase of small medium-calibre artillery for use against personnel;
7. Special arrangements against assault;
8. Anti-aircraft defence;
9. Field and fortress troops to be interchangeable;
10. Increase of staff officers.

Log Bridges for Heavy Loads.—The Rhine having always a large number of felled trees floating down to the saw mills, the author describes types of rafts and bridge piers constructed from these trees and experiments with them. Such rafts offer the maximum of resistance to artillery fire as, unlike pontoons, they cannot be sunk.

The Utilization of the Waters of Morocco.—The author deals briefly with the water situation in Morocco and describes the arrangements at one post for supplying the troops and the native village with water. An improved Hydraulic Ram (the Bollée) is described.

C.LAT.T.J.

REVUE MILITAIRE SUISSE.

(1923. *Nos.* 10 *to* 12 *inclusive.*)

Certain military writers attempted during the early days of the Great War to draw conclusions as to the value of permanent fortifications from the press accounts which were given of the part played by fortresses in Belgium, France and Russia; the verdict of these writers was that the advent of Heavy Artillery, such as that brought into the field at the outbreak of war in August, 1914, had sounded the death-knell of permanent fortifications and that the experiences on the Western Front, as well as on the Eastern Front in Europe, all tended to expose the bankrupt condition of this form of defence. M. Jean Fleurier contributes an article to Nos. 10 and 11 of the *Revue*, which is of particular interest to Sappers; he combats the views of the writers referred to above and points out that the first accounts published as to the part played by permanent fortifications were sensational and misleading. He is of opinion that the deductions drawn from the photographs of the forts damaged by the German artillery were altogether erroneous; these photographs, it should be mentioned, were taken by the Germans for propaganda purposes. In recent times, a considerable number of books have been published by authors who have had an opportunity of personally making a critical examination of the effects of the German Heavy Artillery on the important defences in Belgium and in other countries. The information now made available is of such a character as to render necessary a complete reversal of the early opinions formed as to the value, or rather as to the alleged uselessness, of permanent fortifications. The impression, which gained currency in the autumn of 1914, that permanent works have no resisting power against heavy ordnance can be traced to the deliberate measures taken by the German High Command, as a part of their *manœuvres morales*, to spread the notion that the destructive effect of the projectiles, fired by the weapons designed and constructed at the Krupp and Skoda factories, was so enormous that no Entente fortress could hold out against them for more than a few days at most in the face of an artillery bombardment conducted with the vigour shown by the Germans at Liége. M. Fleurier admits, of course, that very important results were obtained by the German Heavy Artillery, but he points out that the regular sieges of the Great War, and the defence of Verdun in 1916 in particular, all teach that permanent works, when in the hands of those who know how to get the fullest advantage out of them can still be relied upon to play an exceedingly valuable rôle in modern warfare. The course of events on the Western Front and those on the Eastern Front are separately set out in outline in the original article. It is quite obvious from these brief surveys of the war that the results obtained by the German Heavy Artillery had very far-reaching consequences; these results were partly of a moral and partly of a strategical character. The intensity of the German bombardments produced in many cases so great a demoralization in the defending troops as to induce a "voluntary abandonment" of fortified centres. M. Fleurier is of opinion that the too ready abandonment of permanent works can be traced very largely to the mischievous doctrine preached before the war to the effect that "ground in itself has no real military value." It was for this reason that, in the first days of the war, no serious attempt was made by the French Armies to make a stand on the strong positions on the Northern frontier of France, positions for the defence of which projects had been prepared by Seré de Rivières. Later, during the period 1915 to 1918, exceedingly costly operations were undertaken to drive the Germans from these very positions. In the second part of his article, M. Fleurier probes the situation with a view to ascertaining the causes which were responsible for the extremely disappointing part played by permanent fortifications—the enquiry deals mainly with the Belgian theatre—and records his conclusions: briefly, in his view the Meuse fortifications were so placed as not to meet the strategic requirements of the situation; they were not only too close to the German frontier but the works were also wholly inadequate; no permanent works existed at 9 out of the 29 points of passage across the Meuse, and the undefended gaps were so wide that the Germans were able easily to push past the fortresses of Liége and Namur without let or hindrance. M. Fleurier shows conclusively that, so far as the Meuse defences were concerned, they failed to meet the requirements of the situation in three important respects, namely, (1) the works were insufficient in number and disposition properly to bar the lines of advance from Germany into Belgium; (2) the Belgian artillery was insufficient in number of pieces and also in calibre to cope with the German Heavy Artillery; and (3) the number of troops available for the defence of the Belgian Eastern frontier was insufficient effectively to guard the whole extent of the line which should have been held in order to oppose properly the German advance into Belgium. In addition to the foregoing defects, the Belgian High Command was faced with the anxiety arising from the fact that the Belgian fortress troops were of poor quality and their officers without experience. The doctrine that any kind of troops, and, particularly the view that men not good enough for service with active units and formations, were quite suitable for the defence of fortified centres, had not yet been exploded on the Continent.

Among other contributions to the numbers of the *Revue* under notice are articles by M. R. A. Jacques dealing with the design of bombs for the use of the Air Force (in No. 12); an account of the recent retreat of the Hellenic Army in Anatolia (in No. 10); and extracts from the private diary of M. Louis Rambert, wherein events connected with the Greco-Turkish War of 1897 are touched upon.

W.A.J.O'M.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1923. *Nos.* 11 *to* 12.)

The account of the operations of the Belgian Army is continued, some of the events of October 4th and 5th, 1914, being dealt with in the two numbers of the *Bulletin* under notice. The text of the communication addressed by the Belgian War Minister to the British First Lord of the Admiralty and also the text of the telegram sent by the British Foreign Office to the British Legation in Antwerp on October 4th are set out *in extenso*. In the former, the Belgian War Minister conveys the thanks of his Government for the reinforcements sent and the further reinforcements promised by the British Government; the latter repeats the text of Lord Kitchener's message to the First Lord of the Admiralty, wherein are given the particulars of the Expeditionary Force, amounting approximately to 53,000 men, being sent from England and France to the relief of Antwerp. The anxiety of the Belgian High Command, in relation to the protection of the line of retreat from Antwerp to the coast, is clearly revealed in the Belgian War Minister's communication of October 4th; a request is made that the British troops promised by Lord Kitchener, namely, the 3rd Cavalry Division and the 7th Division, should be directed to Ghent as quickly as possible, in order to ensure that the Belgian Field Army should be able eventually to join up with the British and French Armies. The intention of the British Government was to land its quota of the reinforcements being sent to Flanders at Zeebrugge. On the other hand, the French Commander-in-Chief was asking that the 7th Division should be disembarked at Boulogne, in order to join up immediately with the British II and III Corps: his intention being that the British Expeditionary Force should quickly extend its left flank northwards with a view to turning the enemy's right and *thus to join hands with the Belgians.* Sir John French was in accord with the French Commander-in-Chief and supported his proposal. The British Government was not, however, to be moved from adopting the course it had indicated to the Belgian Government as being in process of being carried out; the 3rd Cavalry Division and the 7th Division were conveyed from Southampton to Zeebrugge on the night of October 4-5th, the Admiralty having taken steps to ensure the safety of the transports; at the same time, two brigades of the Royal Naval Division were dispatched from Dover to Dunkirk. Having received an assurance on October 4th, that 22,000 British troops and 23,000 French troops would be landed immediately on the Flanders coast, the Belgian High Command felt less apprehensive as to the safety of the Belgian Field Army, but it was still uneasy as to the movements reported to be taking place westward of the longitude of Brussels. Intelligence received in Antwerp indicated that German forces were already marching from Tournai on Lille and that an action had been fought northward of this line, namely, in the neighbourhood of Audenarde. In consequence, Belgian cavalry, cyclists and machine-guns were hurried to Ghent; clearly, the anxieties of the Belgian High Command were by no means entirely at an end. The view was held in Antwerp that St. Omer, the point at which the concentration of the British Expeditionary Force was now being effected, was really too far to the westward of Lille to enable the British troops properly to cover the retirement of the Belgians from Antwerp to the coast; the Belgian High Command expected that any move made to the northward by the British for the purpose of extending the Entente left towards the Dutch frontier would certainly be met by a vigorous counter-move on the part of the Germans, who would naturally guard against any attempt to turn their outward flank. The prolongation of the German front to the northward would, it was felt, seriously imperil the Belgian Field Army. In these circumstances, the Belgian King made further representations to Colonel Bridges, the British *Liaison* Officer at Belgian Headquarters, and requested that instructions should be issued to ensure that, in addition to holding Ghent with the 7th Division, the British should occupy other points on the line of retreat from Antwerp with additional troops to be provided for that purpose. At one time, the Belgian High Command appears to have entertained the hope that the position in Belgium would have been made so secure that it might have been possible to hold the Germans on the line of the Scheldt between Ghent and Audenarde and thus have prevented them from reaching the coast. But the Germans had pushed forward with almost reckless speed, so that by the morning of October 5th not only had the Belgians been driven to the north of the Nethe and out of Lierre, which was now in enemy hands, but advanced parties of Germans had reached both Termonde and Schoonaerde, whilst their reconnoitring parties were known to be in the neighbourhood of Sotteghem.

A short while back it was announced in the Daily Press that a recent invention made in Germany provided the means whereby the engines of aeroplanes, of airships and of automobiles could, from a considerable distance, be brought to a stand-still whilst in operation. The possibility of such an achievement being within the range of accomplishment by human beings was received with incredulity in some quarters; indeed, it was even held up to ridicule. M. H. Dackweiler contributes an article to No. 12 of the *Bulletin* wherein he suggests that those who have cast ridicule on the alleged invention would have been better occupied, had they, instead, devoted their time and their intellectual equipment to the task of attempting to discover the secret of the mechanism by means of which such a result may be obtainable. M. Dackweiler calls attention to the early experiments of Tesla with high-frequency currents in 1898, and points out that the distinguished American scientist little anticipated at the time how serious would be the consequences resulting from these experiments; the electro-magnetic radiation from his laboratory provided sufficient energy, at a distance of some miles from the locality of its generation, to burn out the powerful dynamos at the Power House of the Colorado Electric Light and Power Company. M. Dackweiler provides, in simple language, an explanation of the effects produced by high-frequency electric currents and points out that, since in modern internal-combustion engines used for propelling aircraft and mechanically-driven vehicles the "mixture" is usually fired either by means of a magneto or an induction coil, the problem of putting the engines of an aeroplane or an automobile out of action resolves itself, in such cases, merely into a matter of generating sufficient heat in the armature windings or in the windings of the induction coil to fuse the wire forming these windings. The problem of disabling such engines is by no means difficult of solution, so long as existing methods of ignition continue to be employed. However, it is foreseen that, the danger being indicated, counter-measures are likely to be adopted and it is anticipated that in due course the present-day types of engines in aircraft and in mechanically-propelled vehicles will be replaced by types which are not similarly vulnerable.

Other articles in the numbers of the *Bulletin* under notice deal, *inter alia*, with the mistake the Germans made in violating the neutrality of Belgium and the serious consequences that followed thereon (No. 11); the conversion of solid into liquid fuel (Nos. 11 and 12); the American Civil War (Nos. 11 and 12). Considerable information relating to the Air Forces of various nations is contained in Nos. 11 and 12 of the *Bulletin*.

W.A.J.O'M.

MILITÄR WOCHENBLATT.

(*15th April*, 1923.)—In a leading article on military-political conditions in South-West Europe, von Winterfeldt commences by observing that the relations of the states of the Little Entente to each other and to the other countries not belonging to this Entente are of so many and opposing shapes that South-West Europe, as of yore, will remain the storm centre of the Old World.

"Even though they may be intent on pursuing their own policy, they are always confronted by their dependence on France. Their other common interests as against Hungary continue to keep the Little Entente firmly united."

He then proceeds to take the various states in turn. Czecho-Slovakia is said to be completely under French influence; the French military mission, the head of which is at the same time Chief of the General Staff, has occupied the chief positions as regards organization, training and leading, so that the Army has been put almost entirely at the service of French interests. "Co-operation with France in the event of any further sanctions is as good as secured. In such an event the further occupation of Silesia and an advance from the neighbourhood of Eger against the Main appear to have been prepared." The Germans in the Army are said to be systematically kept back, and even gradually replaced. The writer insists that Czecho-Slovakia is a French vassal-state, whose army is at the disposal of the French till 1929, and that France can dictate not only its political but its military action against Germany.

Rumania, Serbia, and Austria are then dealt with, the main point being that their armies are not up to a high standard. Hungary, however, though small and still weak, is eulogized for its national ardour and patriotic feeling, which is particularly noticeable in the army, whose value is rated highly. The army reductions, as stipulated by the Treaty of Trianon, have been completed. The Chief of the Entente Commission, the Italian General Zucarini, carries out his work "with benevolence towards Hungary."

Finally, as regards Bulgaria, it is observed that, while universal service has been suspended through the provisions of the Treaty of Neuilly, there are still great gaps in the army, as volunteers are not forthcoming in anything approaching the numbers required.

(*1st May*, 1923).—Under the heading "Nauticus redivivus" the leading article of this issue welcomes with enthusiasm, and sentences of colossal length, the reappearance of this German naval annual. After a lapse of nine years a new volume has appeared, smaller but "supported by courage and confidence and, like its predecessors, endeavouring to tell the German nation about the sea, which for the great part carries its bread and its—*ach so knapp gewordenen*—wealth, the means of support of its life."

The 1923 Annual has set itself the task of answering the question, "What was, and what to-day is, striking the balance between the losses of the war and the value and strength of the present and the future?" Questions of naval power and politics are left to a secondary position, and trade, technique and navigation are the first consideration.

In a military-political review of the general world situation, "Lucius Cincinnatus" devotes the first column to violent criticism of the French, and encouragement to his countrymen in their struggle to maintain passive resistance. Turning to America, he begins with the curious remark that "since Wilson so thoroughly decoyed the German Michael into a trap," no support is to be looked for from America for a long time against French overbearance. After remarking that the mass of the American people take no interest in Germany's fate, he goes on to the oft-repeated statement that the Entente owe their victory to the American assistance, adding that it can be understood that neither England nor proud France are willing to admit this truth.

"In England there has undoubtedly taken place a certain revulsion of feeling in our favour." Comment is directed to the extensive propaganda campaign in favour of France, at the head of which is the *Daily Mail*. In spite of this the upper classes are beginning to realize that it was a mistake to weaken Germany to such an extent. The lower classes are "incapable of political judgment" and allow themselves to be led. "But if the English do not feel in their own persons the disadvantages caused them by French imperialism, they will do nothing for us." He then says that our diplomacy is hampered by our weakness on land and in the air, and so introduces a comparison of French and British air forces. He then quotes from a report on the air forces by Colonel Girod, member of the Army Commission in the French Chamber, who points out that England has lost her isolated position as an island by reason of the danger of attack from the air. This the writer describes as intimidation of England, and then says that England can also certainly cause her "former friend" considerable anxiety, particularly in the Colonies. The paragraph concludes: "However, it seems exaggerated to deduce from an undeniable cooling-off of the friendship that England, in the near future, may take any action in Germany's favour." The concluding paragraphs of the article deal with Italy, the Lausanne Conference, Egypt and India.

It is interesting to observe that in this, as in former similarly entitled articles, the same propaganda are being developed; abuse of France, resignation as regards the U.S., ridicule of England's apparent helplessness, and emphasis at any cost of any and every sign of weakness of allied unity. A further indication of these motives is to be found in that portion of the issue where recent publications are reviewed. Here prominence is given to what appears to be a mere pamphlet written by the French Colonel Gauthier, entitled "L'Angleterre et nous"; the review begins by saying that the author sees in England an open enemy, whose enmity dates from the Peace Conference in Paris. The rest of the review is a translation of what would seem to be the most violent sentences to be found in the pamphlet—good copy, in fact, for the man who wishes to preach from the text that the *Entente* is dead.

(*15th May*, 1923.)—The new Base at Singapore is discussed in this issue; the writer dates the inception of the scheme back to 1919, when "the English Government, by the increasing apprehensions of the Dominions in the South Sea before the Japanese danger, saw itself forced to submit the strategic situation in the Pacific to a close examination," and for this purpose sent Admiral Lord Jellicoe on his mission. This preparatory measure is said to mark the close of one period of measures of security for the English World-Empire, and the beginning of a new one. "The great programme of the English World-Empire, a programme necessitating the defeat of the German, Russian and Japanese dangers, in order to secure the stability of the empire, was approaching its third act. The period of history just ended, which had necessitated the concentration of English naval power in the waters of the North Sea, appeared to be closed, the European situation secured, and the East Asiatic ripe for action." Japan's position in the Far East, her intentions towards China, demanded a new orientation of English policy, which led, in agreement with the United States, successively to the renunciation of the Anglo-Japanese alliance and the summoning of the Washington Conference.

The writer then speaks of Lord Jellicoe's proposals to station eight battleships and eight battle-cruisers in the East, which were dropped partly on financial and partly on diplomatic grounds. The Washington Treaty having settled not only the limits of naval strength, but also the question of fortified points in the Pacific, the new requirements of the situation would be examined. After detailing the provisions of the treaty as regards fortified places, the writer observes that Singapore was not affected by these limitations and the English plans could take a firmer shape. The importance of Singapore is then discussed both from its geographical and economic aspect, its importance being compared to Gibraltar or Panama. "A military base for a fleet at this point means a stronghold for the freedom of the seas of the most genuine type." After paying some attention to the arguments put forward by Mr. Amery, the writer concludes: "The new step is for the moment without deep significance for the European situation. The subjection of English policy through the superiority of French military and air power remains unchanged. There only remains to acknowledge the grandeur of the political conception which, unaffected by such subjection, already undertakes the necessary measures to meet in a period of years the new tasks properly prepared after the European questions have found their solution in one way or another."

(*10th June*, 1923.)—The leading article of this issue deals with the "Military-Political" situation in France. The writer starts by asserting that the readiness for self-sacrifice which the French nation showed before the Great War in order to furnish the necessary military forces for defence still holds good in undiminished measure. The *leitmotif* is unchanged: Security against Germany. "Our total disarmament is overlooked." The alarming, "though inaccurate," reports of alleged frauds with regard to German army strengths are thoroughly exploited. France's love of peace is continually emphasized, but Germany's desire for revenge, her intention to utilize the *Reichswehr* and the *Schutzpolizei* with, in all, 250,000 men as *cadre* for a huge army, aided by the regimental associations, hidden stores of arms, help from Russia in the shape of war material of all kinds—the writer adds a mark of exclamation here—all this prevents France from reducing her army. "There is no more talk of the stipulation of the Versailles treaty that Germany should first get on with her disarmament and that the other powers should then follow suit."

The writer then deals with the army and navy estimates of France, her failure to balance her budget, and her war debts, in order to point out the financial difficulties of the French Republic. He then proceeds to deal with strengths, and passes on to discuss the effect of the falling birthrate. The invasion of the Ruhr, culminating in the verdict at the Krupp court-martial, is next dealt with, followed by a paragraph pointing out the various military problems that France has yet to solve. The writer gives the French peace effectives, and lays stress on the great development of the air forces, which in peace should total 20,000 men and develop a war strength of 300,000. "But in spite of this superiority an airman of repute has bitterly complained in the Chamber about the defective and antiquated machines and the need for improved engines. In reply, the Government pointed out that the French aircraft industry constructed 3,000 new aeroplanes in the first eleven months of 1922. This should give England something to think about. Precisely in their superior aircraft industry has France got an effective weapon."

"The Paralysed German General Staff" is the title of the next article, dealing at considerable length with Professor Delbrück's accusation in the *Berliner Tageblatt* in April last. The professor was writing on the subject of Field-Marshal Count Waldersee's memoirs, which had recently appeared, and the sentence forming the text of this article is as follows:—"The point is the extraordinarily momentous question whether the German General Staff was paralysed in a barren dogmatism, having as consequence the loss of the World-War and the fall of the German Empire, and whether this paralysis had already set in with Moltke's immediate successor, Waldersee." The controversy is only another phase of that between the politicians and the military party as to who lost the war. After saying that the complaint can be directed with less justice against Waldersee than against Schlieffen, "the spiritual creator of the march to the West," the younger Moltke and their disciples who filled the leading positions in the war, the writer then has a general slap at the politicians who supported Bethmann. He propounds two questions to be answered in order to refute Delbrück's thesis:

1. Did the general staff do everything before the war in order to produce in the German Army, by means of organization, armament, internal development, moral and practical education, an instrument which would be capable of undertaking all the heavy tasks that it would encounter in war, or not?

And 2. Did the German General Staff before the Great War do everything in the practical and theoretical education of general staff officers based on their own and foreign, past and recent, war experience, to fit them in the spheres of both strategy and tactics to meet, not only in the superior but in all positions, the many-sided and often antagonistic tasks in the West and the East?

The first question he answers by saying that Marshal Foch, who is regarded as the greatest commander of these times, has himself called the German Army of 1914 "the best army in the world."

The second question is not so quickly disposed of; a column and a half are devoted to its treatment, and finally the question is asked: "Why had the Entente at Versailles nothing more urgent to do than to extirpate the German General Staff?" Keynes is quoted as saying that it was the German terror which overhung them, and this terror was first and foremost the German General Staff. The article then resolves itself into a countercharge against the politicians for the loss of the war and the downfall of Germany, on the same lines of argument that this journal has been following for many months past.

Under the general news at the end of this issue is a short paragraph quoting a story from Mayence, published by the *Kölnische Zeitung*. A "nigger" suddenly appeared in the street there, naked except for a meagre leather apron. His appearance attracted a crowd and two policemen. Both were at once scandalized, but with inborn German courtesy they first enquired of the "nigger" why he was promenading the streets in this primitive attire. Thereupon the "nigger," grinning over his whole face, opened his enormous right hand, from the hollow of which a white paper made its appearance. On the paper was written, over the stamp of the French military headquarters in Mayence: "The negro Bambula has leave. He is permitted to wear plain clothes."

(*25th June*, 1923.)—The only article of interest in this issue is a review of a French Book on the "Battle of Montdidier," as the French call the battle on the 8th August, 1918, and following days, which was won by the British Fourth and French First Armies. After observing that Marshal Foch, in his instruction of 24th July, 1918, had emphasized the supreme importance of surprise in further operations, the critic says that the Germans were well aware of this principle; that up till July they had succeeded in obtaining this element of surprise; "on 15th July it failed. On the 8th August the English and French succeeded in a complete surprise. The measures taken to this end correspond so exactly to those hitherto adopted by us that it almost looked as if German orders had served for examples." After quoting several of the steps so taken, he then says that the most important and decisive means whereby the surprise was obtained, "a means that unfortunately was not at our disposal," was the employment of tanks. The course of the battle, as described by the French author, is then shortly described, before the critic deals with the statement that one of the chief causes of the German defeat was the separation in the German Army of divisions for attack and divisions for position warfare. The critic says that this was only a policy of necessity, owing to the German difficulties in replacing men and horses. "Of there being a German system, which was inferior to a better French system, there can be no question." Finally the critic finds in the French author a supporter of the German policy of wholesale destruction during retreat, a policy that the French condemned as barbaric and contrary to international law. "Armies of to-day have so many needs in order to live, move and fight, that a thorough destruction of means and communication of commerce strikes at its most sensitive spot and can completely paralyse it." The critic seems to overlook the difference between normal military measures and those that were considered barbaric.

E.G.W.

HEERESTECHNIK.

(*October, November and December*, 1923, *numbers.*)

Anti-Aircraft Defence.—The article by Major Gretsch is continued in the October number and deals with searchlights. Searchlights, to be of value, must have a mirror diameter of over 60 cm. They are generally used in batteries of four, and their distribution is dictated by that of A.A. batteries. There should be at least 500 metres between searchlight and guns, however. For the defence of a town or area at least two lines or circles of light must be used. The outer to pick up, and pass on to the inner, any raiding planes. The inner ring should be so disposed as to be able to cover the whole area up to an altitude of 3,000 m. Lights from fixed points may serve eventually as navigation lights to raiding planes. Positions should therefore be altered.

Major Gretsch does not believe in balloon or "sausage" entanglements (such as were used in Paris). He states that their use in Germany was responsible for only one solitary casualty to allied aircraft, that it is very costly in men and material, and is as dangerous to friend as to foe.

The principal task of civil and military co-operation is the organization of an efficient observation service to report all movements in the air. The first use of this system is to give scouts sufficient time to reach their full height before the arrival of bombers, but it may also be necessary to track down spies (put down by aircraft), and also information (and propaganda) dropped, may be collected. An organization is described which groups a few observers under a report centre and a few report centres under an information centre. Communications should be by separate and reserved telephone lines amplified by wireless. Scouts need twenty minutes at least to get their height and therefore the first news should come in when bombers are about 100 kms. distant. From this fact it is deduced that no sufficient protection by fighting planes can be arranged for in the case of towns which are within 50 km. or so of the enemy lines.

Not much weight is laid upon camouflage or upon dummy construction. A few general remarks indicate how valuable it would be to deceive raiders, without indicating how it may be done. Civil precautions should aim at preventing panic by giving civilians a clear idea of how and when to act.

The effect of the growth of artillery fire upon the character of fortified towns is referred to and the opinion is expressed that the town of to-morrow may be designed in some new and startling way in order to escape the dangers which threaten from the air.

Rivers in Battle.—Major Klingbeil resumes his explanation or *précis* of the new training manual *Brückenbau* or bridging. The first cases quoted postulate an undisputed crossing with a possibility of fairly speedy counter-attack. The value of speed, good staff arrangements (*i.e.*, early arrival of engineer and bridging units, etc.), and well-arranged supporting artillery and machine-gun fire are noted.

If the river is already under hostile observation, success will probably only be achieved by night or in poor visibility and must be prepared for very carefully. Camouflage, and well-staged feints, accompanied by thorough reconnaissance and good arrangement, will be essential. The operation will be carried out by covering troops, which provide covering and supporting fire, advanced troops (apparently rafted over, because the preparation of such rafts is emphasized), and a reserve, by which working parties are formed. The necessity for silent approach on straw or manure-covered roads, and for hiding from air observation the bridging material, and preliminary ground work, is emphasized.

We next reach the " ultimate case " of a frontal attack on a strongly-held river line. Everything is to be put in, in such a case, and, of course, with every possible element of surprise. The supports for the pioneer troops immediately engaged on the job should rise to 50 per cent. and every article of equipment doubled. Woods and copses, certain targets for artillery, are to be avoided; covered approaches, perhaps through wide trenches, are to be made. Other pioneer formations are to stand by to undertake repairs, to alter position, or to dismantle, as occasion demands. Pontoon bridges are to be replaced by more permanent forms, capable of carrying heavy loads, at the earliest possible moment.

Bridging in a retreat must be of solid character and provide for crossing on a broad front. Crossing should be at night or under cover of a smoke-screen. Artillery will cross early and cover the operation. Dismantling or destruction to be arranged for. Loss of pontoons is excusable, if troops are saved.

In the defence of a river front counter-attack must find its place, and implies crossing at some time or another. The most important factor is reconnaissance. The line of resistance is the river bank, or outpost line. The rôle of pioneer units is technical reconnaissance, destruction or hiding of all boats, and the preparation of floating mines, etc.

In approaching a river the vanguard pioneers must be strengthened and pontoons must be brought forward by night marches, arranging for their camouflage by day.

A special article deals with rafting or ferrying, and another with the subsequent bridge construction, giving figures and calculations. These emphasize the necessity for a sufficient strength of pioneers—approaches to be marked with signposts which can be illuminated at night.

Camouflage and anti-aircraft precautions are dealt with at length. The main job of A.A. batteries is to cover the whole space over the bridge with fire and to watch the natural avenues of approach (above railways, roads, canals, etc.). Smoke-screens are more likely to help by attracting hostile fire on unimportant places than by actually vitiating aim.

The Influence of Temperature and Wind on the Velocity of Sound in Air.—This paper, by Doctor Kolzer, deals with the phenomena of the propagation of impulsive sounds in the atmosphere, and particularly with the fact that sounds are sometimes heard at great distances from the source (zones of abnormal audibility), although inaudible over intermediate areas (zones of silence).

The author quotes the work of a number of investigators, notably Tyndall, Mohn, Borne, de Quervain, Mölke, and particularly Emden.

(Contribution on the thermodynamics of the atmosphere, in Vols. 1-6 of the *Meteorological Gazette* for 1918.)

An explanation of the observed phenomena is found, which confines the problem to the "Troposphere."

This is opposed to the theory of Borne, which regarded the energy reflected from the hydrogen layers of the upper atmosphere necessary to account for the zones of abnormal audibility.

Equations are given for the paths of sound rays (normal to the wave front) in terms of determined meteorological quantities, and the work includes diagrams of the boundaries of the Zones of Normal Silence, and Abnormal Audibility in three dimensions, taken from Emden's work, and connected with Stated Meteorological Assumptions.

There are numerous compositors' errors and the text is difficult to follow in consequence.

The paper is not yet complete and its conclusion will be reviewed later.

Angular Measurement.—A short article summarizes the different sorts of angular measurement still in current use in the German Army. What with the *Feld Artillerie Strich*, the *Fuss Artillerie Strich*, the *Sexagesimal* and the *Centesimal* systems, one would have thought there were enough to choose from, but there is also given a sexagesimal beginning with quadrants of 90° followed by a centesimal division into minutes and seconds. A captured log-book on this principle caused us some consolation in France, for how can a nation which employs no less than six different systems of angular measurement, alongside each other, throw stones at our barleycorns and perches? Perhaps the idea was to make it more difficult to use captured gun-sights. We have still a few copies of a war-published conversion table, which gives all these freak divisions in terms of sexagesimal units, and which was produced for the edification of those who used captured material.

An article on *The Conduct of French Railways in War* is historical in character. The main conclusion drawn is that France lacked the one central railway authority which is essential to an efficient concentration of effort. At the outset no measures had been foreseen for the provisioning of large centres (*e.g.*, the milk supply of Paris).

The difficulties of organizing additional dock facilities for the carrying away of the enormously increased imports at the Channel ports (and later Atlantic ports), of railing the American troops across France, and of feeding Italy with coal, are dealt with. (Italy took 15,000 tons of coal daily!)

Of 357,000 railway employees, 29,000 were lost on mobilization, and 13,000 were left in the German-occupied areas. Another 19,000 were taken for other military duties just before the battle of the Marne.

About 45,000 wagons were lost to the French in the occupied areas, but some 8,000 replaced by rolling-stock from Belgium, etc. The loss of the big repair shops in territory occupied by the Germans made it difficult to keep rolling-stock in proper order.

The activities of French Army railway units are discussed briefly. Demolitions on the eastern frontier were well carried out, but as no French railway units were present on the northern, little or none were carried out.

Major Klie has, in the November and December numbers, the first two parts of *A History of the Construction of F(eld) K(anone) 16 and L(eichte) F(eld) H(aubitzer) 16*. Most of us will remember their appearance on the western front. The German field-gun 96n/A pattern with an M.V. of 465 m/secs. could not get the necessary elevation for A.A. work. On the other hand, the light Howitzer 98/09 pattern had too little M.V. A compromise, effected by mounting the field-gun on the howitzer carriage, was so successful in increasing range that it was introduced for normal use and seldom available for anti-aircraft purposes. Meanwhile, experiment was continued in designing a new field-gun with increased M.V. The first step was to lengthen the barrel, but the results so obtained were poor until captured Russian ammunition was used: the M.V. was increased in this way to 540 m/sec. but involved a strain on the gun which was considered dangerous.

The next step was to lengthen the loading chamber, and to turn from fixed ammunition to separate cartridge and projectile—the latter of the cigar (stream line) shape which led to its designation (*C-Geschoss*). It was hoped to get 6,000 m/secs. M.V. and a range of 10,000 metres. Actually an M.V. of 547 m/secs. and a range of 9,000 m. was secured.

The comparative merits of an increasing and a constant twist in rifling were settled experimentally in favour of the latter—but field trials were not thorough enough. The gun was introduced, and then it was found that the increased angular velocity of the shell itself put the time fuzes in use practically out of action. Three charges had been contemplated: the lowest for short-range high-angle fire, the normal for everyday use in ordinary circumstances, and the highest for long range.

Difficulty of manufacture prevented the manufacture of the lowest and the fuze trouble interfered with the highest. The normal charge gave an M.V. of 416 m/sec.

The light field howitzer 98/09 had been considered a satisfactory weapon, but there were repeated demands from the earliest days of the war for increased range. The first experiment on these lines was the conversion of captured Russian 12 cm. howitzers. The long barrels of these converted weapons led to their being known as Howitzer guns, They were heavy, but gave an M.V. of 461 m/secs., and a range of 9,200 metres, and proved their value on the Russian front.

A Balloon Theodolite.—A description is given in the November number of an interesting model of a theodolite for recording the path of a small and free balloon. Observation on such balloons plays an important part in meteorological field-work. The balloon is designed to rise at a constant speed. Its vertical rate being constant, the horizontal rate of travel becomes a measure of the wind velocity at different heights. The model in question, a Hahn-Goerz, records position automatically on a table which drops vertically downwards from the theodolite at a constant rate. The "puncher" travels with the theodolite in azimuth and elevation, and a record of the path of flight is thus obtained. The duty of the observer is simply to set his automatic plotting going at a time when he has the balloon on the cross-hairs and to follow the path of flight as accurately as he can; the instrument does the rest.

There is an unsigned article on *The Present Stage of Chemical Warfare.* The author had his tongue in his cheek, and he makes his point to some extent. He starts by accusing the Spartans of originating gas warfare in 400 or so B.C., and shows wherein he thinks that, progressively, Greeks and Romans, Saracens, Dutch, English, Russians, Americans, Japanese and French have shown partiality for it.

From that point he goes to the Hague Conference, jumps the war and gets to Versailles and lastly to the Washington Conference. Then he quotes from French, English, American and Belgium regulations, manuals and articles, and mentions activity in Italy, Spain, Poland, Switzerland, and the Scandinavian countries. He ends off by saying, " These foreign opinions and facts speak for themselves. They point a moral to the Washington Conference, and nothing need be added." The situation does not, indeed, seem to be very clear.

A short article on *Battery Board Equipment of To-day* is interesting because it shows that German gunners are content with their war-time models. The board seems to be sector-shaped with metal arcs and radial arms. The scales given on these arms are at scales of 1/20000, 1/25000 and 1/21000 (for western front, home and eastern front respectively). The socket, the paper arcs for O.P.'s and fittings generally, seem to be of the pattern which was so familiar to us in the war, and no doubt have the same good finish (with bits of cork for drawing-pins, pockets for oddments, etc.).

Two books of considerable apparent interest are reviewed in the December number.

(a) *Innere Ballistik,* by A. Schweickert. Barth. Leipzig. 1923. This book deals with pressures in the bore, and with various propellants.

(b) *Die Fernrohre und Entfernungsmesser,* by A. König, an official belonging to *Zeisswerk.* Julius Springer. Berlin. 1923. This book deals with the theory, manufacture and use of optical instruments.

H.St.J.L.W.

MILITÄRWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN

November–December.

Dr. Lothar Rendulic began an article on the psychology of discipline in the September–October number, and continues it in the number under review. He is not very interesting on the relation of officer to high command, of the rank and file to their leaders, or of authority to subordinate. We have all heard it before, in much shorter compass, and with fewer hairs split. He is interesting when he talks of the bad times of the French Army in 1917 and of the events which led up to Caporetto. His heroes, Pétain and Clemenceau in France, Orlando in Italy, are those who protected the army first, and the nation second, against the doubts and fears of weaker brethren. He quotes Cadorna as writing to his government: " The internal political situation always exerts a decisive and immediate influence on the spirit of the troops in war, and particularly does this apply to modern war." But it is contended that the spirit of the troops must be kept undefiled not only by propaganda, and the weariness and faintness of heart of the nation at large, but must also be saved from the reaction to extravagant claims and statements by the staff. The Italian claims to decisive victories in the Carso are quoted as having had the worst possible influence on the men who fought there. The author might have drawn equally valuable inferences from the events of 1918, but refrains from doing so.

Ludwig Pengoo continues the story of the fight for Col di Lana. The Dolomite front of 100 km. was held at first by 6½ battalions—but no Italian attack developed for a month after the declaration of war. Two Bavarian battalions were on this front at the time and a German officer actually commanded a section of the defence, although war was not declared between Germany and Italy till the end of August, 1916. The garrison of the Col di Lana sector in July was about 1½ battalions, made up of companies of different regiments, with 41 guns. Numerous small attacks developed and in August the Col di Lana was occupied by the Italians, but a counter-attack drove them out.

In October German troops were withdrawn from the sector and after a series of attacks the Col di Lana position was occupied, but left the actual summit in Austrian hands. In fact, it was not before a mine had been driven and exploded under it that it was finally taken on the 18th April, 1916. The Italian position was gradually extended until May and from that time on a modified peace reigned in this sector till the Italian retreat of 1917. The article is a long one and must be studied with a map.

An article, continued from the last number, on aerial tramways is full of computations, tables and formulæ. It was written for inclusion in a book entitled *Technik im Weltkriege* and embodies a lot of useful information.

A translation of an article on our artillery in Italy, by Major Rolleston, R.F.A., which appeared in the July, 1921, *Journal of the Royal Artillery*, is included.

H.St.J.L.W.

THE MILITARY ENGINEER.

November–December, 1923.

Work of the Signal Corps.—A brief history of this Corps from its foundation in 1880. Its policy has always been to co-operate with commercial and public activities. In its early days it founded a meteorological service, which has since developed into the U.S. Weather Bureau. During the war, the Corps expanded from 2,000 to 50,000 and, in addition to its normal work, took charge of the Meteorological Service, the Pigeon Service and the Photographic Service; photographic work involved the preparation of a complete record of the war by camera and cinema.

Topographical Survey from the Air.—An interesting account of recent development in this field. Major Bagley, a joint-author, is the inventor of a four-chambered camera, which takes four photographs simultaneously, thus covering a wide field. The centre photograph is horizontal, the other three at an angle of 35° with the horizontal. The latter are corrected for distortion by means of a transformer, but the photographs still require to be assembled on triangulated points.

Air plane versus battleship.—Major General Patrick, Chief of Air Service, describes recent experiments on the sinking of two obsolete battleships by aeroplane bombs. He considers that anti-aircraft guns will not serve to protect ships and that the Navy must rely on its own aircraft to counter that of the enemy.

January–February, 1924.

Relation of Class Record to Success.—This article should be of personal interest to many officers of the Corps. The author, an Engineer officer, sets out to establish a relationship between success as a student at the West Point Academy and distinction in after-life. He has had at his disposal the records of over four thousand cadets. For his statistics, the relative success of a cadet is measured by his position on the passing-out list, whilst the standard of distinction in after-life is taken as the attainment of the rank of Brigadier-General or higher. The results, which are shown graphically, are remarkable examples of the law of averages. It is clearly shown that the higher a cadet passes out the greater his expectation of success. Curiously enough, an athlete has the same expectation of success, and no more, than any other individual.

Machine-Guns.—This is one of the last of a series of articles on the characteristics of the various branches of the service. Major-General Farnsworth reviews the machine-gun tactics employed by the various combatants in the Great War and explains how present-day American tactics have been evolved from these, combined with their own war experience. The machine-gun in use to-day is a heavy Browning. The fourth company of each battalion is a machine-gun company of eight guns organized into two platoons. The principles of employment in attack and defence are set out in detail and appear to be in close accord with our own.

The Training Problem of the Engineer.—Is evidently a subject of much controversy. The author, a Colonel of Engineers, deals principally with the training of the officer. He considers that the only Engineer units to be maintained in peace should be combat troops, as opposed to specialist troops. No specialist officers are required in peace ; they can be rapidly obtained in war.

The Corps of Engineers is a military organization ; hence the peace training of an officer should be directed to developing his powers of leadership and command, at the same time affording him opportunities for handling men and materials in the field. Too much theory is to be avoided.

Facilities for such training exist in Engineer units and on harbour and river work. On such work, the young officer should be given a definite job and a definite responsibility. The author outlines a proposed training programme divided into two periods, the first period covering seven years, during which the officer will be available for no duty except as a means of training. It comprises two years as a junior officer with a company on first commission, one year at the Engineer School, two years on civil work and two years with troops as a company commander, irrespective of rank.

The second period covers five years, two of which will be in an Engineer District in charge of constructional work, the remaining three being spent on military duty. Thereafter the balance between civil and military duty should be maintained as far as possible.

The article is followed by criticism by several Senior Engineer officers and many points of interest are brought out.

R.I.M.

THE COAST ARTILLERY JOURNAL.

THE *Coast Artillery Journal* prints an interesting article by a Medical Officer of the U.S.A. Army to prove that chemical warfare, contrary to public feeling, is not more inhuman than gunfire. The author was Consultant in Gas to the IV U.S. Army Corps and President Physician-in-Chief to the large gas hospital at Toul.

As the result of poison-gas warfare the vast majority of people visualize large groups of men struggling in torment, gasping, choking and finally dying in acute agony. This picture, once more or less true, is now quite erroneous and produces quite an incorrect propaganda. It was taken from the early accounts of the chlorine gas attacks on our own Army and on the Russians of the Eastern front, but in those days the troops were surprised and defenceless.

Quickly the gas mask, at first quite a flimsy makeshift, sprang into being and gas discipline was learnt in the primeval school of self-preservation. Chlorine and phosgene, which act through the respiration organs, soon lost their efficiency and that form of attack was beaten by the defence, as always happens in the end.

The only unprotected portion of the human body was then the skin, and so mustard gas was produced, not nearly as deadly as its predecessors, but much more effective in producing casualties. The former are only effective when highly concentrated and have the disadvantage of being quickly disseminated in the air. As the author explains, "You cannot chloroform a man in the open unless you hold him down and shut out the air."

He argues quite validly that it is strategically more important to put 2000 men permanently out of action than to kill fifteen or twenty outright. Mustard gas is originated from a heavy oil projected in some form of explosive shell. The ground can be saturated with the liquid, which volatilizes with great difficulty and consequently the danger of the attack lasts for days. The resultant gas acts as a strong irritant on exposed parts of the skin and the patient is really burned with acid and not choked, as inhalation is quite unnecessary. Superficial burns heal in a few days, deep-seated burns take a long time, but are not very painful. The burn leaves few, if any, pathological after-effects. The picture described in the second paragraph has therefore been vastly modified; in place of the hundreds of coughing, choking and torn victims gasping for their lives, are seen men cold from exposure and want of sleep, truly, but quiet and occasionally laughing. Casualties certainly, but not suffering much or likely to be permanently disabled or even scarred. The death-rate calculated by the author was 1·98 per cent. of admission.

His conclusions appear to be that chemical warfare put more men out of action with less hurt to the individual than weapons of any other branch of the Service. He deduces that, as long as attacks on defenceless civil populations of cities and towns are rigidly outlawed, chemical warfare is less inhuman than any other battle method at present known.

D. M. F. Hoysted, *Lieut.-Colonel, R.E.*

VOINA I MIR.

No. 7.—This number starts with an obituary notice to Professor Kelchevsky, the editor, who died in Berlin on April 1st.

An article by Capt. Gorshin discusses the French provisional infantry regulations of February 1st, 1920. He considers that the group organization, with its varied armament, is unsuitable for open warfare and is the result of deductions based on position warfare only, and that the tendency towards an immobile system of defence is a tacit admission of the weakening morale of the French infantry.

Professor Kelchevsky, in an interesting article, summarizes the results of the Great War and states his ideas on the form the next great war will take. Owing to the largely increased importance of material resources, the destruction of the industrial centres of a warring country will be sufficient to insure its defeat. The future war will start with aerial battles, the victors of which will be in a position to spread destruction over the areas in which the enemy armies are mobilizing. After refilling from the numerous stores which would be distributed along the frontier, the aerial fleets would then turn to the destruction of the great industrial centres, after which harbours and naval bases would be attacked. The logical outcome of these possibilities will be the defence against aerial attack of all great industrial centres by means of anti-aircraft armament and aerial nets.

If, however, the initial aerial battles are indecisive war will be carried on by land and sea. Armies will be mobilized under the cover of a strategic screen and an extended reconnaissance will be carried out. A country which has lost its faith in cavalry will carry out the reconnaissance by means of tanks and armoured cars supplemented by small detachments of cavalry and by infantry conveyed by mechanical transport, whereas the country which still believes in the strength of the human spirit will employ cavalry on a larger scale than hitherto, well-provided with mechanical armament. Owing to the enormous frontage taken up by modern armies, it is unlikely that any country will be in a position to construct a sufficient supply of machines to adopt the first method.

It is possible that a recognition of the fact that a complete aerial conquest would entail irremediable damage to the country subdued may lead to the adoption of a "strategy of exhaustion" in place of a "strategy of annihilation" by the warring powers, and the war might then take on a passive form (as in the World War) in which, for the sake of economy, gas in various forms would probably be used on a large scale.

An article by P. Zaliessky gives examples of the use of cavalry from earliest times and discusses the probable manner of its employment in wars of the future.

Lieut.-General Borisov, of the General Staff, in an article entitled "Fortresses of the Future," describes the part played in the World War by certain fortresses on the Russian Western front. For instance, the defeat inflicted by the Russians on Ludendorff in September, 1914, when he was trying to seize the line of the Vistula was largely due to the fortifications at Novo Georgievsk, Warsaw and Ivangorod, though the works at the two latter places had been destroyed some time before the war and had been only half restored. In August, 1915, the fortress of Novo Georgievsk was isolated and invested by the Germans; it fell in ten days. It was the only Russian fortress to put up a defence and it fell through the weakness of the commanders, poor spirit of the troops, lack of artillery and material, and weakness of the defences. Kovno was also isolated, but surrendered at once.

The author arrives at the following deductions regarding Russian fortresses:—

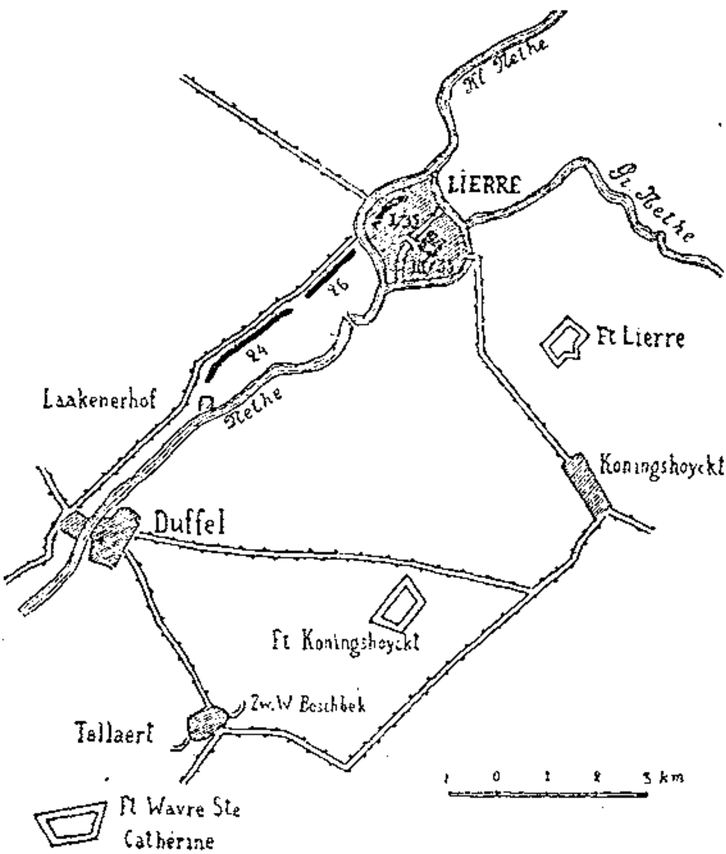
1. The extent of Russian territory excludes the useful action of strategical fortresses.
2. The flatness of the ground necessitates the use of tactical fortresses, as centres of resistance on a wide level theatre of war.
3. Tactical fortresses on the frontier would assist a plan for invading the enemy's country.
4. Fortresses would be useful in connection with bridges, defiles and forests.

By strategical fortresses are meant those which can be held after complete isolation, whereas tactical fortresses are held only so long as they are required for purposes of manœuvre.

The "Arming of Infantry" is a series of extracts (illustrated) from an article by Colonel Morcalli in the *Rivista di Artigleria e Genio*, with an introduction by Professor Kelchevsky.

In an article called "Artillery Intelligence" Capt. Ritter discusses and transcribes an article by Lieut.-Colonel Brood which appeared in the Journal of the Royal Artillery.

The Crossing of the River Nethe at Lierre is a description, by Capt. Ritter, of the passage of the Nethe south of Antwerp by the Germans in October, 1914. The outlying forts of Antwerp south of the Nethe had all fallen to the Germans on October 3rd. The country bordering the river had been inundated to a width of 400 metres and all the bridges had been destroyed. The water was so shallow that pontoons could not be used. The Belgians were entrenched on the north bank and fired at anyone who showed his head, whilst the southern bank was under heavy fire from the fortress guns. A general attack on the whole front would have been attended with heavy loss; it was therefore decided to attack Lierre, which was not only completely surrounded by branches of the Nethe but had a branch running through the middle of it. There were, therefore, three streams to be crossed. The attack was started at 6 p.m. on October 4th by the 1st and 3rd Battalions of the 35th Reserve Infantry Regiment of the 6th Reserve Division and one Reserve Sapper Battalion. Under cover of fire from the infantry, the sappers made arrangements for crossing the first branch, and 25 minutes later a large body of infantry had crossed. There was no bridge over the second stream, but the sappers managed to arrange a crossing, in spite of heavy fire from the houses, and by the evening the 3rd Battalion had occupied the market square whilst the 1st Battalion had entrenched itself between the second and third branches. Unfortunately, the author gives no details of the construction of these bridges. As night fell, the troops who were isolated from the main force on the south bank of the Nethe were subjected to heavy fire from the barricades and houses, and were unable to advance further. The fearless sappers, however, repaired a partially destroyed bridge over the first branch of the Nethe; some guns of the 6th Reserve Regiment immediately crossed, unlimbered in the market square and opened fire. Advance still seemed impossible as long as the western and north-western edges of Lierre were flanked by fire from the Belgian positions north of the Nethe and west of the town. It was therefore decided to cross the Nethe west of the town.



The crossing was carried out by the 26th Reserve Regiment and the remaining brigade (20th and 24th Regiments) of the 6th Reserve Division on the night of the 4th–5th. In the morning this force was in an unpleasant situation, with the river 200–600 metres in rear crossed by one half-destroyed bridge on their extreme right flank. A weak counter-attack by the Belgians was repulsed, a strong one would probably have succeeded. Still the Germans were unable to advance; they were exposed to heavy artillery fire and suffered from want of food and water; fresh supplies of ammunition could not be delivered.

On the night of the 5th–6th the tireless sappers made a bridge over the third branch of the Nethe near the western edge of Lierre. At dawn three batteries were able to cross and rendered the necessary assistance to the infantry which had been held up on the north bank to the west of the town. The Belgians thereupon withdrew to a position further north. About mid-day on October 6th the 1st Battalion of the 35th Regiment crossed the third branch and the object was attained.

Points worthy of notice in this action are: the uselessness of a passive defence even when assisted by a natural obstacle such as a river; the important part played by engineer troops.

Capt. Ritter refers to the Belgians as the "enemy" throughout this article, which is not, apparently, a translation from the German; it seems rather strange that such a term should be used in a Journal produced under the editorship of our late allies.

The Bibliography at the end of the Journal contains a short review of the *R.E. Journal* of December, 1922.

No. 8.—In the eighth number of this journal Captain Ritter, of the German General Staff, contributes a long and interesting article called "A Comparison of the Strategy of Napoleon and Schlieffen." The gist of it is that Napoleon recognized that strategy is an art and not an exact science. He refused to be bound by systems. This contempt for hard-and-fast rules is shown by the absence of Regulations in the French Army of his time, the latest being those of 1791. With a few lightning blows he shattered the false conceptions of the art of war of the post-Frederick period, the essence of which consisted in forcing the enemy to retire by skilful manœuvre with as little bloodshed as possible. He never approached any situation with preconceived ideas, but made a special study of each situation and took special means to meet it. The diversity of his resource, his versatility, his "many-sidedness," are well shown in the campaigns of Jena, Grossgörschen, Ulm and Regensburg; to quote his own words: "Fixed and unchanging rules do not exist; everything depends on the capabilities of the general, the quality of his troops, the time of year and a thousand other things which go to prove that no two cases are ever alike."

Turning to Count Schlieffen, the writer maintains that he possessed the same qualities as Napoleon, as did also his great predecessor Moltke; there was a widespread idea that he was an exclusive devotee of the strategy of envelopment, but this was erroneous. He had certainly advocated a policy of envelopment in several works, notably "Krieg in der Gegenwart" and "Cannæ," but this was because he had realized that in a war where large numbers were employed success could only be gained by action against the flanks. The logical outcome of this idea was that the enveloping movement should begin at the time of deployment, *i.e.*, before the armies had left their own territory. He had made a close study of the Russo-Japanese war and his opinions had been deduced therefrom. He wrote: "Mass formations lead to insufficiently strong frontal blows which, inflicted one after another, become weaker and weaker, producing scarcely any result. . . . Owing to this the modern battle becomes a struggle for the flanks in a greater degree than in former times. In this fight for the flanks the victor will be he who has his reserves, not in rear of his centre, but near the decisive wing. These reserves cannot be directed to the point which the leader in a battle extending over many square miles has, with his eagle eye, selected as the decisive one . . . they must be sent there at the very beginning of the battle."

S. Dobrorolski, in an article entitled "Defence in Strategy and Tactics," states that the strategy of a country depends on its geographical position. The strategy of Russia, with its vast territory, should be a defensive one. A true defensive strategy does not consist in a "stabilized" defence in lines of trenches, such as occurred in the World War, but should admit of every advantage being taken of depth of territory for the manœuvring of armies. Defensive strategy was practised with success by Russia in 1707–08, when Charles XII. was drawn on to defeat at Poltava, and in 1812 against Napoleon. An initial advance, in which serious encounters are avoided, is required in order to allow time for preparation in the case of a country like Russia. In 1914 the Russian advance met with disaster and the retreat was followed by a demoralizing trench warfare. In countries where room for manœuvre is lacking, recourse must be had to fortifications, the value of which, though discredited in some opinions by the rapid fall of Antwerp, Liége and other fortresses, has been fully established by the examples of Verdun, Przemysl, Ossovets and the obsolete Ivangorod. Strategic defence implies mobility and the full use of territory for manœuvre, immobility must be avoided at all costs. Dealing with defence in tactics, the author lays stress on the necessity for depth and the futility of a "wooden" defence in which lines of trenches are crammed with troops determined not to yield an inch of ground. He emphasizes the need for elasticity, that is, the ability to exhaust the attack by recoil and then to advance in counter-attack, which is the soul of defence.

General Zalesski continues his article on cavalry, dealing with their organization, employment, discipline and instruction. He pays a compliment to the horse-mastership and organization of the British cavalry.

In "Artillery at the Attack of Fortified Positions," Captain Ritter describes the gradual improvement in artillery tactics of the German Army during the Great War. At first, in 1914, infantry attacks were carried out with little regard to artillery co-operation. Trench warfare necessitated close co-operation between infantry and guns, and careful preparation before the attack, which, however, militated against surprise. The problem arose as to how adequate artillery preparation could be given without violating the principle of unexpectedness and suddenness.

The author explains at considerable length and in great detail how this end was attained in the German attack on the Anglo-French position on the Chemin des Dames on May 27th, 1918.

A. Shershevski contributes an article on giant aeroplanes. He explains that the limitations to size, as enunciated by Professor Lanchester, have proved fallacious, whilst Professor Rorbach's investigations have led to more reliable deductions. He discusses the nature of material, type of engine, and shape, most suitable for large aeroplanes. He describes several examples either projected or actually constructed; amongst the latter a *hydroavion* designed by L. Caproni in the form of a triple tandem triplane with eight 400-h.p. engines, and capable of carrying 100 passengers. It crashed at its first flight. The article is well illustrated.

No. 9.—In this, the ninth number, the new Russian orthography has been adopted whereby two vowels are replaced by two commoner ones of the same value.

In an article entitled "Corps or Division," S. Dobrorolski discusses the desirability of a permanent Corps formation in times of peace, as against the improvisation of Corps on the outbreak of war. He writes with considerable feeling, for during the war the Division he commanded served at various times in fourteen different Corps, in twelve different Armies, and on all four Russian fronts, so he fully realizes the disadvantages of the temporary allotment of Divisions to Corps.

The Corps formation was first adopted in the peace organization of the Russian Army in 1810, but was abandoned in 1862 and again adopted in 1879, it was therefore in existence at the beginning of the World War. Owing to the fact that the Russian Army, unlike the German, had no reserve Corps formations, on the outbreak of war all their peace Corps had to be reorganized to include Reserve Divisions, a measure which largely detracted from the advantages of the peace organization.

The author attributes the numerous tactical successes of the Germans on all fronts to their permanent Corps system, and gives an example in illustration. He considers that, under the conditions of modern warfare, a permanent Corps organization is more desirable than heretofore.

A.H.B.

VOIENSKO-TECHNITSKI ZPRAVI.

WE have received from the Minister of National Defence of the Czecho-Slovak Republic the first number of their *Military Technique Review*, which is to be published bi-monthly and will treat of technical questions concerning arms and military services. The number contains articles on the effects of artillery projectiles and the construction of dug-outs, military survey, light bridging, etc.

UNITED EMPIRE.

The February number of *United Empire* contains a short account, with photographs, of Australia's Military College at Duntroon, which is to be congratulated at having recently survived a serious attempt to retrench it out of existence.

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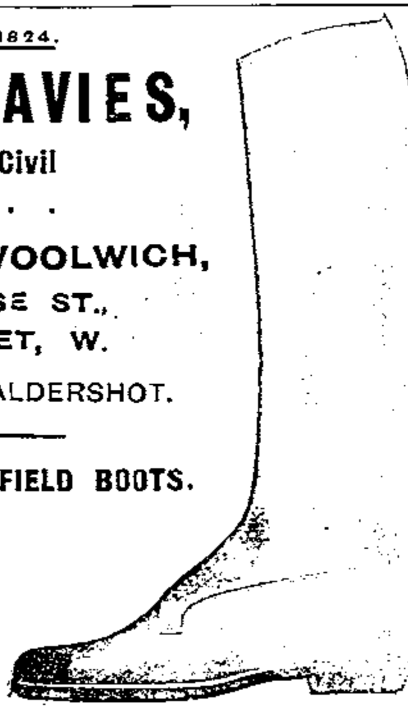

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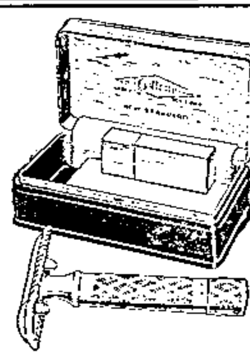

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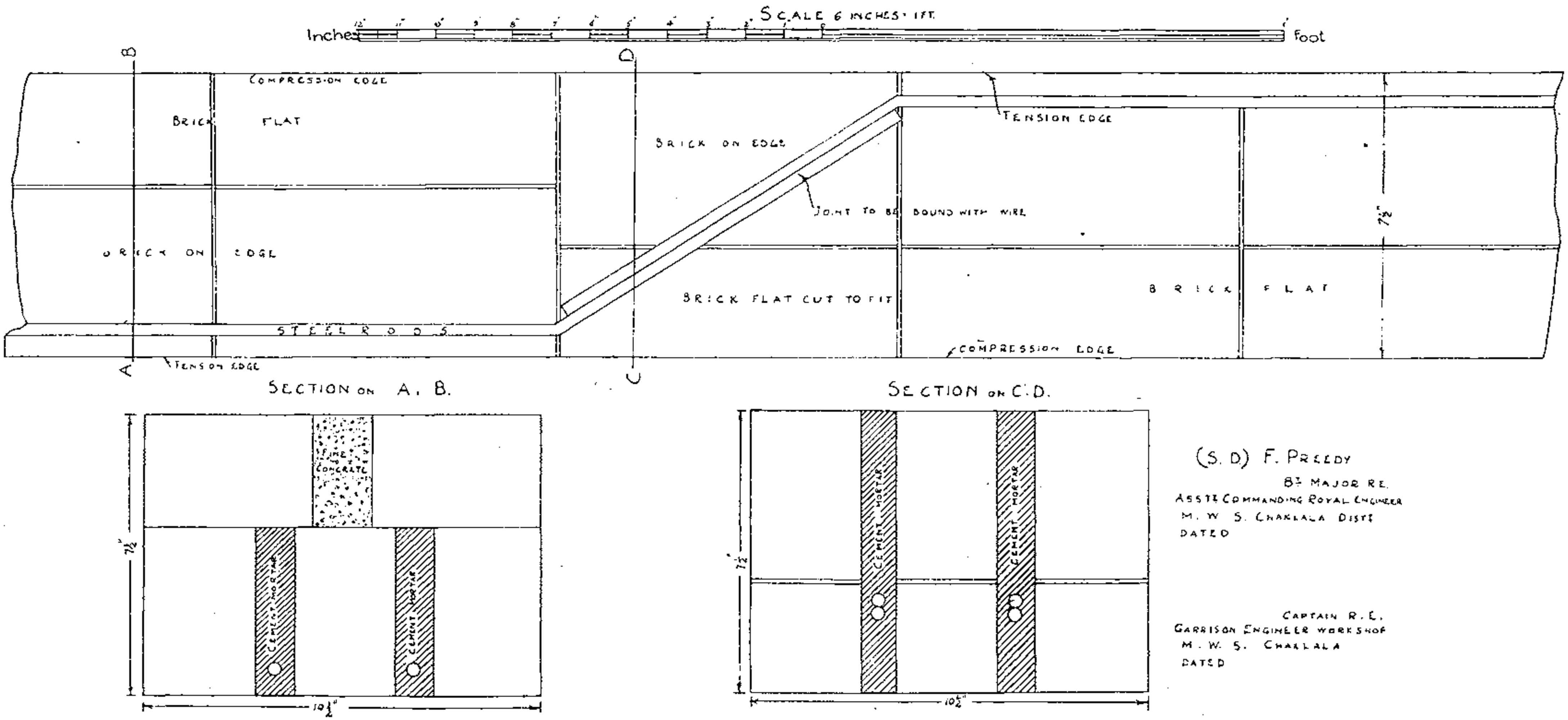
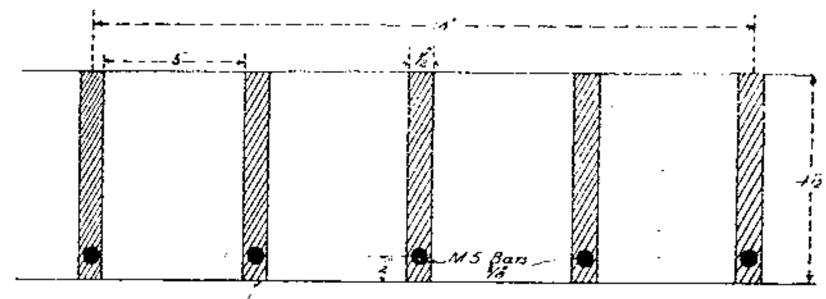
ROUGH SKETCH SHOWING ARRANGEMENTS OF BRICKS AT POINTS OF CONTRAFLEXURE IN VERANDAH BRESSUMER OF OFFICERS HOSTEL.



(S. D) F. Preedy
Bt Major R.E.
Asstt Commanding Royal Engineer
M. W. S. Chaklala Distt
Dated

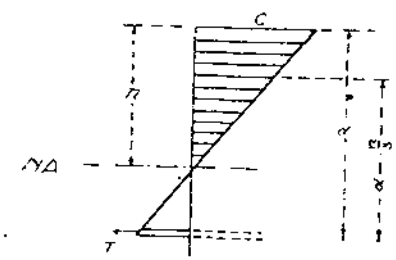
Captain R.E.
Garrison Engineer Workshop
M. W. S. Chaklala
Dated

SKETCH I.



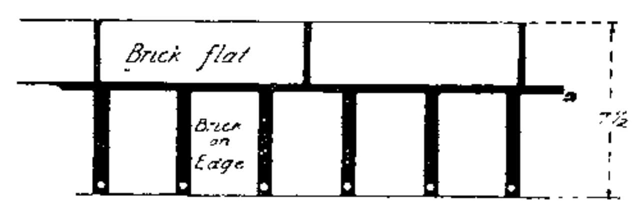
Section through Roof 4½" thick

SKETCH II.



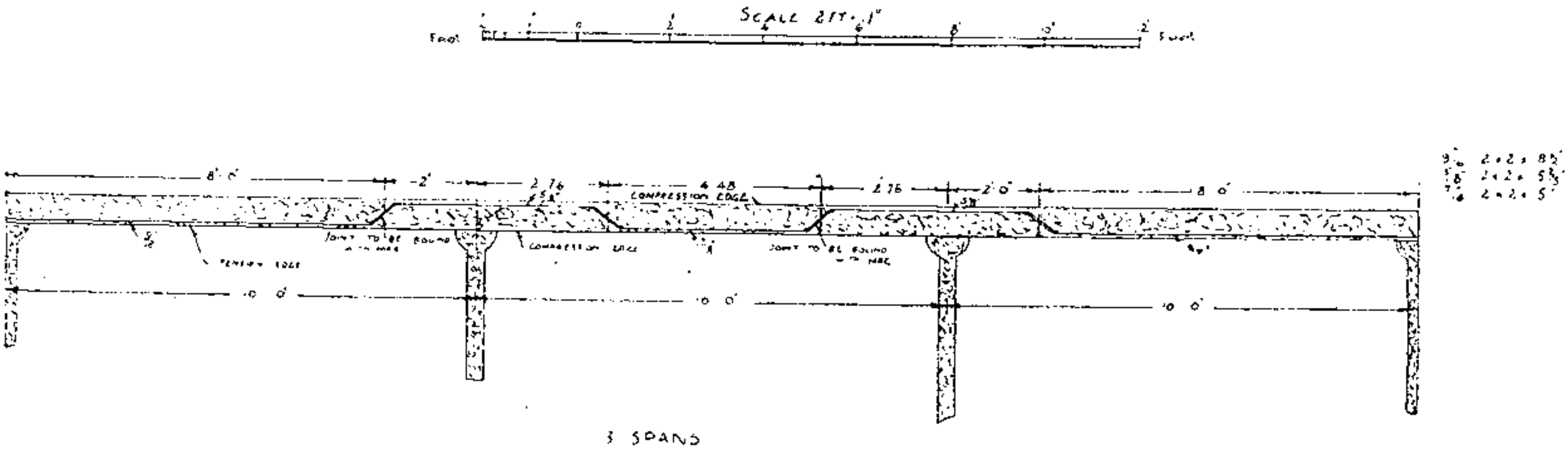
Forces in Beam

SKETCH III.



7½" BRICK ROOF

DETAIL OF REINFORCED VERANDAH ROOF FOR OFFICERS HOSTEL, CHAKLALA.



SKETCH IV.

GERMAN RAILWAY WORKING, 1921-22.

REF		HEADING	GREAT BRITAIN.	GERMANY.	SWITZERLAND.
A	1	Route Miles (all Gauges)	20 281 5	53351 km {51365 km Pass / 22961 km Goods} 33 156 miles	2862 km 1800 miles
	2	Track Miles (Running)	36 751 5 or 71 4% of Total	76735 km 47 664 miles or 64.75% of Total	3953 6 km 2471 miles or 71 5% of Total
	3	(Sidings)	14 726.0 or 28 6% of Total	41 790 km 25 962 miles or 35.25% of Total	1568 5 km 980 miles or 28 5% of Total
	4	Total	51 477.0 or 2.55 miles per Route mile	118 455 km 73 626 miles or 2 22 miles per Route Mile	5522 3451 miles or 1 92 miles per Route Mile
B	5	Engine Train Miles (Coaching)	205 415 970 } 315 124 753	Schnell 38 433 970, Eil 6 868 730, Personen 232 055 423, Milit 1 015 562 } 278 374 265 km 173 983 803 miles } 315 126 675 miles	7 930 000 km } 24 394 000 km 11 206 996 miles } 15246 328 miles
	6	Engine Train Miles (Freight)	109 708 783	Eilgut 19 126 074, Gut 203 078 003, Arbeit 3 616 515 } 225 718 592 km 141 142 872 miles	6 464 000 km 4 039 332 miles
	7	Engine Shunting Miles {Coaching / Freight}	15 708 909 / 87 030 117 } 102 739 026	326 489 010 km 204 055 631 miles	4 626 858 km 2 891 726 miles
	8	Other Engine Miles	48 370 266	84 830 478 km 53 019 050 miles	582 772 km 364 232 miles
	9	Total Engine Miles	466 234 045	572 201 356 miles	29 603 754 18 502 346 miles
C	10	Engine Miles per Route Mile	23.000	17 260 miles	10272
	11	Coaching Train Miles per Route Mile	10 128 } 15 538	5 250 } 9 510 miles	6221 } 8465
	12	Freight Train Miles per Route Mile	5 410	4 260	2244
D	13	Total Passengers Journeys No	1 786 671 112	No. 2 318 499 589	No 80 681 000
	14	Average Length of Journey Miles	10.77	21 22 km 13 26 miles	22 8 km 14 25 miles
	15	Total Journey Miles	19 242 447 876	49 192 919 489 km 30 743 304 550	1 150 000 000
	16	Journey Miles per Route Mile	948 792	957 711	639 000
E	17	Freight capacity Hauled	Wagon miles × av wagon cap 3 780 298 852 × 10 221 tons } 38 638 434 566	axle miles × av cap per axle 10439 959 430 × 7 53 } 78 610 347 877	axle miles × av cap per axle 207 11 184 × 6 7 tons } 1 387 644 932
	18	Freight capacity hauled per Route Mile	1 905 159 tons	2377 559 tons	770 913 tons
	19	Total Ton Mileage	13 288 985 777	55 724 376 642	919 427 555 T km 593 423 391 Tm
	20	Ton Mileage per Route Mile	661 769	1 052 162	329 500
F	21	Relation of Tonnage hauled to Capacity hauled	34 7%	44 3%	42 7%
G	22	Average length of Haul (Freight)	57 58 miles	152 08 km 95 05 miles	79 9 km 49 3 miles
	23	Average Freight Train Load	121 17 tons = 49% of Capacity	249 4 tons = 72% of Capacity	52 5 axles × 2 2 tons 115 5 Tons = 32 75%
	24	Average Capacity per Wagon	10 221 tons	15 37 tons	6.7 tons per axle × 2 13 4 tons
	25	Average Load per Wagon	5 07 tons	11 2 tons	2 2 × 2 4 4 tons
H	26	Coal consumed per Engine Mile	Pre war about 50 lbs; 1919; 1920; 1921 54 8 lbs; 1922 54 04	1914 49 4 lbs; 1919 75.9; 1920 69 9; 1921 63 75; 1922	
J	27	Total Staff & No per Route Mile	3/1921 735 870 - 36 5; 3/1922 676 802 - 33.5	{av 19 48 per km / = 31 66 mile} 4/1921 1 064 966 - 32 1; 9/1922 1 032 243 - 31 2	13 32 per Route km. 1921 38 371 - 21 31
		Staff by Departments			
	28	Administration (Verwaltungsdienst)		0 80 per km 42 804 - 1.29	0 30 per km 865 - 0 48
	29	Bahnunterhaltungs & Bahnbewachungs		3 66 per km 195 593 - 5.87	2 91 per km 8365 - 4 67
	30	Betriebs & Verkehrsdienst		8 40 per km 448 274 - 13.50	6 15 per km 17 717 - 9 81
	31	Zugförderungs & Werkstätten dienst		6 82 per km 364 257 - 11 00	1 99 per km 5 731 - 5 19
	32	Hilfsbetriebe (Service auxiliaires)			1 97 per km 5 673 - 3 16