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THE ROYAL ENGINEERS JOURNAL.

Vol. XXX. No. 6. DECEMBER, 1919.

CONTENTS.

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MONTGOMERIE PRIZE.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded by the R.E. Institute Council in the manner considered best for the encouragement of contributions on professional subjects, by R.E. Officers, to the Corps publications. From the beginning of 1920 it has been decided that the Prize shall be confined to Officers on the Active List not above the rank of Substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions :—

(*a*). Descriptions of works actually carried out in peace or war.
(*b*). Inventions.
(*c*). Design (excluding works of defence).
(*d*). Labour organization on work.
(*e*). Scientific investigations generally.
(*f*). Accounts of exploration work and surveys.

CONTENTS.

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

A NEW METHOD OF SOLVING "VISIBILITY" PROBLEMS.

By MAJOR C. F. ATKINSON, *late East Surrey Regt.*

QUESTIONS of visibility and cover frequently arise in map-reading. These can of course always be solved, so far as the fulness of the contouring and spot-levels permits, by drawing a section of the ground along the line considered. But this method is laborious, and the various methods that have been proposed as substitutes are all open to objection for one reason or another, except in the cases that can be settled by a mere inspection of the map.

The following method, which is believed to be a new one, is simple, rapid and accurate, and needs only a ruler with two parallel edges, one of these having a scale of (any) equal parts.

The problem may arise in one of three forms, (1) to ascertain whether any intervening obstacle interrupts the line of sight between the point of view and the object; (2) to find the nearest point of view from which the object is visible over the top of the obstacle; (3) to find the nearest point beyond the obstacle at which the ground becomes visible from the point of view.

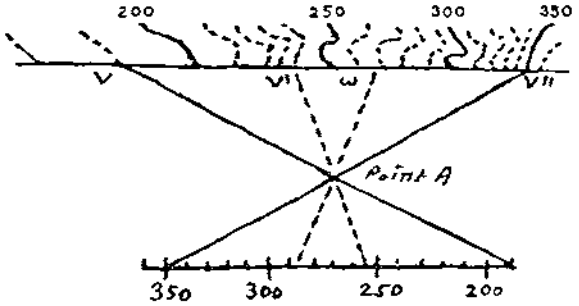
In each case, two points are given, as regards position and height, and the positions or heights, or both, of other points are to be examined with reference to these.

Method.—Parallel to the line of points on the map, draw any other line and graduate it in units of height *backwards* (that is, with the scale zero to the right if the lowest point on the map line is to the left, and *vice versa*). In practice, the actual zero is not required, and a partial scale numbered according to the heights that enter into the particular problem suffices.

Draw a line from each of the two given points on the map-line to its appropriate graduation on the scale line. These lines intersect at a point A and it is by means of this point that the problem is solved, in whichever form it is presented.

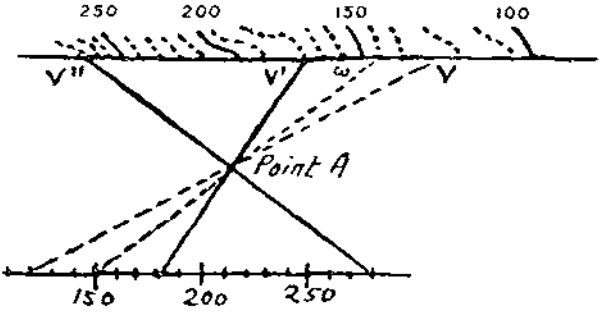
Case (1).—*To ascertain whether any intervening point V′ interrupts the line of sight from a point of view V to an object V″.*—Find point

A by lines from V and V″ to the scale, and test the possible obstacles in succession thus:—from the suspected point V′ draw through A a line to meet the scale. This does so at a graduation corresponding to the *critical* height for an obstacle of that position, *i.e.*, the height at which it is neither above nor below the line of sight V—V″. Comparison of this height with the real height shown on the map at once indicates whether the line of sight is interrupted.



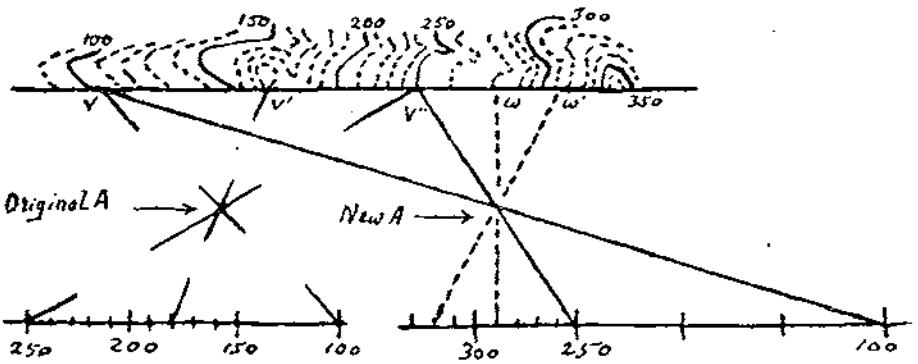
Point V′ has a critical height of 253 ft. and a real height of 240 ft.
Point W has a critical height of 289 ft. and a real height of 270 ft.
Neither, therefore, intercepts the line of sight V—V″.

Case (2).—*To find the nearest point of view V from which the object V″ is visible over the obstacle V′.*—Find point A from V′ and V″ and (working outwards from V′ so as not to miss any significent feature) test likely points on the map-line by finding their critical heights through point A, as in case (1), and comparing these with the respective real heights.



At trial point W, critical height 150 ft. and the real height 140 ft., V″ is invisible.

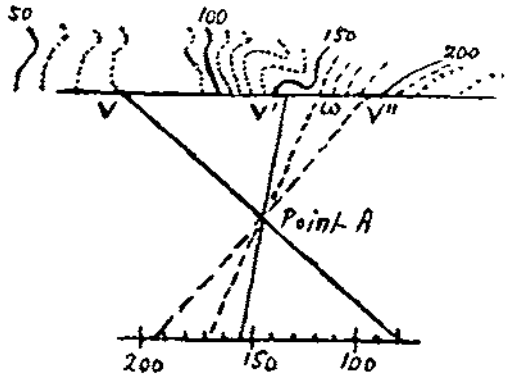
At the second trial point the critical height is 120 ft. and the real height about 124 ft., so this is taken as V′.



V'' having been determined, the ground beyond is tested by a new point A (found from V and V'').

Trial point W is invisible from V (critical height 290 ft., real height 270 ft.). But at point W' the critical height and the real height coincide, and the ground becomes visible.

Case (3).—*To find the nearest point V″ at which the ground is visible from the point of view V over the obstacle V′.*—Find point A from V and V′, and proceed as in case (2).



The trial point W, critical height 170 ft., real height 160ft., is invisible from V.
Point V″, with a critical height of about 193 ft. and a real height of 196ft. is selected.

NOTES.

The accuracy of work depends on a sharp intersection at A, and on nothing else.

To avoid working in negative angles, always assume the observer to be at the bottom, looking uphill. Thus, in finding the nearest point in low ground visible to an observer above the obstacle, proceed as for case (2).

After a little practice, only the scale line and the intersection defining point A need actually be drawn, the rest of the work being done with the edge of the ruler. The line of points on the map must of course be definite.

In cases (2) and (3), if the ground *beyond* the selected V or V″ has to be tested, this point is to be treated as a new potential obstacle and a new point A found. Of course if the selected V or V″ were *exactly* of the critical height this would not be necessary. But in practice a few feet would be allowed as a safety margin in selecting V or V″, and this involves the finding of a new A, which however, is very easily and quickly done, either with the old scale and one of the old lines, or with a new scale. This process can be repeated indefinitely along the line of sight in question. Similarly, in case (1), a piece of ground which has been found to intercept the view from V to V″ may itself be available as a point of view and may be tested by a new point A.

THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR, 1914—1919.

BRIDGING.

(*Continued*).

CHAPTER III.

BRIDGING OPERATIONS—AUGUST TO NOVEMBER, 1918.

(*Reference* MAP *following* PLATE XXIV., *page* 216, R.E.J., *November*).

Introduction.—Army Organisation.—The Ancre River.—Somme River and Canal and Tributaries.—Canal-du-Nord.

1. INTRODUCTION.

Before proceeding to describe the operations during the final advance, it will be as well to summarise briefly the work that had already been done.

At the beginning of the final advance of the British Army the War had already lasted four years, during which time about 180 Standard Span Heavy Bridges had been erected. Of these the only ones built under conditions at all similar to those about to be experienced during the advance, were the Fourth Army Bridges across the Somme in 1917, and to a lesser extent in April—May, 1918.

Steady training had been in progress at the Bridging School, and most of the officers and men of the R.E. Field Units had got a certain amount of knowledge of the nature and handling of the type spans.

Only a few units as such had had either training or practical experience in the work, and the heavy losses of *personnel* during March and April had greatly increased the numbers of untrained men.

Large quantities of material were on order from England, but deliveries were slow, and congestion in all factories made it impossible to accelerate the programme, whilst stocks in France had been much reduced by various causes already explained.

During the bare three months that elapsed between the beginning of the Fourth Army advance and the conclusion of the Armistice, approximately 330 Stock Span or Rolled Steel Joist Bridges were erected, or nearly double the number that had been used during the whole of the preceding four years. A complete account of all the bridging work done during these three months would fill many volumes. All that can be attempted here is to describe generally

the work done in crossing the main rivers and canals, with a few of the more important and interesting operations in detail. A short account of the hasty bridging by Divisional Troops will be found in the next chapter.

2. ARMY ORGANISATION.

Profiting by experience already gained, each army made the most careful preliminary arrangements both for study and reconnaissances of river and canal crossings with which they were faced, and also for the organisation of the special staff, transport, and depôts, that would be required.

The systems followed did not vary much, and in almost every case the most experienced officer available was placed in charge of the Army or Corps Bridging Depôt, the actual superintendence of the work of erection being entrusted to the O.C. of the Unit engaged.

A good deal of trouble was found in providing sufficient skilled labour at the Bridging Depôts, and nearly every variety of R.E. Unit was employed at one time or another. Views taken in an Army Depôt are shown in *Photographs* XXV., XXVI. and XXVII.

The work became increasingly technical and important as the advance went on, and salved material had to be taken over, repaired and re-used. Most of the armies also had to undertake a certain amount of work in dismantling heavy bridges in back areas, which were no longer of use where they were, but were required for re-erection further forward.

The supply of stock spans to keep pace with the advance was a matter of grave concern, and units were urged wherever possible to use stock rolled steel joist spans, of which a large number were always available. These had the additional advantage of being very simple in erection, and were particularly suitable for use by Divisional Field Companies, which had had little opportunity of training in the erection of Girder Bridges.

The increasingly important *rôle* played by Tanks in the advance, and by Heavy Artillery, made it necessary for Divisional Troops to erect bridges to carry the heaviest loads immediately a passage had been secured by the Infantry, and for this purpose the rolled steel joist spans were invaluable. By using them in conjunction with standard piers, bridges of any ordinary length were built under the worst conditions in a few hours; the use of winches and derricks was avoided, and in many cases it was found possible to build such bridges during the night at a comparatively short distance from the enemy; a further advantage was that damage by shell fire was easily repaired. On at least one occasion Tanks were even bridged over a water obstacle with the first Infantry attacking wave.

Great use was again made of the Inglis Rectangular Bridge, of which, however, only a limited amount was available.

3. The Ancre River.

In the first stages of the advance the Third and Fourth Armies were both faced with the considerable obstacle of the Ancre River and its flooded valley.

It was expected that much heavy bridging work would be necessary, but so rapidly did our troops advance that only temporary bridges were required in any quantity, and heavy bridges were constructed only on the main routes.

The Fourth Army work was carried out by the 283rd A.T.Company, R.E., and consisted entirely of R.S.J. spans, with the exception of one 60-ft. bridge across the Railway on the Amiens-Albert Road.

The 147th and 280th Army Troops Companies, and the 2nd Siege Company, R.A.R.E. did the Third Army work, which consisted of three 60-ft., and several R.S.J. spans.

The main causeway across the Ancre valley at Aveluy had been almost entirely destroyed by our own shell fire and by the Germans in their retreat, and this had to be entirely rebuilt. A 60-ft. span, and two 20-ft. R.S.J. spans were erected in the causeway itself in order to release flood water from the upper areas.

4. Somme River and Canal, and Tributaries.

The first crossings were all constructed by the Australian Corps.

A noticeable piece of work was done at Chipilly by the 3rd Australian Pioneers. Two High Level Steel Lattice Bridges existed before August 8th, one a French civilian and the other a French military bridge, the latter being of a longer span than the former. Both bridges were blown at one end by the enemy.

The length of the military bridge left undamaged was found to be sufficiently long to span the civilian bridge abutments. The bridge was picked up, a few new members made, and was placed in its new position in four days, producing a first-class single way bridge for all loads except Tanks.

An 85-ft. length of Inglis Rectangular Bridge was erected at Vaire on the 11th of August.

This was dismantled and re-erected at Bray on the 30th August. It was later replaced here by R.S.J. spans on piles, and was again used in the crossing of the Selle River in October.

The crossings in Peronne were reconnoitred on the 2nd September, and it was found that of the old British bridges only one 60 ft. Class A span remained intact. Temporary R.S.J. bridges for Mechanical Transport were started on the 4th, and completed on the 5th.

Semi-permanent bridges were commenced on the 10th as follows:

At Bristol Bridge site, shortened 60-ft. Class A span opened to all traffic 14th September, 1918, duplicated by a R.S.J. bridge alongside.

At Faubourg-de-Paris—Two R.S.J. bridges alongside each other, 30-ft. span, completed 16th September, 1918.

On Peronne-Flamicourt Road—Tank Bridge made of German Rolled Steel Joists, completed 7th September, 1918, and a salved shortened 60-ft. Class A bridge completed by 26th September, 1918.

All this work was carried out by the 574th A.T. Company, R.E.

The most important crossing of the Somme was at Brie. Reconnaissance of the sites was made on the 5th September.

The Germans had destroyed all the bridges, and the following new spans were erected over the five gaps:—

(*a*). 30-ft. Reinforced.
(*b*). 21-ft. 6-in. Reinforced.
(*c*). 60-ft. Mark II.
(*d*). 21-ft. 6-in. Reinforced.
(*e*). 60-ft. Mark II.

The 60-ft. bridges were erected as deck spans to allow Tanks to cross with sponsons out. This meant a considerable amount of extra work, as approach ramps had to be built up at each end.

The first spans were delivered at the sites on the 6th, and all five bridges were completed and opened for all traffic on the 9th.

It is interesting to compare the time taken with that for the same crossings at the beginning of 1917.

The second series, consisting of three 60-ft. spans, and two made-up rolled steel joist bridges, were delivered at the site on the 14th, and completed alongside the first series on the 18th. This work was carried out by the 216th and 574th A.T. Companies.

The rapidity and smoothness of the whole work was striking proof of the value of the training these Companies had received.

Another series of heavy bridges was erected at St. Christ, by the 4th Siege Company, R.A.R.E.

5. CANAL DU NORD.

The Canal du Nord, which connects the Sensée Canal with the Somme Canal, was at the outbreak of war in process of construction, and its state of completion varied considerably on the front of the First and Third Armies. In the southern portion a considerable

length is carried through a tunnel, and so presented no obstacle to our advance, but the very deep rough cuttings on other portions made a formidable gap, and the steepness of the banks made approaches to low level bridges difficult. A very large number of temporary crossings were made, but the speed of our advance beyond the canal made it unnecessary to build many permanent bridges.

On the Third Army front the most important was on the Hermies-Havrincourt road, where a 180-ft. span Hopkins Bridge was erected, this being the longest single span bridge put up in the advance. This work seems of sufficient interest to be described in more detail.

A reconnaissance of the crossing was made on the 22nd of September by the O.C. New Zealand Tunnelling Company, and the G.H.Q. Bridging Officer. The approach road to the original brick bridge runs along a ridge, and across the canal cutting, which is here dry, 100 ft. above bed level. In order to screen the new bridge from enemy observation a site was selected about 100 yards further south. At this point the gap was 180 ft. wide, and 85 ft. deep.

The tactical situation did not allow any work to be commenced until the 27th September, on which day, in spite of considerable shelling, material began to be delivered at the site; the marking out of the work was completed on the same day. Erection was commenced on the morning of the 28th September, and after twelve hours' work, 24 bays of the lower chords, 2 bays of the top chords, and 15 diagonals had been assembled. Excavations for the abutments, anchorages, and launching gear were also completed.

During the 29th seven bays of the lower chords, 16 bays of the top chords, 48 diagonals, five top cross joists, two bays of wind bracing, and two bottom chord stiffening joists were assembled. A delay of several hours was caused owing to the breakdown of material lorries. All winches were bedded and fixed, and derrick beds were laid and secured.

The assembling of the bridge and rigging of the launching tackle was continued throughout the 30th, and was completed by noon on the 1st October.

The standard method of erection for this type of bridge is to assemble the bridge, less flooring, on one side of the gap, and to haul it into position by means of winches and derricks on the opposite side.

In order to reduce the load on the tackle a counter-balance arm and weight may be used—in this case the girders were extended to a total length of 240 ft., and a 20-ton weight was placed on the end of the extension. The bridge was lowered by means of jacks on to rollers, and was launched forward one bay before dark on the 1st.

On the 2nd October launching was continued until there was an overhang of 112 ft. beyond the centre rollers, the span not then bearing on the abutment rollers.

At this point the lower chord members bearing on the centre rollers showed signs of failure due to longitudinal buckling of the webs of the channel girders. One channel member failed completely and commenced to slip off the rollers. The span was jacked up, and the damaged channel member was replaced by one taken from the end section of the counter-balance extension.

On examination it was found that though the distance between the channel girders of the lower chords was exactly 2 ft., the distance between the rollers of the centre pair where failure had occurred was 2ft. $0\frac{3}{8}$ in. In the case of the other rollers this distance was 2ft. $0\frac{1}{4}$ in.

The channel girders being placed back to back the webs were partly off the rollers when the chords were truly central, and the slightest deviation of the chord from the centre caused one web to gain a better bearing and the other to slide off the roller entirely.

As the rollers could not be altered, a second pair was fixed as close as possible to the abutment pair, and hydraulic jacks were placed under them in order to allow adjustments to be made to distribute the load equally. The fixing of the new rollers and the repair of the lower chord caused a delay of about seven hours before launching could be resumed.

By 5 p.m. on the 2nd October, the head of the bridge was 110 ft. beyond the abutment bearing. On the 3rd October launching was continued successfully until the head of the bridge was within 8 ft. of the east abutment, when one of the winches jammed, and a crib pier had to be erected under the end of the span, which was then jacked up so as to take the weight off the tackle. Shortly afterwards the second winch jammed, and the span had again to be jacked up. Launching was completed, and the span finally bedded at 4 p.m., and the dismantling of derricks and counter-weight extension were at once commenced.

On the 4th of October tarpaulins were slung under the bridge to give the men confidence while fixing the deck beams, and to protect traffic passing along the bed of the canal from any material that might be dropped accidentally.

By the evening all transoms, deck beams and decking had been placed in position, but not finally fixed.

Owing to the length of the span it was thought necessary to provide extra horizontal bracing; for this purpose wire ropes were fixed 60 ft. from either end on both sides of the bridge, and tied back to anchorages on the bank 60 ft. from the centre line. This was all completed by 5.30 p.m. and the bridge was open to traffic at daybreak on the 6th October. *Photograph* XXVIII. shows the tem-

porary diagonal wire rope bracing. *Photograph* XXIX. shows the total length of the bridge with tail. *Photograph* XXX. shows the bridge as it appeared from the bed of the canal. *Photograph* XXXI. shows the attachment of the tackle to the heads of derricks.

Measurement of the rollers used in launching showed that those supporting the heavier loads had been reduced in diameter from $\frac{1}{4}$ in. to $\frac{1}{8}$ in. at the ends where the webs of the lower chord channels were supported.

A light wire rope transporter, which had been erected near the site, was used throughout the work, and was found most valuable as a means of communication across the gap.

During launching, the head of the span dipped gradually to a maximum of 11 ft. below the level of the abutments. The maximum dip occurred when the head was 20 ft. from the far abutment. The average rate of launching was 16 in. per minute while the span was actually in motion. The launching weight was approximately 120 tons.

The camber of the bridge as erected was 9 in. at the centre—on completion it was $7\frac{5}{8}$ in., and after one day's lorry traffic this was reduced to $6\frac{1}{2}$ in. The troops engaged in the work consisted of:—

New Zealand Tunnelling Company ...	11 Officers.	257 O.R's.
565th A.T. Company	3 ,,	48 ,,
577th A.T. Company		5 ,,
Total	14 ,,	310 ,,

Party in Charge of Dump and Directing Transport:—

New Zealand Tunnelling Company ...	2 Officers.	50 O.R's.

The most important of the other Third Army bridges over the Canal du Nord was a three 60-ft. Span Bridge on standard trestles at Etricourt. This work was done by the 147th A.T. Company, assisted by detachments from the 4th Siege Company, R.M.R.E., and the 183rd and 175th Tunnelling Companies.

The steel-work was erected as a continuous bridge on the west bank of the canal, and was hauled across the gap, on rollers.

The time taken upon the erection of the steel-work and completion of spans for traffic was six days, included in which was a delay of a full day owing to the non-arrival of sufficient rollers. 3,475 man hours were employed on this work as compared with 5,760 man hours, which is three times the book estimate for erection of a single 60-ft. span. The officer in charge was confident that but for the hitch in the supply of rollers, the work could have been completed in four days.

The First Army bridges were mostly of rolled steel joist types on trestles or cribs. Two Long Span Inglis Bridges were also used.

In one case an effort was made to launch a 108-ft. Inglis span at night, but this was found impossible and had to be left till daybreak, when the work was completed in 4½ hours. *Photographs* XXXII., XXXIII., XXXIV. and XXXV. show typical examples of work done.

(*To be continued.*)

[Previous articles under the heading of "The Work of the Royal Engineers during the European War, 1914-19" appeared in the *R.E. Journals* of September, 1919 (Introduction p. 105; Anti-Aircraft Searchlights, France, p. 106; Postal Section—Army Postal Services, p. 114), October (Bridging, Chapter I., p. 162) and November (Bridging, Chapter II., p. 209). Copies of these Journals may be obtained through the usual channels.]

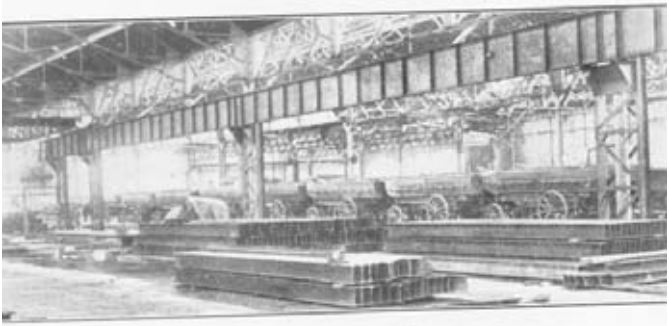
ERRATA CHAPTER II. (R.E.J., NOVEMBER, 1919).

Page 212, line 23, *for* "apan" *read* "span."

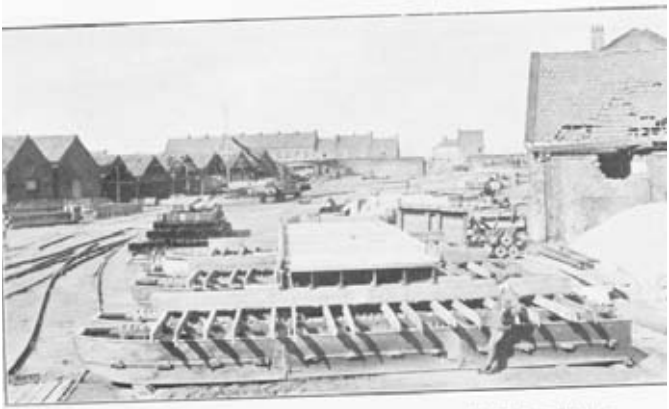
Page 212, line 23, *for* "tube" *read* "cube."

Page 213, line 37, *for* "to be" *read* "been."

Photograph XXV.



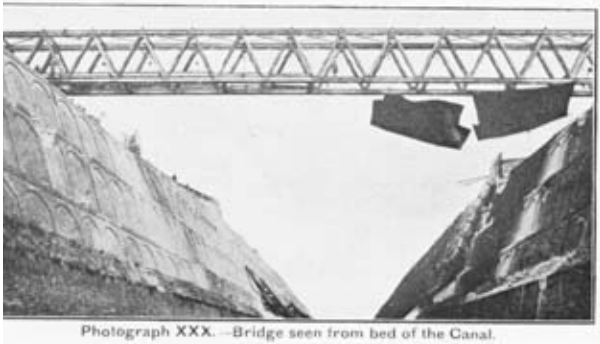
Photograph XXVI.



Photograph XXVII.—Views taken in an Army Bridging Depot.

Photograph XXVIII.—Temporary Diagonal Wire-rope Bracing.

Photograph XXIX.—Total length of the Bridge with tail.



Photograph XXX.—Bridge seen from bed of the Canal.

NOTES ON STATIONARY STORAGE BATTERIES.

By Captain H. DE C. TOOGOOD, A.M.I.E.E, R.E.

THE desirability of some notes to emphasize, and perhaps to amplify, the principles laid down in text books for the Engineer entrusted with the operation and care of stationary storage batteries, which are apt to be sometimes somewhat generally insufficiently regarded, came to my notice during the four years I was an Assistant Inspector of R.E. Stores at Woolwich from 1914—1918. These notes are not intended as an exposition of all the principles connected with the subject, for which the reader is referred to any standard text book.

Design.—The usual service type consists of a Planté positive and a box negative, often having wood separators. The advantages claimed for these over other types, *e.g.*, glass amongst others, is that the battery has a longer life at full capacity owing to the porosity of the plates being more permanently maintained. Another practical value of the wood separator is the prevention of internal short circuits.

The positive plate must be prevented from a continuous close contact with the wood separator to obviate quick rotting of the wood separator. For this reason the separator is a thin diaphragm supported by circular or grooved dowels. The negative plate is always designed to have excess capacity over the positive plate, and this condition must be maintained in the cells by proper operation and maintenance.

The positive plates are worked at a higher current density than the negative plates. It will be noted that the negative plates in a cell exceed the positive plates in number.

The size of the battery to be installed is in the service usually decided upon for the Engineer and it is his duty to maintain the battery up to its maximum capacity during its life.

Capacity.—It does not seem to be sufficiently realized that an accumulator is analogous to an athlete in this respect. The capacity of the battery may be compared to the capacity of an athlete. It is just as absurd to take a long distance champion and use him for sprinting races for which he is by nature unsuited, as it is to use a 1,000 A.H. battery for the purposes for which one of 200 A.H. would

suffice. Apart from being uneconomical, the battery would fail as assuredly as the athlete if, after only doing 100 yard sprints, he were without training suddenly called upon to run in a two-mile race.

Necessity for Working the Battery.—Exercise and work then, and *of the right sort*, intelligently mapped out, is an essential condition for maintaining a battery in a healthy state, so that on emergency it will do its performance without "letting you down."

Discharge.—In plain language this means arranging your production of power so that the battery is discharged at a suitable rate and sufficiently exhausted, sufficiently often per week, say at least up to 60 to 70 per cent of its capacity, and that further, say once a week, the battery is run down to the lower limits given on the maker's card of instructions, in conjunction with which the customary voltage and specific gravity readings are taken and intelligently interpreted with a view to discovering and diagnosing weak cells and other signs of disease or irregularity not previously observed, correct treatment for which must be put in hand without delay.

It should be noted that the capacity of the battery varies with the rate of discharge according to the well-known Planté type curve. Thus, assuming the capacity of a battery, at 60° F., at the 5-hour rate of discharge, to be 100 A.H., the capacity at the 10-hour rate is 120 A.H., and at the 1-hour rate is only 60 A.H., *i.e.*, half as much at the same temperature. Thus in working the battery due regard must be paid to the rate of discharge. The capacity of the battery increases with rise, and decreases with fall of temperature at the rate of about 1 per cent. for each 2° F. above and below 60° F.

The final permissible volts per cell on discharge also vary with the rate of discharge. At a 10-hour rate of discharge the R.E. specification permits a voltage drop down to 1·85 v. per cell. At a higher discharge rate it is permissible to run the battery down so that the voltage per cell is lower, *e.g.*, at the 1-hour rate of discharge this figure may be as low as about 1·7 v. The maker's chart should be followed however, as this figure varies with the make.

In measuring the voltage it is desirable that the discharge rate be not less than the 10-hour rate at the time of taking the reading. Readings taken on open circuit or with small currents flowing are valueless.

The reason for the reduced capacity at higher discharge rates lies in the fact that a less depth of active material is worked upon by the acid, which tends to become weaker in the pores of the plates than in the bulk of the electrolyte owing to the quicker sulphation set up on the surface, which tends to restrict free circulation of the electrolyte in the deeper layers of the active material of the plates.

The negative plates having excess capacity, the capacity of the battery is that of the positive plates.

Photograph XXXI.—Havrincourt, Canal du Nord: Attachment of the tackle to the heads of derricks.

Hopkins 120-ft. Type Bridge, Clear Span 180 ft.
Work started 28th September, 1918.
Photo taken 3rd October, 1918.
Bridge opened for Traffic 6th October, 1918.

Photograph XXXII.—Canal du Nord: R.S.J. Spans for all loads.

Photograph XXXIII.—Canal du Nord. Typical R.S.J. Span across Lock.

Photograph XXXIV.—Canal du Nord: Timber Railway Bridge.

Photograph XXXV.—Canal du Nord: Typical Timber Ramp.

BRIDGING

Charge.—It is further essential to charge the battery intelligently. It would seem not uncommon to allow any odd amount of current, however small, to flow into the battery in order to keep the plant running at maximum efficiency, or to use the battery as a steadying load for the plant on light loads, notwithstanding that it is fully charged. Irremediable harm is liable to be done to the battery by such a policy. Low charging rates have a forming action on the positive plates, and excess charging is also harmful as the gassing produced scrubs the active material off the positive plates. The final volts per cell obtained during charge are also affected by the rate of charge.

The battery should be charged at the rate laid down by the makers, usually based on putting back the full capacity at the 10-hour rate in $5\frac{1}{2}$ hours, which is called the normal charging rate. When the cells begin to gas freely, this rate must be reduced to half normal, to obviate the scrubbing action mentioned above with violent gassing. There is no harm in exceeding the normal charging rate to the top rate allowed by the maker up to this point. Voltage readings on the cells must be taken with the charging current flowing; these should rise to 2·75 v. per cell during the extended charge. On open circuit this drops to about 2·05 v.

To obtain true specific gravity readings, they must be taken on open circuit, as the gassing in the electrolyte will give a false reading. With a view to maintaining homogeneity throughout the whole body of the electrolyte, the cells should preferably be topped up just prior to charging; only pure distilled water should be used for this purpose, and may with advantage be introduced into the bottom of the cell.

The range on the acid measured by the fall in the specific gravity at the 10-hour rate should be about 50°. The exhaustion of the battery can be gauged by the amount of fall in the specific gravity of the acid to which it is directly proportional, *e.g.*, if 50° is the correct range for the battery, and the specific gravity has fallen from 1215 to 1190, *i.e.* 25°, $\frac{25}{50}$ or one half the capacity of the battery is exhausted.

The ampère hour capacity of the battery is independent of the rate of discharge, and is 90 per cent. for a healthy battery before depreciation due to age or faulty operation and maintenance sets in. This means that normally the amount put back should be what has been taken out plus 10 per cent.

The wear and tear on a battery is reduced by not continuing the charge beyond this point for ordinary charges, and consequently the useful life of the battery is prolonged.

Once a week the battery should be given the extended charge, when all the symptoms of a fully charged battery should become manifest in a healthy battery. These are that the volts per cell,

measured when the charging current is flowing, and the specific gravity have both ceased to rise for about an hour with further charging and are up to the figures given above. Any weak or defective cells should be detected during this extended charge and treated accordingly. The object of the weekly extended charge is to fully reduce every particle of sulphated active material, and to do this sufficiently often to prevent the formation of malignant sulphation difficult if not impossible to reduce.

It is useless to put back more, as is sometimes done in anticipation of a heavy discharge. The battery is like a jug in this respect; when it is full it is no use trying to pour more in, as it merely runs over the side to waste; so with the battery any unnecessary charging is merely dissipated in electrolysis and waste of the acid by the spray produced in gassing. Yet this is not so uncommon a procedure as one would suppose.

In working the battery, it will not suffice to go entirely by the ampère hour meters. These are only accurate up to a point, even if in correct adjustment, and such errors if cumulative may cause the battery to be persistently under- or over-charged. The cell voltmeter and hydrometer must be used as well to ensure that such is not the case.

In reading the hydrometer for purposes of comparison, the specific gravity of the acid must be corrected for temperature. The usual standard temperature taken is 60° F., and to compare readings they should be corrected by deducting 1° in specific gravity for every $2\frac{1}{2}$° F. rise, and by adding similarly for any fall in temperature below 60° F.

A point to take note of during charging is the gassing. Both plates should commence to gas simultaneously and both should gas freely as the charge proceeds. If the charge is interrupted both plates should gas immediately the charge is continued.

It is sometimes found that the negatives gas prematurely. This shows that they have become low in capacity and the reason should be sought.

Under no circumstances should a cell be allowed to become reversed in polarity. It is bad to allow a cell to run down to zero, but it is infinitely more harmful to allow the cell to become charged up in the wrong direction. Arrangements must be made to cut the cell out before this has occurred.

Regulating Cells.—It is a common fault in design to see these all grouped together at one end of the battery with no provision made for changing them over so that they can be made to form part of the battery for exercise. It is essential that arrangements be made for working these cells adequately, and this is not a difficult matter. Regulating cells should preferably be grouped at both ends of the battery.

Necessity for Uniformity in a Battery.—Another and not uncommon fault, is to make up a battery with cells of unequal size and capacity. This is a bad and uneconomical arrangement. Suppose that a battery of 750 A.H. cells is extended with cells of 500 A.H. capacity. It is apparent that the 750 A.H. capacity cells will be insufficiently worked, with the result that they will get into a sluggish state and will eventually be reduced in capacity to 500 A.H. In charging too, it is apparent that the rate of charge is incorrect for one or the other, either the smaller capacity cell will be charged at too high a rate or the larger capacity cell will be charged at too low a rate.

Renewals.—It is also bad practice to renew the positive elements in cells in which the negatives have become deficient in efficiency.

Extensions.—Similarly it is most detrimental to increase the capacity of an old battery by the addition of new plates to existing elements.

Points to Guard Against in Maintenance.—The following extract, taken from Mr. E. C. McKinnon's invaluable articles on Storage Battery Management, gives the points to beware of in order to keep the battery in condition, and are reproduced by permission of The Chloride Electrical Storage Company, Ltd. :—

Failing to give the battery a proper initial charge.
Failing to give a new battery plenty of work and liberal charging.
Charging the battery too little.
Charging the battery too much.
Working the battery too little.
Running the battery too low in voltage and specific gravity between charges.
Running the battery too long between charges, irrespective of the amount of work done.
Charging the battery at too high rates, especially towards completion of charge.
Charging the battery at too low rates (less than half-normal).
Allowing the sediment to reach the bottom edges of the plates before having it removed.
Having the battery room too hot or letting too strong a breeze blow through the room, both of which cause an increase in the rate of evaporation.
Using unsuitable water to compensate for evaporation.
Not adding water sufficiently often to keep the plates always covered with electrolyte.
Adding any acid unwarranted by the condition of the plates or working conditions.
Using acid unsuitable in strength or purity.
Neglecting to observe the indications of irregular treatment.
Neglecting to attend to weak cells promptly.

Failing to clear internal short circuits.

Allowing individual cells to be thoroughly exhausted (volts run down to zero).

Allowing individual cells to receive charge in the wrong direction with the rest of the cells on discharge.

In bolted up batteries, allowing the connections to become dirty, corroded, slack (which sets up heating and melting of the lead lugs).

Having the regulating switch discharge lever across a greater number of cells than that across the charge lever, during simultaneous charging and discharging.

There is a wealth of information underlying the above which the reader would do well to digest thoroughly, and then to critically examine his battery records to see how completely he avoids these pit-falls for the unwary.

If in spite of this, the cells become defective and the remedy is beyond the experience of the Engineer in charge, my advice is to call in without delay the W.D. Expert, the Chief Inspector of Royal Engineer Stores, for advice.

One more word of advice, do not use the Cadmium Testing Strip unless you know how to use it, otherwise you may get unreliable readings.

Records.—Records are generally regarded as a bugbear, but the necessity for keeping proper records of all charges, discharges, voltage, and specific gravity readings is an absolute essential, and is a point insisted upon by the Battery Makers in all Maintenance Agreements.

In conclusion I would acknowledge my indebtedness to Mr. E. C. McKinnon, A.M.I.E.E., of the Chloride Electric Storage Co., for the help he has given me in this subject, especially during the time I was on the Staff of the C.I.R.E.S.

THE BATTLE OF THE SOMME.

R.E. PREPARATIONS IN THE 31ST DIVISIONAL AREA.

Extracts from the Report of LIEUT.-COLONEL J. P. MACKESY, D.S.O., R.E., *C.R.E., 31st Division.*

1. On 6th April, 1916, instructions were received that preparations must be made and completed by 30th April for attack against the German Lines.

As time was so short the work started at first was of a hasty nature and consisted mainly of clearing and opening up trenches which had been disused during the winter, and in constructing Divisional and Brigade Battle Headquarters and Observation Posts, Dressing Stations and Royal Artillery O.P.'s.

Later, when the date had been postponed, a more deliberate class of work was undertaken. The time available for preparation was however, curtailed through all possible men being for two weeks diverted to :—

(i.) Constructing or re-opening a new Front Line along the whole Divisional front.

(ii.) Constructing or re-opening a strong Second Line.

A long spell of wet weather considerably interfered with work in the trenches, and for the last week most of the Infantry were employed carrying ammunition, rations and gas cylinders to the front area.

2. The General Idea on which the preparations were based was that for the attack two brigades should be in front, with the third brigade close behind in reserve. The arrangements for work were complicated by having to garrison and prepare the trenches of a large area on the right which was to be occupied by another Division (the 4th) during the operations.

As the Division was holding only a brigade, or a brigade-and-a-half frontage, and brigades changed in and out of the trenches every eight days, it was difficult to secure continuity, and this was only obtained by keeping the Field Companies working steadily in the same areas.

3. The R.E. and Pioneer Battalion worked under the C.R.E., and were distributed for work as follows :—

Two Field Companies, R.E., each had a Pioneer Company placed at its disposal, and worked, one in the Forward Assembly Area of one Brigade and of the 4th Division, the other in the whole back Assembly Area of the third Brigade and of the 4th Division. The third Field Company had two Sections working in the forward Assembly Area of

the second Brigade, and the other two sections were employed on back area work. The remainder of the Pioneer Battalion was employed as follows :—

One company assisting R.A. in the construction of gun emplacements and dug-outs, and in cutting trees for them ; one company on miscellaneous work, such as mending roads, sinking wells, constructing medium trench mortar emplacements and dug-outs, constructing Army and Corps Signal dug-outs and making horse standings and cross-country tracks.

4. The Divl. area was organized for the operations as follows :—

Four main avenues of communication led up to the dividing line between the reserve Brigade and the two front Brigades. This dividing line was a main lateral communication trench.

Beyond this line eight communication trenches led up to the front line, of which four were in each Brigade assembly area. Of these groups of four the two outside ones were allotted to forward traffic only and the two centre ones to return traffic only.

In each brigade area four dumps were constructed, each to hold rations and water for two days for one battalion. The rations and water were made up into men loads and put in covered recesses in assembly and disused trenches. One day's supply for a battalion occupied 432 cubic feet. Fifty thousand rounds S.A.A. were also stored at each dump.

R.E. dumps were formed as under :—

Four small ones at a short distance behind the Front Line ; two larger ones in rear of each Front Brigade Area ; one in Reserve Brigade Area ; and one large one as far forward as vehicles could go at night.

All the ration and R.E. dumps were placed between an up and a down trench for convenience of access. At least two deep dug-outs were constructed in the assembly trench of each battalion (except in the Front Line), and numerous other deep dug-outs were made in the Support and Reserve trenches of the front system. Two deep dug-outs, and in one case three, with an O.P. adjoining, were made for the Battle Headquarters of each Infantry Brigade in its assembly area.

Accommodation for a large number of wounded was provided by the construction of five large dug-outs, each ten feet by thirty feet, in rear of the Reserve Brigade assembly area, and five more large dug-outs, each ten feet by forty feet, at the advanced dressing station at Colincamps.

Two cross-country roads were marked out from Colincamps to the front trenches for the use of forward and return traffic. The trenches on the route were bridged to take motor ambulances, and several spare bridges w re prepared to replace those broken by shells.

Every man was provided with a pick and shovel to carry on his

person during the assault, and large numbers of wire-cutters, hedging gloves, mallets, trench ladders, trench bridges and sand-bags were issued to units.

5. The following is a summary of R.E. work done during this period of preparation :—

(i.) Eight miles of new trenches were made, including 10,630 yards of main approach trenches, 2,460 yards of communication trenches and 2,370 yards of assembly trenches ;

(ii.) Thirty miles of other trenches were cleared, deepened, repaired, improved and restored ;

(iii.) Eighty-six dug-outs were constructed (excluding those mentioned in xiv., xv. and xvi., below), details as under :—

No. constructed.	Type.	Thickness of earth on the top, in feet.	Superficial area, in sq. feet.
12	Curved Steel (Elephants)	5 to 10	2,800
42	Deep Mined.	14 to 20	5,000
31	Framed and Mined.	5 to 8	6,200
1	Special with 12½ feet head-room inside.	5	350
	Total		14,350

(iv.) Thirty-four Observation Posts were completed, viz. :—one for Army Survey, three for Division, four for Infantry Brigades, one for each Battalion, and 25 for R.A. ;

(v.) Thirty-six special emplacements for 360 gas cylinders were made in the front line ;

(vi.) Twenty-seven bridges were made over trenches to carry vehicles and motor ambulances, and four bridges to take heavy motor traffic over trenches on the Serre road ;

(vii.) One-and-a-half miles of steel tramway, with two intermediate sidings, were laid in a trench for taking up ammunition and evacuating wounded by day over open country ;

(viii.) Twenty-two Tramway trenches were made and a Tramway traffic control establishment formed ;

(ix.) Six sets of water tanks, to hold 3,250 gallons, were placed in trenches, and connected to water pipes ;

(x.) An engine and pump were installed in an old demolished farm, in the front area, where there was a deep well, and connections made to the water pipe system. During the operations this was the only water supply available in the trenches owing to the pipes of the main supply being continually broken by shells ;

(xi.) A Russian sap was started, but after progressing about 30 yards it was continually being blown up by trench mortar bombs and shells ;

(xii.) Twelve dumps were constructed to hold rations and water for 10,000 men for two days ;

(xiii.) Two concrete and steel shell-proof shelters were erected over the main forward pumping station;

(xiv.) Emplacements and dug-outs, not included in (iii.), were constructed for 21 Medium Trench Mortar batteries, close to the front line;

(xv.) Dug-outs were made for 16 Batteries, R.F.A., which were not included in (iii.), also gun-pits;

(xvi.) Five deep mined approaches (totalling 2,500 feet) were run to within 30 yards of the German Lines, and 20 Stokes' Mortar Emplacements were constructed off them in the middle of No Man's Land, for intensive bombardment prior to assault;

(xvii.) Numerous Bangalore torpedoes, made of one inch piping, in 10 to 17 feet lengths, and filled with ammonal, were made and issued to the troops for use in raids, and to demolish the enemy's wire during the assault;

(xviii.) Name boards and Notice boards were placed in all trenches, particularly at junctions and along cross-country road routes;

6. The following work was, in addition, carried out in the back area:—

(i.) One hundred shelter huts were erected in a wood to accommodate four battalions, and four huts for the sick of a Field Ambulance;

(ii.) Two wells were sunk 28 and 27 feet deep, and tanks and pumps were fixed to supply water to the above hutments;

(iii.) Seven huts were built for officers, etc.;

(iv.) Two deep wells were sunk to a depth of 130 feet each, with bore holes 130 feet below that, and motor pumps and tanks with stand pipes erected to fill water carts;

(v.) Two reservoirs were constructed to hold 21,000 gallons, and $3\frac{1}{2}$ miles of 4-inch piping were laid to form a water point, where troughs were erected to water 8,000 horses, and stand pipes to fill 75 water carts per day;

(vi.) Two R.A. Ammunition dumps and one grenade and mortar dump were constructed;

(vii.) 2,600 trees were cut down for making dug-outs and gun emplacements, and the branches were used for entanglements and revetment posts and for fascines;

(viii.) Several cross-country roads were laid out and prepared for the movement of troops;

(ix.) 2,500 yards of flint were quarried, which, with 1,300 yards of road metal, were used in repair of roads; about 2,000 fascines were also made and used on the roads;

(x.) An enclosure for Prisoners of War was erected. It was divided into three parts, for Officers, N.C.O.'s and men.

R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919—*continued.*

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Durham No. 1 Co. (W.)	1/1 526th Field Co.	2/1 By 79/7634 (A.G.1.) of 22. 6. 15. these were to be raised with Imperial Service *personnel* to the establishments of 3rd line depôts of Field Cos., R.E., on higher establishment, shown in table A of 79/6988 (A.G.1.) of 25. 3. 15.	There was no authority under 79/7634 (A.G.1.) of 22. 6. 15 for the formation of 3rd line Cos. for the Durham Fortress, but owing to some misunderstanding in the N. Command three Cos. were formed and existed as Nos. 1, 2 and 3 Cos., Durham Fort. R.E. They can therefore only be regarded as 3rd line Cos. After some discussion on 9/Engrs./8162, it was decided, in view of the impending reorganization of R.E. Coast Defence units, to allow them to remain until absorbed. The reorganization took place by 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18, and the three Cos. were disposed of as follows: No. 1 Co. was merged into 16th Tyne Fort. Works Co. No. 2 Co. was merged (with 1/1 and 2/1 N. Riding) into 595th Tees Fort Co. No. 3 Co. was merged partly into 594th (Tyne) Fort Co. and 16th (Tyne) Fort. Works Co.
,, ,, 2 ,, (W.)	1/2 527th Field Co.		
,, ,, 3 ,, (W.)	1/3 528th Field Co.		
	These three 1st line Cos. were formed into Field Cos. Auth. 79/7634 (A.G.1.) dated 22. 6. 15.	2/2 By 9/Engrs./7611 (A.G.7.) of 8.1.17, these units (with 2/1 E. Riding Field Co.) were designated 530th Durham Reserve Field Co., and belonged to the Northern Group Reserve Field Cos. A.C.I. 2420 of 1916. The Northern Group was subsequently reorganized by 20/Engrs./5214 (A.G.7.) of 12. 1. 18, and *personnel* distributed to 4th Reserve Battn. and R. Monmouth Reserve Battn., R.E.	
		2/3	

R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
N. Riding E.L. Co.	1/1 and 2/1 595th Tees Fortress Co., No2 Durham Fort. Co., was also absorbed into 595th Co. 20/Engrs./5215 (A.G.7.b.) of 10.6.18. *Note.*—(There was no auth. under 79/7634 (A.G.1.) of 22.6.15 for the existence of the Durham Co. See note against Durham Fortress 3rd Line.)	2/1 was merged with 1/1 into 595th (Tees) Fortress Co., R.E.	No 3rd line formed.
E. Riding No. 1 Co. (W.) ...	1/1 529th Field Co. Auth. for formation into Field Co. 79/7634 (A.G.1.), 22.6.15.	2/1 raised to establishment of 3rd line depôt of a Field Co. on higher establishment as in Table A of 79/6988 A.G.1. of 25. 3. 15. See 79/7634 (A.G.1.) of 22. 6. 15. Subsequently merged into 530th Durham Reserve Field Co. (A.C.1.) 2420 of 1916. See 2nd line of Durham R.E. for later developments.	No 3rd line formed.
E. Riding No. 2 (E.L.)	1/2 Amalgamated with 596, 597 and 581st Works Cos.		
Hampshire No. 1 Co. (W.) ...	1/1 559th A.T. Co. Converted into an A.T. Co. for Medn. E.F. 20/Engrs./5073.	2/1 561st (Works) Co. The formation of this was approved on 9/Engrs./4125.	No 3rd line formed.
,, ,, 2 ,, (W.) ...	1/2 560th A.T. Co.	2/2 562 (Works) Co. Disbandment ordered by 20/Engrs./5382 (A.G.7.b.) of 2. 4. 19.	No 3rd line formed.
,, ,, 3 ,, (W.) ...	1/3 563rd Works Co. Reduction to Cadre of 1 officer, 8 other ranks, ordered by 20/Engrs./5382 (A.G.7.b.) of 2.4.19., but disbanded 17.6.19. 20/Engrs./5334.	2/3 564th Works Co. The formation of this was approved on 9/Engrs./4125. Being disbanded 20/Engrs./5382 (A.G.7.b.) of 2. 4. 19.	No 3rd line formed.

R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919

Pre-War Unit.	Present 1st Line	Present 2nd Line.	Present 3rd Line
Hampshire No. 4 Co. (E.L.) ...	1/4 and 2/4 Amalgamated with 603, 604 and 605th (Portsmouth) Fortress Cos. 20/Engrs./5215 (A.G.7.b.) of 10.6.18.		
,, ,, 5 ,, (E.L.) ...	1/5 and 2/5 Amalgamated with 603, 604 and 605 (Portsmouth) Fortress Cos. 20/Engrs./5215 (A.G.7.b.) of 10.6.18.	2/4, 2/5, 2/6 and 2/8 reorganized with 1st lines into 603rd, 604th and 605th (Portsmouth) Fortress Cos. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.	No 3rd lines formed for 1/4, 1/5, or 1/6.
,, ,, 6 ,, (E.L.) ...	1/6 and 2/6 Amalgamated with 603, 604 and 605th (Portsmouth) Fortress Cos. 20/Engrs./5215 (A.G.7.b.) of 10.6.18.		
,, ,, 7 ,, (Works) ... (Not pre-war.)	1/7 506th (Hants) Field Co. Auth. for conversion to Field Co. 79/7634 (A.G.1.) d. 22.6.15.	2/7 was raised with Imperial Service *personnel* to the establishment of 3rd line depôt of a Field Co. on higher establishment (shown in Table A of 79/6988 (A.G.1.) of 29. 3. 15) by 79/7634 (A.G.1.) of 22. 6. 15. Subsequently absorbed into 508th Wessex Reserve Field Co. See Wessex Divl. R.E.	No 3rd line formed.
,, ,, 8 ,, (E.L.) ... (Not pre-war.)	1/8 and 2/8 Amalgamated with 603, 604 and 605th (Portsmouth) Fortress Cos.	See 1st line.	No 3rd line formed.
Fortress R.E. (T.).			
Wiltshire Works Co.	1/1 565th (Wilts) A.T. Co., France.	2/1 566th (Wilts) Works Co. (Disbandment has been ordered by 20/Engrs./5382 (A.G.7.b.) of 2. 4. 19.	No 3rd line formed.
Dorset E.L. Co.	1/1 606th (Portland) Fort. Co. (20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.)	2/1 Absorbed (with 1/1) into 606th (Portland) Fortress Co.	No 3rd line formed.

R.E., T.F., REORGANIZATION SINCE AUGUST, 1914. TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Devon No. 1 Co. (W.)	1/1 567th (Devon) A.T. Co. (Gibraltar 12. 12. 14 to 24. 3. 15 as a Works Co., France 24. 6. 15 as an A.T. Co. Selected for Army of Rhine 121/France/3384.)	2/1 570 (Devon) A.T.Co.	Regarded as Cadres for Reserve Army Troops Cos. by 121/9015 A.G.7 of 12. 6. 17. Converted to A.T. Co. by 121/8547 (Mob 1.), of 29. 8. 17. at W.E. 351/43, Part VII., 1916, for service in Egypt. Embarked for Egypt 26. 9. 17. Required for Army of Occupation, Egypt, G.B./8212 (A.G.7.b.).	No 3rd line formed.
,, ,, 2 ,, (W.) ...	... 1/2 568th (Devon) A.T. Co. (Gibraltar 24. 3. 15 to 29. 10. 16 as a Works Co., France 13. 3. 17 as an A.T. Co.)	2/2 571st (Devon)A.T.Co.		No 3rd line formed.
,, ,, 3 ,, (W.) ...	... 1/3 569th (Devon) A.T. Co. Egypt. (Now reduced to cadre "A" G.B./8212 (A.G.7.b.)).	2/3 572nd (Devon Works Co. To France 5. 8. 18 as a Works Co,		No 3rd line formed.
,, ,, 4 ,, (W.) ...	... 1/4 616th (Devon) Fort. Co. To Gibraltar in 1915.	2/4 Merged into 607th and 30th (Plymouth) Fortress Co., R.E. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.		No 3rd line formed.
,, ,, 5 ,, (E.L.) ...	... 1/5 Amalgamated with 607 and 30th (Plymouth) Fortress Cos.	2/5 Merged into 607th and 30th (Plymouth) Fortress Co., R.E. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.		No 3rd line formed.
Cornwall No. 1 Co. (E.L.)	... 1/1 608th (Falmouth) Fortress Co. (Reorganized by 20/Engrs. 5215 (A.G.7.b.) of 10. 6. 18.)	2/1 Merged (with 1/1 and one Section of 18th Co., R.E. Regulars) into 608th (Falmouth) Fortress Co., R.E. 20/Engrs./5215 A.G.7.b.) of 10. 6. 18.		No 3rd line formed.
,, ,, 2 (W.)	... 1/2 573rd (Cornwall) A.T. Co., France 24. 1. 15. Selected for Army of Rhine. See 121/France/3384. G.B./8315 (A.G.7.b.)	2/2 575 (*Cornwall*) *Works Co.* Mobilization by 121/France/2467 (Mob. 1.) of 13. 7. 18, at W.E., page 155 of W.E. Part XIV. (Home) except 2 Bugrs. To France 27. 8. 18.		No 3rd line formed.

R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Cornwall No. 3 Co. (W.) ...	1/3 574th (Cornwall) A.T. Co., France, 4. 4. 15.	2/3 576 (*Cornwall*) *Works Co.* Disbandment ordered by 20/Engrs./5382 (A.G.7.b.) of 2. 4. 19	No 3rd line formed.
Essex E.L. Co.	The Essex Fort, R.E., amalgamated with 21st (Harwich) Fort. Co., R.E. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.		
Kent No. 1 Co. (W.)	1/1 495th Field Co. (Authority for formation into a Field Co. is 79/7634 (A.G. 1.) of 22. 6. 15.)	2/1. By 79/7634 A.G.1. of 22. 6. 15 these units were raised to the establishment of 3rd Line Depôts of a Field Co. on the higher establishment shown in the Table "A" of 79/6988 (A.G.1.) of 25. 3. 15.	No 3rd line formed.
,, ,, 2 ,, (W.)	1/2 496th Field Co.	2/2. They formed part of the Eastern Group Reserve Field Cos., A.C.I. 2420 of 1916, and merged into 499th (Home Counties) Reserve Field Co. 9/Engrs./7611 (A.G.7.) of 8. 1. 17.	No 3rd line formed.
,, ,, 3 ,, (W.)	1/3 497th Field Co.	2/3. On the reorganization of R.E. Reserve Battns. by 20/Engrs./5214 A.G.7.b.) of 12. 1. 18, the Eastern Group Reserve Field Cos. merged into 5th Reserve Battn., Christchurch, which has been disbanded 15. 3. 19. 20/Engrs./5323.	No 3rd line formed.
,, ,, 4 ,, (W.)	1/4,2/4 Reorganized under 20/Engrs/5215 (A.G.7.b.) of 10. 6. 18 into 598th Thames and Medway Fort. Co., R.E. Some of the *personnel* may have been merged into the 580th Thames and Medway Fort. Works Co. It is hardly likely that Kent Fort. *personnel* were transferred to 599th (T. and M.) Fort. Co., London Electrical Engrs., which was formed mostly from No. 2 Co., London E.E.		
,, ,, 5 ,, (E.L.)	1/5, 2/5	See 1st line.	No 3rd line formed.

R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.		Present 2nd Line.	Present 3rd Line.
Kent No. 6 Co. (W.) ... ... (Not pre-war.)	1/6 546th Field Co.	These units were converted to Field Cos. for the 73rd U.S. Div. 79/9368. When the 73rd Div. was broken up (20/G.N./4833 (A.G.1.) of 22.12.17 20/Engrs./5237, G.B./4681 (A.G.7.) & 114/G.N./5763) the Cos. were on aerodrome work. Later the 546th and 547th were re-mobilized for the new 72nd Div. (at W.E. 627, Part VII. A of 1. 8. 17. and embarked for France 22. 6. 18.	2/6 579th (Kent) Works Co. absorbed into 580th (Thames and Medway) Fort. Works Co. by 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18. See below.	No 3rd line formed.
,, ,, 7 ,, (W.) ... ... (Not pre-war.)	1/7 547th Field Co.		2/7 580th (Thames and Medway) Fort. Works Co. (formerly Works Co.). Also absorbed 579th (Kent) Works Co. 20/Engrs./5215 (A.G.7.b.) of 10 6. 18.	No 3rd line formed.
Cinque Ports E.L. Co. 1. ...	1/1 and 2/1 Amalgamated with 600th Dover Fortress Co., R.E. (20/Engrs./5215) (A.G.7.b.) of 10. 6. 18.		2/1. See 1st line. Reorganized and designated (with 1/1) 600th (Dover) Fort. Co., R.E. 20/Engrs./5215 (A.G.7b.) of 10. 6. 18.	No 3rd line formed.
Sussex Works Co.	1/1 577th (Sussex) A.T. Co. Went to France.		2/1 578th (Sussex) Works Co. Mobilization at W.E. page 155 of Part XIV., 1918, less 2 Buglers by 121/France/2467 (Mob. 1.a.) of 22. 8. 18., at Newhaven. Embarked for France as a Works Co. on 9. 9. 18.	No 3rd line formed.

R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919

Pre-War Unit.		
London Electrical Engrs.		
No. 1 Co.	Absorbed with Devon R.E., etc. with 607th and 30th (Plymouth) Fort. Cos.	Peace Establishments, Part II., 1913—14, of London E.E., was 21 officers and 447 other ranks. 9/Engrs./1644 (T.F.1.) of 11. 10. 14 authorized an increase of 50% N.C.O.'s and men (that is authority to form a Home Service Unit). 9/Engrs./1825 (A.G.7.) of 17. 11. 14 authorized an increase of 173 other ranks to the original establishment of 447, making the establishment of 620 and for the 50% increase of establishment authorized by A.O. 399 of 1914, to be calculated on this increased establishment, making it 620+50%=930 other ranks. For details of ranks see (9/Engrs./1969 of 12. 12. 14. 9/Engrs./2748 (T.F.3.) of 29. 7. 15 authorized an increase of establishment of London E.E. of two majors for combined 1st and 2nd lines, and to be temporary only. 9/Engrs./2131 (A.G.7.) of 19. 6. 15 authorized an increase of total War Establishment E.L. Cos. of London E.E., to be increased by 8 subalterns to provide for extra lights for fixed defences and A.A. Guns. 79/8494 (A.G.7.) of 25. 12. 15 and 11. 1. 16 authorized a total establishment of 74 officers, 2,030 other ranks, inclusive of 1st and 2nd lines, and amended W.O. letter 79/7634 (A.G.1.) of 22. 6. 15 by deleting the numerals in Columns 4 and 6 of that letter (*i.e.*, designations 1st and 2nd line Cos.) and inserting the words "Special Establishment." In addition to its functions in Garrisons, the London E.E. formed A.A.S.L. Cos. The A.A.S.L. Cos. have been reorganized as separate units, but the London and Tyne E.E. are parent units of all *personnel* attached to R.G.A. Anti-Aircraft Cos. The establishment of the London E.E. is under consideration on G.B./9018 (A.G.7.b.) The re-formation of T.F. Headquarters has been dealt with on 9/Engrs./8392.
,, 2 ,, ...	Absorbed into 599th (Thames and Medway) Works Co.	
,, 3 ,, ...	Was reorganized as 601st (Dover) Fortress Co., London E.E., by 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18, but 601st Co. subsequently disbanded by 20/Engrs./5305 (A.G.7.b.) of 5. 8. 18.	
,, 4 ,, ...	602nd (Newhaven) Fortress Co. London E.E. 20/Engrs./5215.	
,, 5 ,, ...	615th Fortress Co. London E.E.	
,, 6 ,, ...	Became No. 6 A.A.S.L. Co., R.E. 29. 7. 16, but was disbanded 26. 1. 18 and used to form Nos. 10—12 A.A.S.L. Cos., R.E. 20/Engrs./5266.	

Pre-War Unit.	
Eng. and Railway Staff Corps ...	This only consists of officers—none below rank of Major—establishment about 60, and is administered by S.R.I.a. not A.G.7.
Army Postal Service (T.F.) ...	The establishment of the A.P.S. (T.F.) was published by War Office letter 79/4941 (A.G.7.) of 12. 9. 14. Substantial modificationwas subsequently approved on War Office files 91/Engrs./1148, 91/Engrs./1193, 9/Engrs./8115 and 79/77. The amalgamation of the A.P.S. (T.F.) with the R.E. Postal Section was recommended in letter from D.A.P.S. (Home), dated 26. 4. 18, in 20/Engrs./5259, and again in October, 1918, on 9/Engrs./8333, but no decision was given. A further letter, d. 11. 4. 19, from D.A.P.S. (Home), which is being dealt with on 9/Engrs./8333, states unit has been disembodied with exception of a small Cadre (and 20 volunteers for Army of Rhine, who have been posted to R.E.P.S.), which has completed demobilization functions. It is asked whether the unit is to be disembodied or retained as a distinct organization from R.E.P.S.

[*The List of R.E.T.F. Organization was commenced in the October number of* R.E. JOURNAL, *page* 182, *and continued in the November number, page* 225.]

THE DEVELOPMENT OF THE WORKS DIRECTORATE, MESOPOTAMIA EXPEDITIONARY FORCE.

PART I.—BUSRA, AND THE LINES OF COMMUNICATION.

Compiled from Notes supplied by COLONEL D. K. EDGAR, D.S.O., *Director of Works, M.E.F.*

THE original Expeditionary Force dispatched from India in the autumn of 1914 contained no organization for Works on the Lines of Communication, and at first all construction was carried out by Field Engineers and Sapper and Miner Companies, with the assistance of such local labour as the country could supply, and such fatigue parties as regiments and depôts could spare.

Busra, which was occupied on 22nd November, includes the native city, lying about three miles south of the Shatt-el-Arab, with which it is connected by the Ashar Creek, the Ashar Bazar at the mouth of the Creek, and a few houses along the bank of the Shatt-el-Arab, the property of European firms and rich local Arabs.

After the occupation, the main administrative area was sited to the south of the Ashar Creek. G.H.Q. was located in the British Consulate, the L. of C. headquarters and Base Commandant took over the house of a local German, the Supply and Transport had a brick building close by, and the Turkish Commodore's house was allotted to the R.E. services and became Royal Engineers House. The Ordnance branch and the Telegraph Department were accommodated in two other brick buildings in the neighbourhood. The Turkish Infantry Barracks in Ashar became the British Base Depôt, and the Naval Barracks were turned into the Indian Base Depôt. In addition, three or four large buildings about a mile above the mouth of the Creek were lent by the Sheikh of Mohammerah for use as hospitals.

For the Engineer Field Park the original suggestion was the tennis court of the German Consulate, but eventually a site on the south side of Engineers House was selected, and here some stores hastily purchased by the Divisional Engineer Commander, Lieut.-Colonel (afterwards Brig.-General) U. W. Evans, on his passage through Bombay, were accommodated. They were landed from the steamer into Mahelas (dhows of various sizes), and thence carried to the only pier then existing at Busra, and there unloaded and stacked by working

parties. The staff of the Park consisted of one officer, one staff-sergeant, and one native sapper, and their office was a shed improvised from casks and roofed with corrugated iron. The Park in 1918 covered 52 acres, and its workshops alone covered nearly 36,000 sq. ft. and contained machinery valued at 2½ lakhs of rupees.

The work of providing shelter for troops and sick was put in hand at once and by the end of 1914 hospital accommodation for 650 British and 850 Indians, and troop accommodation for 2,255 British and 5,675 Indians was provided. Materials in large quantities were purchased from local contractors after the beginning of December, and included timber, both sawn and in spars, and some iron and hardware. These contractors were subsequently encouraged to keep stocks of materials as a useful reserve in case of necessity.

In March a Works Company arrived from India, and the Works Directorate may be said to have commenced operations under a Deputy Director, Major A. F. Cumberlege, but up to the end of 1915 all work was carried out by local labour and the services of local contractors were utilized in the construction of rough huts for the accommodation of troops.

During the spring of 1915 one of the chief difficulties to be contended with in Mesopotamia was experienced for the first time. In that year the floods were exceptionally early and high. The whole camping area of Makina, a mile or two from the Shatt-el-Arab, was flooded by the waters of the Euphrates, which overflowed its banks and covered the desert between Busra and Shaiba. At Busra the problem of protection from floods was taken in hand during the summer of 1915. A protective bund, about ten miles long, from Magil on the Shatt-el-Arab some five miles above the mouth of the Ashar Creek, to Shaiba, was sanctioned, and also the road from Busra to Zobeir, which now carries the railway, and which was to be raised above flood level. These bunds were designed to enclose an area of 45 square miles, and include all the camping grounds around Busra.

The original design of the Shaiba bund provided for a bank averaging 6½ ft. high and 10 ft. wide at the top, with side slopes of 1 in 2½ The top was calculated to be 5½ ft. above high flood level.

Owing to the difficulty of obtaining labour it was not possible to start work until the end of October. Even then work progressed very slowly, and up to the end of January, 1916, the average number of coolies employed was only 350, in spite of the orders of the Army Commander to the Chief Political Officer to impress Civil labour. In February numbers increased to 3,000, but it was necessary to place the coolies under a guard to prevent desertion. Owing to these delays it was not possible to complete the bund to its full section, and when on the 19th April the flood water from the Euphrates came up, it was very weak in places. To protect its face against wave

action revetting by means of mats, pegged down, was tried, but these were torn away and the earth scoured out behind them. Sand-bag revetment proved a failure, as the fine silt of the desert was washed out of the bags in a few hours when exposed to the waves. Eventually the whole face of the bund for a length of about six miles was revetted with corrugated iron sheets, backed with mats and sandbags. At this time 2,000 troops and half a Labour Corps, in addition to the Arabs, were working on the bund. In June and July the water subsided. Before the flood season of 1917 the bund was brought up to full section and the front slope decreased to 1 in 5. The corrugated iron was left in it as an additional protection. No flooding occurred during 1917, and before the spring of 1918 a wave-breaking fence had been erected and the face of the bund protected by mats and fascines of reeds. Experiments were made to induce vegetation, reeds and trees, to grow along the toe of the bund, but none of these protective methods proved efficient, and finally the whole of the front face was covered with six inches of coarse sand from Shaiba Ridge, which successfully withstood the floods of 1919, when the erosion was very small.

To return to the conditions of the first year of the war. On the capture of Busra, roads were practically non-existent, the inhabitants travelling about along the various creeks, which intersect the palm gardens, in local boats, called bellums.

A Turkish bridge existed over the Ashar Creek to Ashar Bazaar, but this was not strong enough to take heavy loads, and was replaced by a stronger bridge, designed to take loaded motor lorries, and constructed by a Sapper and Miner Company. An unmetalled road was opened up through Ashar Bazaar and across two creeks, the Khandag and the Robat, to Makina. With the increase of the force it was soon found that the restricted area along the river front and Ashar was insufficient, and a scheme for transferring the Ordnance and S. and T. Depôts to Magil was projected. A few temporary jetties were built there, and a road was constructed connecting Makina and Magil.

The only piped water supply which existed in Busra was a line delivering water from a small engine and pump on the bank of the Shatt-el-Arab to the Turkish Barracks at Ashar. Other camps and billets drew their water from the centre of the river in tanks, loaded in bellums. Early action was taken to prepare schemes, and material was ordered to provide a water supply for Makina, Magil, Ashar, and the River Front Areas.

The maintenance of roads, which eventually reached a length of nearly 40 miles in the Base alone, presented many difficulties. As no stone was procurable locally the roads were built of earth, raised on embankments above flood level. The soil of the country is very fine silt, which cuts up badly under traffic. During the rains the roads

became quagmires, and although improvements were tried by laying palm leaves and reeds on them, transport became practically impossible during the winter of 1915—16. So bad did the roads become that the Army Commander ordered 14,000 tons of road metal from India, for the purpose of providing one main metalled thoroughfare between the River Front Area and Magil, *viâ* Makina. This stone arrived in April and May, 1916, and was off-loaded and stacked in various depôts near the river, but owing to transport difficulties it was not possible to start using it before the autumn of 1916.

Experience showed the necessity of electric lights and fans during the hot weather, and an order was placed for material to provide these for hospitals totalling 7,000 beds. Meanwhile the Searchlight Section was able to obtain and erect five small lighting sets, which provided a limited amount of power for the British Hospital, G.H.Q., Ashar Barracks, and H.Q., L. of C.

At the end of 1915 the Works Directorate had representatives at Busra, Kurna, Amara, and Ahwaz, and had a very extensive building programme ahead, with a very limited amount of *personnel*. But early in 1916 additional labour and officers began to arrive. In January the 2nd Labour Corps arrived from India and was followed shortly by the 1st Labour Corps which had been in Egypt. The 3rd, 4th and 5th Corps arrived shortly afterwards. Later in the year the 2nd Corps was sent up country, and approval was given for the Director of Works to enter into an agreement with an Indian labour contractor to supply 1,100 labourers with a proportion of artificers. Some of these men arrived in September and were of the greatest value. Eventually this corps, known as Fadooany's Coolies, became the nucleus of the 9th Corps. A proportion of the artificers were Chinese carpenters, and were not altogether a success, owing to various causes.

At the end of January, 1916, an Electrical and Mechanical Section was formed from *personnel* of the Searchlight Company and placed under a D.A.D.W., who shortly became A.D.W. In March the title of A.F.E. in charge of the Engineer Field Park was changed to A.D.W. Park, and the Field Park became an integral part of the Works Directorate. At the end of April Col. E. R. B. Stokes-Roberts became D.D.W., and in August he was made Director of Works with the rank of Brigadier-General. In September a War Establishment of the Directorate and Works Companies was submitted which provided for 32 officers, including six A.D.W.'s.

During the first seven months of 1916 the hospital accommodation was increased by 4,710 beds, and additional hutting for 14,750 troops was constructed. In addition, 8 miles of new roads were made in Busra and nine bridges were built to carry heavy traffic.

With the stone from India there arrived two 6-ton steam rollers, their size being limited by the strength of the bridges, which had not

been constructed to carry loads greater than eight tons. When at last it was possible to commence spreading the metal, it was found that the hard Bombay trap would not consolidate under these rollers, and the road could not be built under ordinary methods. The winter rains were approaching and the matter was becoming urgent when the idea was conceived of binding the metal with concrete. An experiment was made of laying the metal dry and grouting in with sand and cement in a mixture of 1½ to 1. It was found that layers of broken stone, 4 inches deep, could be grouted successfully, so that all interstices were filled. The progress by this method was much faster than by mixing concrete in the ordinary fashion, and it was adopted. The thickness of the slab varied from 8 in. to 4 in., dependent on the stability of the surface below.

It was soon found necessary to supplement the Indian stone, as the quantity was insufficient, and steps were taken to investigate, and if possible, develop, any sources of local supply, to provide for immediate and future requirements. Jabal Sanam, a hill about 25 miles S.W. of Busra was visited in September, 1916, but although a certain amount of good stone was to be found there, it was not considered a feasible source of supply at the time, owing to the difficulty of transport into Busra, and meanwhile arrangements were made to obtain stone from Koweit in native craft. This lime stone proved quite useful as road metal, but the supply was uncertain and very limited. A small amount of sandstone was also brought from near Ahwaz.

In October, 1916, it was reported that a good limestone was to be found on Kharaq Island, situated 30 miles from Bushire and 90 from Fao. The Director of Works inspected the island and decided to develop it as a source of supply. But meanwhile a report came in that stone was found in the desert, near the railway, between Busra and Nasiriyeh, and in December investigations were made at El Jalib and Legait, and ten miles S.W. of Tel-el-Lahm, but they revealed only a very poor class of sandstone, which was of no practical value for road work where heavy traffic was involved.

The first quarry party, consisting of 250 men of the 5th Labour Corps, consequently, sailed for Kharaq Island in February, 1917, and from that time this became the principal source of supply The work was soon taken over by Persian labour. In all about 28,000 tons of stone were imported, almost entirely in native craft, of which over 170 boats were employed on this work. The maximum export in a single month was 3,100 tons (100,000 c.f.). A jetty was made to accommodate boats drawing up to 14 ft. of water, and about four miles of tramway laid, the haulage being done by mules imported into the island. A camp was made, and a wireless station erected, giving communication with Busra. The main difficulty in connection with this source of supply was the uncertainty of transport,

which practically ceased during the winter months. Transport also proved a very heavy item in the cost of the stone at Busra.

During the spring of 1916 the floods were extremely high, and in spite of bunds along the banks of the river and creeks, much damage was done. Many of these bunds were merely mud walls, and these were often breached and whole areas of date gardens were flooded to a depth of three to four feet, through which the raised roads ran like causeways across a marsh. Around the more important areas occupied by buildings earthen bunds of good section were constructed, but even these were powerless to keep the enclosed areas dry on account of the percolation of the water through the soil. Pumps were installed in various places to deal with the soakage water, but this method could not be considered a permanent arrangement. Since the whole country was level and cultivated to a depth of 2 to 3 miles from the river it was not possible to obtain earth for reclamation purposes in the vicinity, and as the ground had to be raised to a safe level before buildings could be constructed on it it was decided to lay down a light railway to bring the necessary earth from the desert. Forty miles of track, 10 locomotives, and 850 trucks were ordered from India, and in September, 1916, a Reclamation Section of the Works Directorate was formed. Meanwhile, pending the arrival of the material and equipment for the line, all earth for filling was obtained either from borrow pits—which will eventually have to be filled in again—or brought by small native craft from long distances up creeks, but the first of these methods was insanitary, as the pits could not be drained, and the other slow and laborious. There were in Busra ten miles of 9-lb. track with four motor tractors, which had arrived from England about August, 1916, and this was laid to assist in the distribution of the road metal referred to above, and formed the first lines of the Reclamation system. This 9-lb. track proved too light even for motor tractors, and was replaced as soon as the heavier rails began to arrive from India in October.

The War Establishment of the Reclamation Section, under an A.D.W., was put forward in September, and in October an officer was sent to India to recruit the necessary *personnel*. On the arrival of these men work was pushed on, and by the end of the year platelaying was progressing favourably. As all material, both of permanent way and rolling stock, was secondhand, considerable repairs were necessary, and in January, 1917, a further order for material was sent to India, as it was foreseen that the amount of work to be done could not be handled by the existing stock. A line connecting the river front with Makina was laid to facilitate the distribution of stores and release motor lorries for the forward areas.

After the fall of Baghdad a large proportion of the rolling stock and *personnel* were sent up country, and the progress of the Reclamation line was severely handicapped. In the hot weather of 1917

the work was further delayed by sickness, and it was not till October, 1917, that the project as originally designed was nearing completion. The construction work had been heavy. The permanent way had to be laid on high embankments above flood level, many bridges had to be built across the numerous creeks, repair shops for locos. and rolling stock had to be erected, quarters for staff and numerous other arrangements made, all of which had been accomplished only by the hard work and devotion of the officers and men of the Section. On 14th October, 1917, the Reclamation Railway was handed over with its staff to the Railway Directorate, and passed out of the control of Works.

During 1916 the Medical Authorities took great pains to ensure that the water used by the troops was purified before use. The usual method was to pump the water into an expense tank and add a specified amount of bleaching powder, after which the water was allowed to stand half-an-hour before being drawn off. Towards the end of 1916 Lieut. Myers, I.A.R.O. designed an automatic suction chlorinator for attachment to the pumps used for drinking water. A small tank containing bleaching powder solution was connected through a needle-valve with the suction pipe of the pump. The suction of the pump drew in a small amount of solution with the water. As practically all the pumps were centrifugal, the bleach solution and water were intimately mixed during their passage through the pump. It was found that in all installations the passage of the water through the rising main and overhead tank to the consumer took more than the half-hour necessary for the solution to purify the water. The percentage of solution added to the water could be accurately controlled by adjusting the needle-valve. The system was improved by several officers, and was brought into use at all pumping stations throughout the country.

Owing to the deterioration and shortage of the stocks of bleaching powder it was decided towards the end of 1917 to undertake its manufacture by electrolysis. This was commenced at Baghdad and was successful after a few experiments, at a lower cost than that at which the bleaching powder could be imported. The manufacture was extended to Busra in the following autumn.

The experience of the hot weather of 1915 showed the necessity of providing electric light and fans for all hospitals, British and Indian. The original order for plant to supply 7,000 beds was complied with and the work of erection was well in hand by the hot weather of 1916. At the end of July India was informed that installations for an additional 7,000 beds would be required, and it was decided that a central power station should be erected in Busra. In September Major Pitkeathy arrived as A.D.W., E. and M. A certain amount of steam generating plant was immediately available in

India, and the power station was designed to utilize this, the rest of the plant being ordered from England.

Owing to the short time available for construction, it was decided to erect a station with both alternating current high-tension and direct current three-wire plant.

The plant available in India consisted of two complete steam-driven alternators, each of 130 kilo-watts at 3,000 volts, with Babcocks and Wilcox boilers, chimney, switch-board, and all accessories, intended as a stand-by plant for the Kashmir durbar; two 120 kilo-watt 440 volt continuous current dynamos from the North-Western Railway of India, with a few accessories and four Babcocks and Wilcox boilers, with chimney, under construction for a textile firm in Bombay. It was proposed to have the Kashmir alternators rewound to 6,600 volts, but this was not found practicable, and 3,000 volts had to be accepted as the generating voltage. To economise in engine power it was decided to fit two continuous current dynamos in tender with the Kashmir alternators. Additional plant ordered from England for the station consisted of two 250 kilo-watt continuous current dynamos, a 200 kilo-watt alternator and a 150 kilo-watt rotary convertor.

The site decided for the central power station was on Ashar Creek. It was acquired at the end of September, 1916, and work was at once started clearing the palm trees, laying foundations and raising the ground to above flood level.

The power station was designed to supply power to the hospitals, the River Front area, Basra city and Ashar, on 440 volts, three wires; three sub-stations being provided at Magil, Makina, and Tanooma to convert high-tension alternating current to continuous current, to suit the existing current consuming devices. The sub-station machines with all necessary accessories were ordered from England.

A misfortune occurred in the loss of the ship carrying a large proportion of this plant. Steps were taken by the War Office to replace the losses immediately, but as the new plant could not arrive in time for the hot weather, it was necessary to get more plant from India. The scheme was considerably modified and by this means the Central Power Station commenced taking the load in March, 1917, releasing small plants for re-erection up-river. The duplicate plant arrived during the hot weather and was shipped to Baghdad and erected there.

The site was further designed to include a well-equipped workshop, an ice factory and cold store. The demand for ice in the Force had increased enormously, and the sanctioned programme for the hot weather of 1917 allowed for the manufacture of 40 tons daily. The factory at Busra was designed to make 20 tons a day, with an ice-store to hold 250 tons. Several one-ton plants were mounted

on barges for use of the troops in the field, and new plants were erected at various stations.

By February, 1917, the responsibilities of the Director of Works had so greatly increased that his staff now included two Deputy Directors and eleven assistants. The latter were distributed as follows:—One on the D.W. Headquarter Staff; one in charge of Electricity and Machinery; one in charge of the Park; and one in charge of each of the following districts:—River Front, Magil, Reclamation, Euphrates Line, Kurna, Amara, Sheikh Saad, and Tigris Road.

The history of the Tigris road is interesting. On 18th January, 1916, instructions were received to construct a raised road above flood level along the river bank from Kurna to Amara. A certain amount of preliminary reconnaissance was necessary and arrangements for material and labour had to be made, and it was not until the 15th February that working parties were detailed to proceed from Busra. The distance by road from Kurna to Amara is 70 miles, and 2,200 men were detailed to five sections of the road. In addition to the working parties the political officers endeavoured to collect Arabs, and eventually from 3,000 to 4,000 were got to work. Between Kurna and Mantaris, a distance of about 35 miles, the road lay almost entirely along low swampy ground, which entailed the construction of an embankment three to four ft. high to keep the road above high flood level. In addition, many creeks, which drained the swamps, had to be bridged, and the whole work had to be completed before the flood season at the end of April. Instructions were received to make the bridges capable of taking a 3-ton load, representing a Fiat lorry fully loaded.

In order to obtain the maximum benefit of this road it was decided to extend it to a point six miles below Kurna, where steamers up to 12 ft. draught could proceed, and land troops and material. Early in March three landing-stages were constructed at Steamer Point, and the road constructed from there to Kurna. This entailed a considerable amount of earth work and bridging, which was carried out by the 71st Field Company, R.E. A pontoon bridge was thrown across the Euphrates as a temporary measure, and was afterwards replaced by a bridge of bellums or small native craft. Work on the road was pushed on rapidly. No. 4 Company Sappers and Miners constructed all the bridges and culverts on the southern section as far as Qalat Saleh. The whole road was reported open on 25th April, although the last section of a couple of miles had to be completed under great difficulties, all the ground being flooded, and earth to make the embankment having to be brought by boat for a distance of three or four miles.

On the completion of this section of the road a few working parties were put on the road between Amara and Ali Gharbi, 69 miles in

length, and a track was opened, passable by wheeled traffic, but not by motors. At the same time a reconnaissance between Ali Gharbi and Sheikh Saad (29 miles) was carried out by the Field Troop, 2nd S. and M., and showed that the road could be extended to that place without much difficulty.

At the end of May, 1916, the road from Kurna to Sheikh Saad, a total distance of 232 miles, was placed in charge of an A.D.W. for construction and maintenance. North of Amara the chief difficulty encountered was the presence of innumerable irrigation channels running at right angles to the river, used by the Arabs to carry the flood water from the Tigris to irrigate the lower land a mile or two from the river bank. These cuts were from three to five feet deep and eight to ten feet wide, and three to four hundred of them had to be bridged between Amara and Sheikh Saad. During the period of low water they were dry, and the road was taken through them as a temporary measure by ramping the sides. For the permanent road, however, corrugated iron culverts, or small timber bridges had to be installed. In June, 1916, a working party of 500 Pioneers was asked for, and the road could then have been completed in 60 days, but no troops were available, and as the local Arabs would not work during the Ramzan, the construction of the road was somewhat delayed. Transport for distributing material was also very scanty, and faced by these difficulties the life of the A.D.W., Tigris Road, was not a happy one. In August, 300 pioneers were allotted, and by the end of September, 1916, a road suitable for light motor traffic was open from Amara to Sheikh Saad. Meanwhile a railway was under construction from Kurna to Amara, and many portions of the raised road between Kurna and Qalat Saleh were utilized as the railway embankment, thus effectively destroying the communication by road during the floods. A low level road was demarcated, which was passable until the floods rose in the following March.

Between Busra and Kurna several large bridges were required, the most important one being at Gurmat Ali across a branch of the Euphrates. Here the river is 200 yards wide, very deep and tidal, the marshes a few miles inland acting as a huge reservoir, so that with the rise and fall of the tide in the Tigris a swift current flows either up or down the river. There were available at Busra some double cylindrical dredger pontoons, each cylinder being five feet in diameter and about 24 feet long. Lattice girders were ordered from India to take a load of 11 tons over a 30-ft. span, and with these the Euphrates was bridged, by the Tehri Garhwal Imperial Service Sappers, in August and September, 1916. At Shafi and Kurna boat bridges were constructed, and the other nullahs were spanned by trestle bridges. Thus direct communication by road was established between Busra and Sheikh Saad, a distance of 272 miles.

After the advance to Baghdad the extent of road became too great

to be administered by one A.D.W., and the road was placed in charge of the A.D.W.'s Magil, Kurna, Amara, Kut, and Baghdad, each being responsible for the section of road in his district.

On the completion of the railway from Busra to Kurna the railway bridges over the Euphrates at Gurmat Ali and Kurna were used for the road, and later a temporary railway bridge over the Shafi Nullah was handed over as a road bridge. The former Gurmat Ali road bridge was dismantled and sent to Baghdad for re-erection.

Early in 1917 instructions were received to make all road bridges strong enough to carry 4½-ton axle loads, and, as labour permitted, to construct a road which would be passable during flood time throughout. This entailed a great deal of earthwork, especially between Busra and Qalat Saleh, which was still progressing at the end of 1918.

Towards the end of 1917 a fleet of refrigeration barges was sent out from England to carry frozen meat, and it was decided that these should be placed under the Works Directorate, in order that ice and cold storage should be under one control. The fleet consisted of 13 barges, and each had on board a four-ton Lighfoot ice-plant, with two refrigerated holds. Capt. K. Lightfoot, R.E., was in charge, and he and his staff worked so successfully that they never lost a cargo.

Before the construction of the Busra cold store, the medical authorities found it impossible to keep vaccines in the country during the hot weather. The Busra ice-store included a compartment for the storage of vaccines, and when the refrigeration fleet was put in commission, the vaccines were carried up country cooled in the barges.

The lower part of Mesopotamia is practically devoid of all natural products useful in the building trades, and all materials except bricks have to be imported. The soil of the country makes fair bricks, but the supply of these has usually been short of the demands, owing to the difficulty in obtaining fuel for the kilns. Experiments have been tried in using oil-fuel and satisfactory methods have been brought into use.

After the capture of Hit a small quantity of bitumen became available for water-proofing roofs of houses and billets, and for repairing pontoons. The Turks used it for covering several of the roads in Baghdad, but, with the increase in horsed and motor traffic after the British occupation, it was not found suitable for a road surface, and none has been used in this way by the British.

In November, 1917, the Directorate suffered a great loss in the death at Baghdad of Brig.-General E. R. B. Stokes-Roberts, C.B. His place was taken by Brig.-General C. H. Roe, C.I.E., who was invalided in January, 1919, when his place was filled by Brig.-General A. J. H. Swiney, C.B., C.M.G.

CORRESPONDENCE.

HOUPLINES RAILWAY BRIDGE.

To the Editor of the R.E. JOURNAL.

SIR,

May I be allowed to supplement the last paragraph of Major Sinauer's account of the repair of the Houplines Railway Bridge, given in the *R.E. Journal* for September, 1919, by a few further notes as to its later history?

The bridge was very badly damaged by the German bombardment of June and July, 1917. Though it had not then fallen, the number of large shell holes, particularly at or near important joints, was so great as to make further repair out of the question in the event of the Passchendael operations resulting in its being required for use in a hurry. Further bombardment might at any moment result in the wrecked span falling into the river again. If this had occurred we should have been faced with a long and difficult job, as was already proved by experience elsewhere, in removing the wreckage before being able to construct a temporary bridge. The high bank and marshy ground on either side, as well as the proximity of Houplines station rendered the rapid construction of a deviation impracticable. Fortunately a solution of the difficulty was presented by the fact that the abutments as shown in Major Sinauer's drawings were built for a double line, though the bank and bridge were only suitable for a single line. If, therefore, the damaged bridge could be moved on to the other unoccupied half of the abutment it would be out of the way of future work, whether it fell or not. The proposal to move it in this way was agreed to, and the work was carried out in the autumn of 1917 by a detachment of the 109th Rly. Co., R.E., under the direct supervision of Capt. (afterwards Major) E. Lyall, D.S.O., R.E. The conditions as regards hostile observation and shell-fire were then if anything worse than in 1915, and so much damage had been done to the roads and railway tracks in the neighbourhood that the necessary gear could only be brought to the Western outskirts of Armentières by lorry and taken forward from there by hand. The girders were jacked up sufficiently to allow of greased rails being inserted under them across each abutment, and the whole span was pushed sideways by horizontal jacks. The enemy fortunately, failed to notice that anything unusual was being done.

I never saw the bridge again after this was done, and should be interested to know whether the anticipation that the wreckage of it would fall sufficiently far to one side as not to hinder the construction of a temporary bridge practically on the old centre line, turned out to be correct.

Yours faithfully,

E. P. ANDERSON, *Major, R.E.*

Simla, 28th September, 1919.

Lieut.-Colonel Sir Henry Trotter, K.C.M.G., C.B.

Lt Col Sir Henry Trotter KCMG CB

MEMOIR.

LT.-COL. SIR HENRY TROTTER, K.C.M.G., C.B.

I FIRST knew Henry Trotter at Addiscombe College where, in the year 1859, he was already an old cadet whilst I was but a last joined member of the College and recognized, together with the Company that joined with me, as a "Green." Between the "Old Cadets" and the "Greens" there was but little intimacy. The special privileges accorded to them placed the old cadet on an upper shelf that was beyond the reach of the Green, and thus set a definite space between Trotter and myself which was not bridged over before he obtained his commission in the Bengal Engineers. I did not even know his name. Naturally, in days that were pervaded by the romances of Dickens he was known as "Job." When in due time I obtained my commission I found to my bitter disappointment that no more commissions in the Bengal Engineers were to be given to "nominated" cadets, and that I must serve my time afresh at Woolwich as a "competitive" if I aspired to join the Engineer Service. So it was three years before I met Trotter again, and then I found him in India doing excellent work in the Survey Department to which I was myself posted. The great trigonometrical branch of that department was then spreading out its network of scientific measurements from India to India's Hinterland in the Himalayas and beyond. Such men as Walker, Montgomerie, Herschell, and Bassevi (all Engineers) were building up the great skeleton which was to be the foundation of future map-making in Asia. It was in such good company that Trotter first commenced his scientific career. For 13 years he enjoyed the supreme satisfaction of adding year by year to our very immature knowledge of the geography of Northern India, and then occurred his great opportunity. The mission of Sir Douglas Forsyth to Yarkand in 1873-74 was a plunge into the regions of unmapped and almost unknown Central Asia. Trotter was appointed to the mission as Geographer and it was his success in mapping those remote Khanates, and in unravelling the skein of much confused geographical record of preceding times, that made his reputation and earned him the gold medal of the Geographical Society. At that time certain tentative efforts to secure trustworthy geographical mapping of the Oxus regions had already been made by Montgomerie, who had trained native explorers for the purpose.

Trotter improved on Montgomerie's methods, and from that time forward the employment of natives in the field of geographical discovery has been uninterrupted and extraordinarily successful. But Trotter had always a hankering after diplomatic service, and he exerted himself successfully to exchange Indian experiences for those of diplomacy in the nearer East. After special service in China in 1876 he was appointed Assistant Military Attaché at Constantinople during the Russo-Turkish War of 77—78. He saw some wild service in Asia during the campaign, where he was present at the Seige of Kars and the Battles of Yeshek, Ilias, and other engagements. After this he became Consul in Kurdistan and after superintending relief operations at Scio following the great earthquake he once again was appointed to Constantinople as Military Attaché. He was Consul-General in Syria for four years, subsequently *Chargé d'affaires* at Bucharest and finally Consul-General in Rumania from 1894-96, and Delegate on the Danube Commission. Thus Colonel Trotter acquired a very wide knowledge of Eastern affairs which has been found most useful since his retirement both to Government and to The Royal Geographical Society which had always been an object of almost affectionate interest to him. He served on the Council of that Society for some years, and at the time of his death after a long illness (which he bore with great resignation and patience) he was Chairman of the Council of the Central Asian Society. I believe that Trotter had few really intimate friends. Always courteous, and rather reserved in manner, he was universally popular, but I never heard that he gave his entire confidence to anyone. Personally I knew him to have been a loyal and devoted friend, one who was utterly trustworthy and sound. As a young man he was a sportsman with something of a record: I believe he was the first European to shoot Ovis Poli in the Pamirs, and I know that he was one of a very few who have shot lions in Gujrát. His adventures in the field of Indian sport were many and varied, though he never spoke of them. I am aware, however, that on one occasion a very angry tiger was heaved by an angry elephant over the Mahout's head into Trotter's howdah, alongside of him, and this I think an incident unusual even in tiger annals. Taking it altogether, few men have lived more strenuous and adventurous lives than Colonel Sir Henry Trotter. He was one of the last links connecting that splendid old service, The East India Company's Engineers, with the modern Imperial List, and with his peaceful passing away we can almost count the few that remain on the fingers of one hand.

T. HOLDICH.

REVIEWS.

REINFORCED CONCRETE CONSTRUCTION.

By HENRY ADAMS, M. INST. C.E., M.I. MECH. E., F.S.I., F.R. SAN. I., etc., and ERNEST R. MATTHEWS (Captain R.A.M.C.). A.M. INST. C.E., F.R.S., (ED.), F.R. SAN. I., F.G.S.

The authors deal very little with the theory of Reinforced Concrete Construction and make no attempt to demonstrate the formulæ that they use, but the book contains a large number of excellent photographs which are very suggestive of the uses that can be made of Reinforced Concrete. Many detailed drawings are also reproduced, the value of which would be even greater were they more fully dimensioned.

H. L. LEWIS, *Lt.-Col., R.E.*

THE VITAL CHOICE: ENDOR OR CALVARY.

A Reply to Sir A. Conan Doyle's *The New Revelation*, by Lt.-Col. D. FORSTER, C.B.E., D.S.O., R.E. (Morgan and Scott). 2/-

Colonel Forster states clearly and concisely the case of the impiety of modern Spiritualism. The genuineness of the manifestations is not disputed, but the view that the very specific opposition of the Old Revelation to magic and sorcery may in these latter days be disregarded is opposed by arguments which merit serious consideration.

YPRES, 1914.

An Official account published by Order of the German General Staff. Translation by G.C.W. (Constable and Co., Ltd.), 5s.

This is the translation of the book "Die Schlacht an der Yser und bei Ypres" which was announced as in course of preparation by Brig.-General J. E. Edmonds in his article, "Some Books on the War" (*R.E.J.* September, 1919, p. 129), and is advertised in *The Times Literary Supplement*, under the title of "The Battle of the Yser and of Ypres, 1914." The translation, with its introduction and abundant notes by the Historical Section (Military Branch) Committee of Imperial Defence, gives, in a compact form and with great clearness, the truth, "as far as it has yet been officially revealed" of the great battle which Lord French describes as "more momentous and fateful than any other" that he directed during the period of his command in the field.

F.E.G.S.

NOTICES OF MAGAZINES.

THE MILITAR-WOCHENBLATT.

September, 1919.

Articles by our friends Generals von Bernhardi and Balck give the numbers quite a pre-war flavour. There are particularly interesting articles on the bridging of the Marne at the second battle in 1918, and on the operations of Field Marshal French against the German First Army, in which some Supreme Command operation orders are given.

No. 28.

Sir Douglas Haig's Dispatch.—Translation of the Dispatch of 10th April, 1919.

Survey of the Events on the Russian Battle-fronts, 20th July—15th August, 1919.—The writer considers that signs of the impending fall of Lenin and Co. are increasing: peasant risings, hunger revolts, street fighting and conspiracies in the large towns, all indicate that the feeling against Bolshevism is rising fast. Privations in the coming winter will be severe and will ring the knell.

Regimental Unions.—The list of these, continued from No. 20, shows a total of 42.

Rolls of Honour.—Field Artillery Regiment No. 61: officers killed in 1914, 7; 1915, 1; 1916, 10; 1917, 12; 1918, 18. Infantry Regiment No. 140: 105 officers and about 5,000 other ranks killed. Mounted Jäger Regiment No. 4: 16 officers killed.

No. 29.

On the Infantry Attack.—By Lieut.-General Balck. This well-known writer re-appears. His article, with examples from the Bulgarian-Turkish war and an attack of the XI. German Corps on 8th September, 1914, at Barten, seems to aim at showing that German methods were right and French wrong. The striving for fire superiority, advance by rushes, covering fire, which he praises, were practised by the British Army before the war; General Balck, though he was a recognized authority on the British Army, does not, however, refer to this.

Preventive War.—By General von Bernhardi. This well-known writer re-appears in print to defend himself from press attacks for having advocated preventive war, that is knocking down likely adversaries before they are too strong. His defence is that Frederick the Great practised it and that all would have gone well if the Germans had won the battle of the Marne. He adds that although Bismarck in his "Gedanken und Erinnerungen," deprecated it, he was old when he penned the book, and when young, 1866 and 1870, himself engineered preventive wars. A thoroughly cynical and genuinely Prussian article.

Sir Douglas Haig's Dispatch.—Continuation of the translation.

Rolls of Honour.—Field Artillery Regiment No. 50: 26 officers and 339 other ranks killed. Guard Foot Artillery Regiment: 84 officers killed. The Colonel signs the roll as "the last commandant."

No. 30.

Denmark and the League of Nations.—A complaint that whilst the German Army is being reduced to a police force, the Danes, without hindrance from the League of Nations, are increasing their forces.

Charges against the Governor of Maubeuge, General Fournier.—In view of the charges of treason made against the General who surrendered Maubeuge in September, 1914, General von Zwehl, who commanded the investing force, gives certain particulars. He states that Maubeuge was originally invested by the 14th Reserve Division (less two battalions), with six field batteries and 80 heavy guns, and a reinforced infantry brigade (the 26th of the 13th Division), with three field batteries. 13th Reserve Division arrived on the 1st September only. The French garrison, as is known, consisted of one regular infantry regiment, the rest of the 43,000 being made up of reservists and territorials. The original plan had been for parts of the IX. and VII. Corps to attack Maubeuge, but they had been hurried on past it. General von Zwehl states that the surrender was due to bombardment by heavy guns. Forts Brussois and des Sarli were badly damaged. Bersillies and Salemangne had badly suffered. The well constructed defences between the forts were "quite undestroyed." He adds that as the troops marched out they saluted General Fournier respectfully. He ends by saying that Fournier should not be blamed for a defeat by the Germans as the French and English could not have won the war without American help.

The End of the Imperial War Museum.—The project for this museum has been abandoned.

Sir Douglas Haig's Dispatch.—Translation continued.

Cadet Establishments.—Six are to continue in existence: Köslin, Karlsruhe, Naumburg, Plön, Potsdam, Wahlstatt.

Rolls of Honour.—Pioneer Battalion No. 23: 46 officers, 137 N.C.O.'s and 1,194 men killed, 2 officers missing. Pioneer Battalion No. 1: 35 officers, 160 N.C.O.'s and 1,049 men killed, 2 officers missing. Infantry Regiment No. 31: 95 officers, 1,647 other ranks killed.

Advertisements.—Conversion of uniform into civil clothes. "Officer's cape makes a complete suit; officer's greatcoat, coat and waistcoat or overcoat; tunic and jacket make elegant sport jackets; frock coat makes evening coat," etc.

No. 31.

England's Imperial Air Programme.—A summary of information as to the state and organization of our air forces.

Kriegervereine and Officers.—These associations of old soldiers which have existed since 1871, will in future admit officers as ordinary members without the special privileges of rank and station they formerly enjoyed.

Sir Douglas Haig's Dispatch.—Continuation of translation.

Rolls of Honour.—Infantry Regiment No. 68: 125 officers and 2,355 other ranks killed.

No. 32.

The Technical Instruction of Artillery Officers.—The article brings to notice a paper written by the well-known Lieut.-General Rohne, in which he states that the German Field Artillery was without doubt inferior to that of the French, not only in equipment, but instruction. In Germany the instruction of the officers was neglected. It is suggested (1) that only young men with good mathematical knowledge should be accepted as officer candidates; (2) that every artillery officer should receive a thorough technical scientific training; (3) that specially qualified officers should receive further instruction; (4) that officers who do exceptionally good technical work should receive the same promotion privileges as the former General Staff; (5) that the Artillery Committee should be provided with a scientific section, and (6) that scientific literature should be made available for officers.

The English Campaign in Mesopotamia in the Autumn of 1918.—A translation of General Marshall's dispatch, which is continued in the following number.

Removal of the Private Property of Members of the Army from Alsace-Lorraine.—Nothing has apparently been done to send this property back to Germany yet, and the complaints are loud.

The Gazette contains a number of steps in rank without pay.

Rolls of Honour.—Pioneer Battalion No. 2: 35 officers and 1,171 other ranks killed. Infantry Regiment No. 42: 98 officers and 2,985 other ranks killed. Infantry Regiment No. 26: 144 officers and 2,921 other ranks killed.

No. 33.

The Russian Soviet Armies.—There are about half a million men in arms in 15 armies: about 45,000 on the north and west front, 170,000 on the west front, 170,000 on the southern front and 135,000 on the east front. In the interior are 725,000 men more. Mass desertion is rife; the results of mobilization of all men under 40 have been poor. The spirit of *Nitchevo* and *Avos* ("it doesn't matter" and "perhaps it will be all right") prevail; even a Red Army cannot be efficient without sense of duty and discipline, and these are lacking. It is wonderful how a Government supported by such an army can go on.

Compensation for Increased Cost of Living.—Civil officials are receiving this, but officers are not.

Rolls of Honour.—Foot Artillery Regiment No. 27: 17 officers and 385 other ranks killed. Infantry Regiment No. 91: 128 officers and about 4,000 other ranks killed.

No. 34.

The Military—Political Situation in Russia in the latter half of August, 1919.—It is considered evident that the Bolshevists are getting the worst of the fighting everywhere.

The Pioneers on the Marne in July, 1918.—A most interesting article, giving an account of the engineer operations in the successful bridging of the Marne in the last German offensive, which deserves translation. The river, 240 feet wide, presented no special obstacle, but as the slope

down to it commenced 3,000 to 4,000 yards away and was in full view of the enemy, the pontoons had to be carried down by night and hidden in holes, trenches, etc., and camouflaged. A company could only carry down four pontoons a night. Everything was carefully rehearsed for several weeks, the reconnaissances were not commenced until 14 days before the passage. It was planned that every division should have (a) a pioneer battalion with a Corps bridging team for the ferries; (b) two pioneer companies with five divisional bridging trains for the bridges; (c) three pioneer companies for engineer duties on the far side of the Marne; (d) one pioneer company in reserve. Owing to lack of material and an influenza epidemic, this ideal was not reached.—(*To be continued*).

The Danger of German Aviation.—The writer quotes with some glee the fears expressed in French newspapers that Germans will build a commercial fleet of aircraft easily convertible into fighting machines.

Roll of Honour.—Guard Grenadier Regiment No. 2: 133 officers and over 4,500 other ranks killed.

No 35

The Operations of Field Marshal French against the First Army and the VII. Reserve Corps in the Summer of 1914.—By General von Zwehl (Commander of the VII. Corps). This is a fairly sharp criticism of Lord French's book, which has been translated in the columns of the *M.W.B.* It is described as a medley of operation orders, wishes and anxieties with excursions into unimportant side issues, the activities of small units, even of patrols. What the German General cannot understand is what he thinks is the Field Marshal's evident ignorance of things German, his extraordinary bad taste in bestowing praise and blame on living officers, and his unprovoked attack on General Lanrezac. It is astonishing he says, that a man of Lord French's reputation should write so unscientifically and confusedly. England, as regards writing military history is evidently still in its "child's shoes"

The History of Tanks in England.—A summary from the English papers. (It is remarkable how much is taken from English sources in the present day *M.W.B.*, it ignored us before the war).

The Pioneers on the Marne in July, 1919 (continued).—Details of the construction of the bridges are given. As is well known, the Americans put down a barrage 10 minutes before the German zero, at 1 a.m. on the 14th; the men carrying down the pontoons had to put on their gas masks, with results that may be imagined on a pitch dark night, and when they reached the water's edge, they came under M.G. fire; nevertheless, of the 130 pontoons to ferry over the first advanced parties, 108 were got into the water. Eventually it was only possible in some divisions to make one bridge instead of two; that of the 10th Division was sunk, that of the 36th Division was not completed until evening; the 23rd Division made two, but one was sunk by a direct hit; the 200th Division made two, but one was destroyed and replaced by a foot trestle bridge; the Guard Infantry Division made two bridges, as did the 37th Division, but the second was only completed at 11.30 p.m. on the 15th; the 113th Division did much the same.

When the Germans recrossed the river in retreat, of the original six corps and 29 divisional bridging trains enough was rescued to make 1½ corps and three divisional ones. Thus ended the activity of the German Pioneers on this "bad luck river," as the article calls it. The total losses of the 59 Pioneer Companies are not given, but the 28 G.H.Q. Companies lost: killed, eight officers, 157 men; wounded 28 officers, 783 men; missing, one officer, 52 men. A fine performance of the German Pioneers.

Rolls of Honour.—Field Artillery Regiment No. 31: 19 officers and 200 other ranks killed. Railway Troops: 120 officers killed, or died in consequence of hardships. Jäger Battalion (Hanover) No. 10: 111 officers, and 2,924 other ranks killed (these figures for a battalion are the heaviest infantry losses yet noticed).

No. 36.

The Operations of Field Marshal French (continued from No. 35).—A most interesting number. The German difficulties on account of not knowing when the English would appear and the actual surprise of their appearance at Mons are brought out. The following Supreme Command orders quoted are of importance.

"28th August, 1914.

"The First Army, with the II. Cavalry Corps, will march towards the Lower Seine, west of the Oise. It must be ready to co-operate should the Second Army become engaged. It will deal with any hostile new formations in its area.

"The Second Army, with the I. Cavalry Corps, will advance *viâ* the line La Fère-Laon on Paris.

* * * * * * * *

"Should the enemy offer determined resistance, on the Aisne and subsequently on the Marne, the direction of the Armies may be changed from south-west to south."

"3rd September.

"The intention of the Supreme Command is to drive the French in a S.E. direction away from Paris. The First Army will follow echelonned in rear of the Second Army, and will be responsible for the flank protection of the Armies."

Mouvement Tourné.—An article dealing, *apropos* of the battle of the Ourcq, with the turning of the flank of a turning force. The battle of the Lisaine, January, 1871, is discussed to show that von Werder used these tactics then.

The Peace Treaty and German Flying.—This points out Germany's favourable central position in Europe for air communication.

Rolls of Honour.—Infantry Regiment No. 172: 137 officers and over 3,000 other ranks killed. Reserve Infantry Regiment No. 220: 76 officers and over 2,500 other ranks killed. Pioneer Battalion No. 29: 24 officers and 1,070 other ranks killed.

No. 37.

The Officers' Compensation Law.—The text of the law as passed by the Reichstag and promulgated is given. Officers under five years'

service who are compulsorily retired receive a year's pay; between five and eight years' service, two years' pay; between eight and ten service, three years' pay. Officers with over ten years' service receive the pension that they would have been entitled to if found unfit for further service.

The French Colonial and North African Army.—Extracted from *The Times* of 6th September, 1919.

The Operations of Field Marshal French (continued from No. 36). This deals with the battle of the Marne, and only brings out that von Kluck strongly opposed the retirement to the Aisne, when the order was brought to him by a special representative of the Supreme Command.

Roll of Honour.—Foot Artillery Regiment No. 3: 95 officers killed.

No. 38.

The World Military-Political Situation.—Contrasts our reduction of the Army of the Rhine with Marshal Foch's demands for more troops, and gleefully sketches our entanglements in Russia, Egypt, and elsewhere.

The Operations of Field Marshal French (continued from No. 37).—Deals with the battle of the Aisne, in which the writer's Corps took a distinguished part. On the 13th September, 8 a.m., the heads of its two divisions were about 10 miles S.E. of Laon. It then received orders to support the left of the First Army. No sooner had this movement been got under way than the Second Army ordered the corps to come to its support *viâ* Berry au Bac. General Zwehl stuck to his original orders unfortunately for us. The articles end with a paragraph insisting that the retirement from the Marne was a "voluntary one."

The Economic Position of Officers.—A long article about the recovery of officers' furniture left in Alsace-Lorraine.

Rolls of Honour.—Foot Artillery Regiment No. 59: 36 officers and 501 other ranks killed. 11 officers died of illness contracted in the field. Infantry Regiment No. 57: 142 officers and 5,100 other ranks killed on the west front. Infantry Regiment No. 118: 118 officers and 2,900 ranks killed, four officers missing.

J. E. EDMONDS.

REVUE MILITAIRE SUISSE.

No. 9.—September, 1919.

THE GERMAN AND FRENCH CAVALRIES IN THE GREAT WAR.

The article on the above subject by Colonel Poudret begun in the March number of the *Revue* (*vide R.E. Journal* for June, 1919, *et seq.*) is continued in the number of the publication under notice.

The author of the original article devotes attention to the work carried out by *cavalry patrols*. He points out that for a quarter of a century and more the much vaunted work of the German cavalry patrols in 1870 has been constantly paraded for the edification of cavalrymen. The circumstances under which the German cavalry had to operate in the year mentioned were vastly different to the conditions prevailing in 1914. In 1870, the German patrols had little to fear from the French

Cavalry; their security services were nevertheless badly carried out, they were frequently surprised and often lost contact with the opposing forces.

It is for want of better examples, and for no other reason, that the work of the German patrols, including that of the famous Zeppelin patrol, has been so constantly brought before students of military history during the past four decades, in spite of the fact that practically every conceivable mistake which could have been committed was actually made by the German patrol leaders.

From the outset of the campaign in 1914, it was realized that, with the short distance separating the contending armies, it would only be in rare circumstances that cavalry reconnaissances could result in procuring intelligence concerning the enemy without serious fighting. Consequently reconnaissances were made in great force, and even then the difficulties encountered were immense. The results obtained, although considered very satisfactory, were secured at a great price, having in view the casualties suffered. The intelligence collected in Belgium by Sordet's cavalry and the provisional cavalry division in the critical days of August and September, 1914, was particularly accurate, abundant and more important than is generally recognized to have been the case.

Colonel Poudret gives short accounts, in the original article, of the work done during the last year of the war by many of the patrols sent out by the divisional cavalry. Much of this work proved of immense value to the French troops. In one case, the intelligence collected by the patrols of the divisional cavalry was so complete, it is said, that *the infantry was not once ambushed, nor did it make a single useless march*, but was able to make all necessary dispositions betimes in order to meet the enemy's moves and to provide for its own security. Further, the long turns of dismounted duty during the four years of trench warfare, largely on the defensive, exercised no adverse influence on the keenness of the French Cavalry when again employed as a mounted arm in its normal sphere of activity.

The war has cleared away many erroneous doctrines; the ruins of the delusions having been swept away, it has been possible to build up, on a solid foundation, proper conceptions relating to the sphere of utility of cavalry. Colonel Poudret tells us that the lessons of the war indicate that the field of action for cavalry is comprised under the following heads:—

1. It must reach the important defensive positions betimes and hold on to them tenaciously until the infantry can arrive to take over the defence; that is to say, its function is to gain time.

2. It must at once fill or close up any breaches or gaps made in the front on which its own side is fighting.

3. It must mask the withdrawal of troops from the fighting line.

4. It must move quickly as reinforcements to a threatened point on a distant part of the far-flung battle front.

5. It must exploit the success gained by its own infantry by passing through the breach made for it in the enemy's front.

6. It must act against the enemy's lines of communication by turning one of the enemy's flanks.

The cavalry should, says Colonel Poudret, be always held in *reserve* as near the battle front as possible so that it may be thrown into the fighting line as early as possible. From the earliest days of the war, the necessity was realized of having troops, more mobile than infantry, readily available for the purpose of rapidly reinforcing threatened points and the parts of the front temporarily uncovered.

So long as necessities of this kind are likely to occur cavalry will always have a sphere of action on a modern battlefield.

Comments are made in the original article on the French Regulations most recently issued. It is pointed out that although the Swiss Army cannot expect to be provided with tanks, heavy batteries, Q.F. guns, and the other technical appliances with which modern armies are endowed, nevertheless its weak cavalry brigades should have an increase in the numbers of machine-guns allotted, and should be issued with automatic rifles. Further, in view of the importance of *liaison*, it is suggested that a better provision should be made in the matter of motor-cars, motor-cycles, field telephones, wireless telegraphy, etc.

It is pointed out also that a study of the French Regulations shows that the methods of training in vogue in the Swiss Army require to be thoroughly revised and brought up to date.

The original article concludes with a copy of a document issued by Marshal Pétain on 3rd August, 1919, entitled: *Note pour les armées au sujet de l'instruction dans les corps de troupe de cavalerie.* This Note lays down the *Principles for the Employment of Cavalry*, and discusses the *Conditions under which it is to be employed*; *The Cavalry of the Future*; and *The Methods and Means of Training.*

Permanent Fortifications in the Great War.

The article on the above subject begun in the number of the *Revue* for July last (*vide R.E. Journal* for October, 1919) is continued in the number under notice.

The defence of Antwerp (September 28th to October 10th, 1914) is considered. A brief description of this famous fortress is given: it comprised three successive lines of defence:—

(*a*) The old ramparts of the town remodelled in 1860 by Brialmont;

(*b*) The inner line of 14 forts, with intermediate works, on a circumference measuring about 28 miles, constructed by Brialmont in 1860. These forts were from 2½ to 3 miles from the town, and their armament was similar to that in the forts round Liege and Namur.

(*c*) The outer line, at an average distance of nine miles from the town, consisting of 19 forts on a circumference measuring about 62 miles. The construction of these defences was begun in 1890. Of the guns and mortars forming the armament of these forts, none of the former exceeded a calibre of 15cm. and none of the latter exceeded 21cm. in calibre.

The events connected with the retirement of the Belgian Army into Antwerp are briefly stated in the original article. Between the 25th August and 27th September, the Belgians made three sorties against the German line of communications, but, in view of the superior forces brought against them they had to retire within the protecting works of the great retrenched camp of which so much had been expected.

The besieging army was commanded by General von Beseler, the German Inspector-General of Fortifications, who had played a similar *rôle* at Liege, Namur, and Maubeuge. His command consisted of the Third Reserve Corps, the 26th and 37th Landwehr Brigades, a Division of Fusilier Marines, the 1st and 4th Ersatz Divisions, a Bavarian Division, a Garrison Artillery Brigade, and a Brigade of Siege Pioneers, totalling approximately 150,000 men. Fearing operations against their lines of communication, the German siege artillery having been liberated by the fall of Maubeuge, the Great General Staff decided to make a concentrated effort to capture Antwerp. The principal attack was directed against the 3rd sector—the front between the Dyle and the Petit Nithe; whilst a feint was arranged for on the 4th sector—the front between the Dyle and the Scheldt.

On the 28th September, the siege commenced with an attack on the forts known as Waelhem and Wavre-St. Catherine; 10 shots a minute were fired against the former.

On the 29th September, the attack against the 4th sector was begun, but produced no immediate result. At the same time the attack against the 3rd sector was intensified. The destruction, by an explosion, of the magazine at Fort Wavre-St. Catherine compelled the garrison to evacuate it after a defence of 18 hours; the moral effect of this was disastrous, as it destroyed the confidence of the Belgian troops in their great stronghold. Measures were at once taken to create a base at Ostend, and the withdrawal was begun from Antwerp without delay. During eight nights convoys passed westward over the Scheldt by a single bridge at Tamise, in doing so passing within three miles of the German lines; the fortifications, at least, enabled the supplies accummulated at Antwerp to be withdrawn.

The forts in the 3rd sector became untenable on the 2nd October and had to be evacuated. Two days later the British Naval Brigade, 2,200 men strong, arrived in Antwerp, and on the same day the Germans crossed the Nithe and forced the passage of the Dendre; the enemy was now in rear of the Belgian first line of defence. By the 6th October, the breach in the 3rd sector had been widened and formed a gap measuring some 12½ miles of front. The Belgian Army began to retire on Ostend during the night of 6th-7th October. For the defence of the citadel there now remained the garrison of the forts, the Belgian 2nd Division, three British Naval Brigades and a few regiments of fortress infantry.

On the 7th *idem*, the attack on the inner line of forts was begun and at midnight the town itself was bombarded. Two days later, a few Germans penetrated into the town, after capturing some of the inner forts. On the 10th *idem*, the fortress capitulated, after all the troops had evacuated the town: 30,000 men, who had defended Antwerp, crossed into Holland and were interned.

The Germans fired approximately 300,000 projectiles—weighing more than 30,000 tons in all—against Antwerp and its defences. It took 100 trains of 30 wagons each to transport this ammunition to the besieging force, whilst 100 additional trains were needed for bringing up other stores, etc. About 200 trains were required for the siege artillery, which required a powerful army to support it. This then is a

measure of the *effort* expended by the Germans in the capture of Antwerp.

Although Antwerp only held out for 12 days, after the siege was begun, it played a most useful purpose in the days from the 4th August to 28th September preceding the German onslaught. In order properly to appreciate the value of permanent fortifications the whole of the circumstances must be taken into account. The fortress of Antwerp fully justified, as events show, all the expenditure that had been incurred in bringing it into existence.

The defence of Verdun is touched upon. During the epic days, at the beginning of 1916, the works here played only a passive *rôle*. It was the garrison artillery and the troops which were responsible for the hard times that the Germans had to face. Owing to a hasty decision, forts were either lacking at Verdun, or, where forts existed, they were ill-found. Undoubtedly, permanent fortifications remain to-day, as they have always been, a most precious adjunct in defence, where care is taken to ensure that certain conditions are fulfilled in relation to them.—(*To be continued*).

Criteria of Physical Strength.

The original article is from the pen of Dr. F. E. Koby, a Surgeon-Lieutenant in the Swiss Army. He calls attention to an article contributed by him on "A New Measure of Physical Strength" to the *Revue* for April, 1919 (*vide R.E. Journal* for June, 1919). Dr. Koby alludes to the methods employed in evaluating numerically the "robusticity" of an individual, and briefly passes in review matters affecting the muscles, heart, and lungs. He mentions the use of the dynamometer in connection with the measurement of the physical strength of certain groups of muscles and the use of the ergograph for determining the fatigue curve of an individual. He points out that the methods of exploring the heart are numerous, but not reliable; pulsations of the heart can be counted, the beats of the pulse graphically recorded, arterial tension measured, etc. Nevertheless, the foregoing information does not enable the medical man to form a definitive judgment on the functional value of the heart, and only the nature of the reaction produced by muscular effort can provide a solution to the problem in question. The effect of physical exercise on cardiac acceleration is briefly reviewed.

Questions affecting respiration are next dealt with and also the methods employed to measure "pulmonary ventilation," that is to say, the total amount of air displaced during physical exercises extending over a definite period of time. A formula is obtained by Dr. Koby for what he terms the "pulmonary co-efficient," a factor which plays an important part in the determination of the "vital capacity" of an individual.

Notes and News.

Switzerland.—Colonel Sonderegger has taken over the duties of Chief of the Swiss General Staff. He has a difficult task before him. It is pointed out that the whole of the Swiss Army system requires overhauling; the administrative methods, the organization, the disposition, the

methods of command. Some doubt appears to exist as to the capacity and willingness of the new Chief to carry through the necessary reforms.

The question of a successor to the *Revue Militaire Suisse* is discussed. It is stated that a Central Committee of the *Société des Officiers* is at the present time considering the matter of starting a new paper. The proposal is to publish a fortnightly bilingual journal of 16 pages. It would seem that the intention is to issue a journal devoted to social matters, but comprising two supplements containing articles of a scientific nature; one of them in French, with occasional articles in Italian, and the other in German. Should this project succeed, the *Revue* is likely to be absorbed in the new venture, since there is scarcely room in Switzerland for two first-class military journals.

INFORMATION.

Switzerland.—The difficulties which arose in connection with the training of the 1st Battalion of Carabiniers at Zurich during August last, owing to the applications for the exemption of men employed by municipal, cantonal, and federal authorities, and by commercial houses is referred to. The situation thus created amounted almost to a scandal.

Although the Regulations forbid men to take uniform and articles of equipment home with them on demobilization, little attention is paid to these regulations. It is pointed out that the practice which has recently come into vogue of men wearing uniform when engaged on civilian work is likely to add to the military budget, since military garments are thus being worn out prematurely. It is suggested that the inspection of arms, equipment, etc., which prevailed before the war, should be reinstituted as a check to secure observance of rules and regulations.

Bulletin Bibliographique.—Notices appear relating to two works:—*La guerre sur mer*, which is a translation of Rudyard Kipling's well-known volume, and *Les germes de la grande guerre*, a translation by M. Cuno Hofer of the German volume *Die Keime des grossen Krieges*.

W. A. J. O'MEARA.

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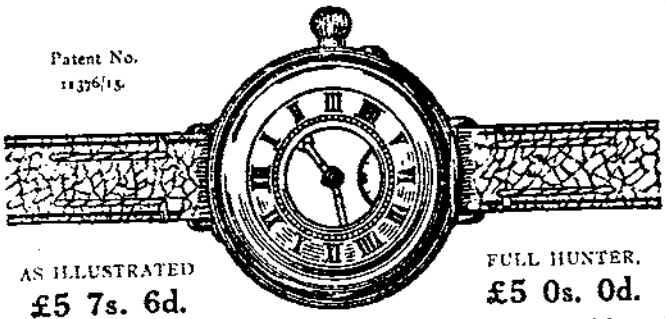

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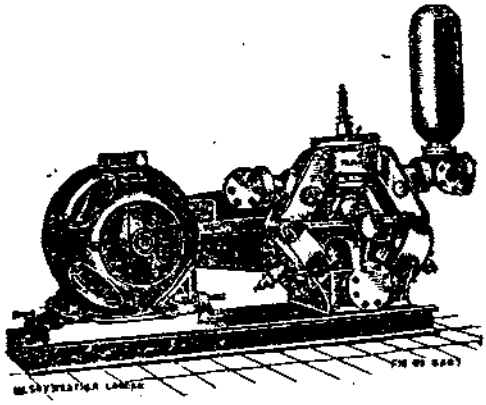

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